5TH INTERNATIONAL CONGRESS ON SOLDIERS' PHYSICAL PERFORMANCE

Défense nationale National Defence

BOOK OF ABSTRACTS

INTRODUCTION
BOOK OF ABSTRACTS

The 5th International Congress on Soldiers' Physical Performance (ICSPP) carried on the rich legacy of knowledge sharing and dialogue in amongst international partners from the first and second meetings in Jÿvaskÿla in 2005, and 2011, followed by Boston in 2014, and Melbourne in 2017. This year's meeting held in beautiful Québec City, Canada, had the highest attendance to date with a high quantity of quality scientific and operational research.

Keynote addresses, symposia, thematic sessions, and oral and poster presentations covered topics within an expanded domain of subjects including physical training programs and adaptions; occupational and physical performance; testing and assessment; injury prevention and surveillance; fatigue, sleep, public health and health promotion; nutritional considerations; human factors; data analytics and technology; clothing and equipment design; biomechanics, load carriage; gender integration issues; thermoregulation and environmental issues; basic training and field training considerations; and psychological and cognitive factors. Special emphasis was placed on winter warfare and the relevance and application of research to the military operator.

As part of the legacy of professional exchange that was accomplished over the week, we hope the 5th ICSPP Book of Abstracts serves not only as a reference for the excellent scientific content hosted by ICSPP, but as a reminder of the great memories and insightful conversations you experienced.

The success of this event was due to the collective effort of many. A big thank you to all that contributed: The Organizing Committee, the Scientific Committee, Agora Event Management, delegates, presenters, volunteers and all the sponsors. Finally, this congress would not have been possible without the unwavering support from the Canadian Armed Forces and the Canadian Forces Morale and Welfare Services / Personnel Support Programs.

WE LOOK FORWARD TO SEEING EVERYONE AGAIN IN 2023 IN THE UNITED KINGDOM.

Patrick Gagnon
Chair – Organizing Committee
5th ICSPP

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#ABS079
POSTER PRESENTATION

FEBRUARY 11, 2020

A ROYAL NAVY SUBJECTIVE JOB TASK ANALYSIS: THE COLLECTIVE IMPORTANCE OF SCIENCE AND JUDGEMENT

PURPOSE

A subjective job task analysis is one of the first steps in the development of a Physical Employment Standard (PES). Typically, an interdisciplinary team of scientists and job incumbent Subject Matter Experts (SME) collaborate to identify a valid short-list of tasks. This study highlighted the collective importance of science and SMEs in this process.

METHODS

A short-list of common, seafaring Royal Navy (RN) role-related tasks emerged following three task list down-selection steps. Step one, a rank stratified sample of RN personnel (n=77, mean ± SD; age 40 ± 8 years) attached to different platforms completed one (of eight) focus groups to produce a list of common platform-specific tasks. Duplicate tasks were clustered and tasks of unquestionably low physical demand, or not role-related were excluded. Step two, a convenience sample of n=545 personnel (mean ± SD; age 29 ± 7 years) completed one (of eight) platform-specific surveys that subjectively rated the physical demand (i.e. very light – maximal) and criticality (i.e. irrelevant – critical) of each focus group task list. Numeric threshold criteria excluded tasks with median physical demand and criticality ratings of 3 (out of 6). Step three, a senior military judgement panel (n=4) supported by advisors (n=6) followed a task down-selection decision tree that clustered similar tasks, and excluded tasks not performed by most ranks, trade specialisations, or on-board Naval frigates / destroyers.

RESULTS

Step one: focus groups sifted 684 tasks, which resulted in a compendium of 84 role-related tasks across eight operational platforms. Step two: the numeric survey threshold criteria reduced the overall list from 84 to 39 tasks. A lack of differentiation in task physical demand ratings prohibited further task list reductions via the numeric criteria. Step three: a military judgement panel of SMEs systematically reduced the task list from 39 to 14 tasks.

CONCLUSIONS

The identification and validation of a short-list of tasks to progress onto a subsequent phase of RN PES research was an interdisciplinary collaboration reliant upon both science and SME judgement.

OPERATIONAL RELEVANCE

This work will ensure that the appropriate role-related functional movements are translated into future RN PES policy such that physical component of operational effectiveness is maintained and musculoskeletal injury risk mitigated.

AUTHORS

Clare Eglin (1)
Jennifer Wright (1)
Matthew Maley (1)
Jennifer Wright (1)
Sarah Hollis (2)
Michael Tipton (1)

(1) University of Portsmouth (Portsmouth, United Kingdom); (2) Regional Occupational Health Team (Catterick, United Kingdom)

PHYSIOLOGICAL IMPACT OF STRESS INOCULATION TRAINING IN POLICE CADETS AND ITS RELATIONSHIP TO PHYSICAL FITNESS

PURPOSE

Stress inoculation training (SIT) aims to promote psychological preparedness and resilience. Commonly adopted in law enforcement training, SIT is often combined with physically challenging scenarios to simulate occupational tasks and demands. The primary aim of this study was to assess the physical demands of a SIT in police officer cadets and secondly, to identify any relationships between fitness and physiological response to SIT.

METHODS

Retrospective data were collected for 23 police cadets (18 males) by a US state law enforcement agency. Police cadets were put through a high SIT, which included a sensory deprivation scenario. Cadets fitness was assessed through the one-minute sit-ups and push-up, VO2max and vertical jump tests. Heart rate (HR) and blood pressure (BP) measurements were obtained prior to and post-event, and peripheral capillary oxygen saturation (SpO2) was assessed after the event. Paired t-tests were performed to compared physiological response to the SIT. Regression analysis explored possible relationship between fitness assessments and physiological response to the SIT.

RESULTS

Cadets took on average, 5.5+0.05 minutes to complete the SIT. As expected, the SIT had a significant effect on HR and systolic BP, with average increases of 58+23bpm and 40+20mmHg, respectively. Three cadets experienced exaggerated hypertensive response to the SIT with the difference in systolic BP (pre-versus post-event) surpassing 60mmHg. Thirteen cadets had post-SIT diastolic BP over the ACSM-recommended threshold for maximal exercise of 90mmHg. Cadets were working on average at 87+6% of their age-predicted maximum HR (APMHR) with peak levels reaching 97+5% of APMHR. SpO2 after the SIT averaged 90+6% with the lowest saturation reaching 68%. The scores in fitness assessments did not account significantly for the variability in the physiological responses to the scenarios.

CONCLUSION

SIT with a sensory deprivation scenario elicited the desired physiological high-stress response in police cadets, comparable to that experienced by officers undergoing occupational tasks. Physiological responses to SIT appear to be more dependent on psychological perception and response to stress rather than physical fitness to endure the SIT.

OPERATIONAL RELEVANCE

The results suggest that the SIT undertaken by the cadets are effective in simulating the stress they will experience. Therefore, an opportunity exists to teach police officers how to mitigate their stress and to ensure physical and more importantly psychological preparedness to endure such stresses.

AUTHORS

Elisa F.D. Canetti (1)
Chloe Chapman (2)
Ben Schram (1)
Charles Kornhauser (3)
Ryan J. Holmes (3)
Jay Dawes (4)
Robin Orr (5)

(1) Tactical Research Unit, Bond University (Gold Coast, QLD, Australia); (2) Bond University (Gold Coast, QLD, Australia); (3) Colorado State Highway Patrol, Training Academy (Lakewood, CO, United States); (4) Oklahoma State University (Stillwater, OK, United States); (5) Tactical Research Unit, Bond Univeristy (Gold Coast, QLD, Australia)

THE INFLUENCE OF INHIBITORY CONTROL, HARDINESS AND TOLERANCE OF EXERCISE-INDUCED PAIN ON BRAZILIAN NAVY SPECIAL OPERATIONS COURSES CONCLUSION

PURPOSE

The Brazilian Navy has special operations courses, with high technical, physical and psychological demands. The aim of the present study was to verify the influence of inhibitory control, hardiness and tolerance of exercise-induced pain on Brazilian Navy special operations courses conclusion.

METHODS

Forty-eight male military personnel participated in the study (28.2 ± 3.0 years, 79.8 ± 7.4 kg, 177.3 ± 5.7 cm, 50.9 ± 3.2 mL.kg-1.min-1). The following tests were performed: Incongruent Stroop word-color test, Dispositional Resilience Scale-30 (DRS-30) that estimates hardiness and tolerance of exercise-induced pain test. After ensuring Gaussian distribution, an independent t-test was used to compare the incongruent Stroop word-color test, DRS-30 and tolerance of exercise-induced pain scores between approved and non-approved students. Analyses were completed using Graph Pad Prism 5 (Graph Pad Software Inc., California, USA) at a significance level of p 0.05.

RESULTS

The overall attrition rate was 62.5% (n = 30). The results indicate that students approved in special operations courses completed more correct answers during the incongruent Stroop word-color test (212.5 ± 35.8 vs. 186.7 ± 46.1, p = 0.04), presented greater hardiness (28.5 ± 4.5 vs. 25.3 ± 5.4, p = 0.03) and greater tolerance of exercise-induced pain (8.5 ± 3.1 vs. 6.5 ± 3.4, p = 0.04) when compared to the non-approved ones.

CONCLUSIONS

The main finding was that students approved in special operations courses exhibited superior performance during the incongruent Stroop word-color test, which is indicative of greater inhibitory control, greater hardiness and greater tolerance of exercise-induced pain. Therefore, we suppose that a military with better inhibitory control, greater hardiness, and greater tolerance of exercise-induced pain is more likely to persist in strenuous training programs, dietary restrictions, limitations to social life and also be more capable to control negative thoughts (desire to give up), adverse feelings (dyspnea, muscle pain and thermal discomfort) and actions during the operations assigned to them.

OPERATIONAL RELEVANCE

The information contained in the present study could be used in the elaboration of training approaches to increase the resilience of military personnel to sustained stressors and could aid in the selection of personnel for such occupations.

AUTHORS

Allan Inoue (1)
Daniel Alves (2)
Maria Miranda (3)
Thiago Lopes (2)
Priscila Bunn (4)

(1) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science, Rio de Janeiro, Brazil; Exercise Psychophysiology Group, School of Arts, Sciences and Humanities, University of São Paulo, São Paulo, Brazil; Exercise and Sport Sciences Postgraduate Program, Rio de Janeiro State University, Rio de Janeiro, Brazil; Operational Human Performance Postgraduate Program, Air Force University, Rio de Janeiro, Brazil (Rio de Janeiro, Brazil); (2) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science, Rio de Janeiro, Brazil; Operational Human Performance Postgraduate Program, Air Force University, Rio de Janeiro, Brazil (Rio de Janeiro, Brazil); (3) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science, Rio de Janeiro, Brazil; Exercise and Sport Sciences Postgraduate Program, Rio de Janeiro State University, Rio de Janeiro, Brazil (Rio de Janeiro, Brazil); (4) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science, Rio de Janeiro, Brazil; Exercise and Sport Sciences Postgraduate Program, Rio de Janeiro State University, Rio de Janeiro, Brazil; Operational Human Performance Postgraduate Program, Air Force University, Rio de Janeiro, Brazil (Rio de Janeiro, Brazil)

1.1
MENTAL AND PHYSICAL RESILIENCE

#ABS314
POSTER PRESENTATION

FEBRUARY 11, 2020

SURVIVAL OF THE FITTEST IN A SPECIALIST TACTICAL POLICE SELECTION COURSE

PURPOSE

Entry to specialist police tactical teams is typically governed by performance on a selection course, which are typically physically intense and psychological demanding, designed to match the operational tempo of occupational tasks. The aim of this study was to determine the fitness attributes associated with completion of a weeklong, specialist police selection course.

METHODS

A retrospective cohort study was designed where data pertaining to 18 candidates was obtained from barrier testing prior to the course. Data included initial fitness measures of 1-minute push-ups, loaded (17kg) pull-ups, loaded (17kg) 30m crawl, an agility run, a 1.2km run and multi-stage fitness assessment which was converted to relative VO2max. Measures of those who did and did not complete the selection week were subsequently assessed for significant differences. A hierarchical multiple regression was performed to determine a model which could predict course success using these variables.

RESULTS

A total of eleven candidates finished the selection course. Those who were successful completed significantly more pushups (+9.1 reps), more loaded pull-ups (+2.9 reps), were significantly faster in a 1.2km run (-30.1 secs), a loaded 30m crawl (-6.3 secs), an agility run (-0.67 secs) and had a significantly greater VO2max (+4.8ml/kg/min). The regression analysis found that the combination of the results of the pullups, 30m loaded crawl and agility time could predict 76% of the variability in course completion ($R2=0.76$, $F(3,17) = 14.373$, $p= 0.001$). As independent predictors including pushups which only explained 0.02% of the variance, the 1.2km run (0.29%) and VO2max results (0.12%) did not have a significant influence on course completion.

CONCLUSIONS

Candidates who completed a specialist police selection course possessed greater aerobic fitness, upper limb strength and endurance and agility than those who did not complete the course. Upper limb strength, the ability to move under load and agility appear to be predictive of course success.

OPERATIONAL RELEVANCE

This study highlights the importance of a multitude of fitness attributes in this population, with aerobic fitness in particular not being predictive of course success. This may be due to a ceiling effect however. Health professionals working with candidates or individuals planning on attending selection courses should aim to maximize upper limb strength, agility and the ability to move under load to maximize chances of course completion.

AUTHORS

Ben Schram (1)
Robin Orr (1)
Jeremy Robinson (2)

(1) Tactical Research Unit, Bond University (Robina, Australia); (2) Australian Federal Police, Specialist Response Group – Tactical Response Team (Canberra, Australia)

1.2 OPTIMIZING THE WINTER SOLDIER

#ABS021

FEBRUARY 11, 2020

THERMOREGULATORY CAPABILITIES OF A CLOSED CELL WETSUIT AT VARYING DEPTHS

PURPOSE

To evaluate a closed cell wetsuit for thermal protective capability during long-duration cold-water exposure at various depths. Additionally, to measure changes in skin and core temperature as a function of depth.

METHODS

Thirteen (n=13) U.S. Navy SEALs and support divers who were tasked with cold-water training participated in this study. To mimic various depths, the Ocean Simulation Facility (OSF) at the Navy Experimental Diving Unit was utilized across six diving days (one dive per day, six total dives). Water temperature remained at 1.82.0C for all dives. The OSF was pressurized to simulate dive depths of 30, 50, and 75 fsw. Four divers dove each day and used the MK 16 underwater breathing apparatus with gas mixes of either N202 or HeO2. Skin (Tsk) and core temperature (Tc) readings were obtained every 30 minutes during the 30 fsw and 50 fsw dives, and every 15 minutes during the 75 fsw dive. The termination temperatures were previously determined to be Tsk= 10C and Tc= 35C to prevent any non-freezing cold injuries. Mean skin temperature (MnTsk) was calculated using methodology described by Ramanathan (1964).

RESULTS

Tc was preserved across all dives (post-dive Tc= 36.5±0.4). The lowest individual Tc recorded was 35.79C, during the 75 fsw dive breathing HeO2. The expected decrease in Tsk, particularly in the extremities, resulted in termination of three dives due to hand and foot temperature. Mean post-dive hand and foot temperatures were 17.2±3.9C and 15.56±3.1C, respectively, with the lowest hand temperature: Tsk= 10.18C, and the lowest foot temperature: Tsk= 10.63C. MnTsk decreased (post MnTsk= 24.24±1.7C) at an expected rate due to the prolonged time spent in the water. The ability to create predictive equations for the determination of physiological temperature changes based on dive depth, duration, and gas mix are in the early stages of development.

CONCLUSIONS

These findings demonstrate that Tc is preserved and that changes in Tc and Tsk are a function of dive duration independent of depth for a closed cell wetsuit in cold water at various depths.

OPERATIONAL RELEVANCE

These data demonstrate that missions and operations in arctic-like conditions at various depths is sustainable without compromising operational readiness. These pilot data allowed for creation of preliminary models of the rate of heat loss over time in these extreme conditions.

AUTHORS

Laura Arrington (1)
Jake Bernards (1)
Andrew Jensen (1)
Karen Kelly (1)

(1) Naval Health Research Center (San Diego, United States)

REFERENCE

Ramanathan, N. L. (1964) A new weighting system for mean surface temperature of the human body. Journal of Applied Physiology, 19, 531533.

ANALYSIS OF PROGRESSIVE ENERGY COMPENSATION DURING A 15-DAY EXPEDITION IN THE COLD THROUGH AN ASSESSMENT OF COMPONENTS OF EATING BEHAVIOR

PURPOSE

Multi-days expeditions/trainings in the cold are characterized by negative energy balance (EB) leading to body mass loss. However, an accurate and frequent measurement of several components of eating behavior has never been realized to understand how soldiers adapt to high levels of physical activities in the cold.

METHODS

Twelve French soldiers realized a 15-d ski expedition in Greenland (150 km;-24 to-11 °C). Participants had access to daily bag of palatable foods (~20000 kJ) designed for two large meals (breakfast and dinner) and 3 to 6 snacks during the day. Each day, in a paper notebook, they had to report food and beverages consumed and the time of intake to calculate a posteriori energy intake (EI). Appetite and thirst were assessed using visual analog scales before breakfast and dinner. Energy expenditure (EE) was calculated using heart rate measurements. The reward value of food was measured at the end of each 3 periods using the food preference questionnaire. A body mass and composition measurement was done just before and the day after the expedition. The 15 days were cut in 3 parts (D1-D5, D6-D10 and D11-D15) for analyses.

RESULTS

Slight decreases in body mass (-0.9 ± 1.1 kg, $p = 0.020$) and fat mass (-1.7 ± 1.5 kg, $p = 0.002$) were observed. Mean daily EE, EI and EB were 17510 ± 1651, 16336 ± 1989 and-1174 ± 2436 kJ, respectively. Time analysis revealed that EI and EB were higher during D11-D15 than D1-D5 (+2338 ± 865 kJ; $p = 0.003$) and D1-D10 (+4277 ± 1595 kJ $p < 0.001$), respectively. Further analysis revealed that this energy compensation only occurred in morning (between 06:00 and 14:00). Hunger in the morning ($p = 0.030$) and thirst scores in the morning and the evening ($p = 0.003$ and < 0.001, respectively) were higher during D6-D15 than D1-D5. Liquid intake was yet not modified. Finally, food preference in sweet foods increased during D11-D15 compared to D1-D5 ($p = 0.048$).

CONCLUSIONS

Energy compensation seems to occur after ten days of expedition. This compensation seems anticipatory but insufficient to contain increases in hunger, thirst and preference for sweet foods.

OPERATIONAL RELEVANCE

The subdivision of EI and the utilization of palatable foods likely limit the energy deficit during an expedition in the cold. These advices are all the more pertinent with expeditions lasting less than 10 days since compensatory behaviors do not yet occur.

AUTHORS

Keyne Charlot (1)
Camille Famel (2)
Philippe Colin (1)
Cyprien Bourrilhon (1)

(1) Département Environnements Opérationnels, Unité de Physiologie de l'Exercice et des Activités en Conditions Extrêmes, Institut de Recherche Biomédicale des Armées (Brétigny-sur-Orge, France); (2) Ecole Centrale d'Electronique, Paris, France (Paris, France)

INVESTIGATING THE ROLE OF SEX IN COLD INJURY PREVALENCE AMONG SEARCH AND RESCUE PERSONNEL AND MILITARY TROOPS

PURPOSE

Garments providing thermal protection, including mittens or gloves, help mitigate cold-injuries and cold-induced decrements in performance of manual tasks. Females typically have smaller hand masses, surface areas and volumes but a greater surface area to hand volume which predisposes them to faster hand cooling rates than males. The purpose of this study was two-fold: 1) to determine differences among male and female SAR workers and military troops in their currently employed hand protection, and, 2) to assess the prevalence of cold injuries across the sexes. It was hypothesized females experienced more cold-related injuries compared to males amongst search and rescue (SAR) personnel and military troops.

METHODS

Local SAR groups and USA military troops were sent an online survey with questions focused on the thermal performance of currently employed protective garments and their effectiveness in preventing cold injuries. This study was approved by the SFU Office of Research Ethics.

RESULTS

A total of 21 males, 5 females, and 2 persons that preferred not to specify their sex, for a total of 28 SAR or military troops completed the survey. They had a range of 25-75 years of age with an average height of 1.79 ± 0.09 m and weight of 84 ± 21 kg. Four individuals or 13% reported cold injuries, including frost bite, vibration white finger, Raynauds syndrome, and cold-water immersion injury. All injuries reported were among SAR personnel, and no injuries were reported among military troops. Using a Chi-square test analysis, males ($p=0.750$) were just as likely to have experienced a cold injury as females. Despite the low prevalence of cold injuries, 21.9% of individuals felt the design of their current hand cold protective gear did not meet their needs in cold weather conditions.

CONCLUSIONS

In conclusion, these preliminary results suggest there are no differences in the occurrence of cold injury in females than males hands.

OPERATIONAL RELEVANCE

Cold-induced decrements in manual tasks and hand cold injuries remains a problem since antiquity while debilitating frostbite on the hands was evident in the Canadian Military troops as recently as January 2019. Prevention of the cold injuries and improvements in manual dexterity for both sexes during military deployments in the north remains an ongoing need for effective and injury free deployments in cold arctic conditions. These preliminary results mark the start on an ongoing study of SAR and military personnel hand cold injury prevalence.

AUTHORS

Clara V Etter (1)
Elizabeth Gnatiuk (2)
Amanda E Kirk (2)
Jacob MT Cartwright (2)
Emily, J Heaps (3)
Andrew S Perrotta (2)
Matthew D White (2)

(1) 1Laboratory for Exercise and Environmental Physiology (Burnaby, Canada); (2) Laboratory for Exercise and Environmental Physiology, Department of Biomedical Physiology and Kinesiology, Simon Fraser University (Burnaby, BC, Canada); (3) Wilson School of Design, Kwantlen Polytechique University (Richmond, BC, Canada)

1.2 OPTIMIZING THE WINTER SOLDIER

#ABS381

FEBRUARY 11, 2020

MICROCLIMATE AND SURFACE SKIN TEMPERATURES OF THE UPPER LIMB PROTECTED THE CANADIAN MILITARY WINTER KIT MITTS AND GARMENTS DURING EXTREME COLD EXPOSURES

PURPOSE

To examine microclimate and surface skin temperature responses of the upper limb protected by the Canadian Military Winter Kit (CMWK) garments during extreme cold exposures.

METHODS

Participants were (mean ± SD) 4 males who were 39.3 ± 17.9 years of age with a body fat of 17.1 ± 6.3% and for 3 females who were 29.7 ± 3.5 years of age with a body fat 27.9 ± 1.6%. Surface skin temperatures (TSK) and heat flux (HF) disks were measured at 16 sites on anterior and posterior sides of all fingers, the thumb, hand, forearm and upper arm. iButtons measured microclimate relative humidity and temperature on both sides of the hand and forearm. The dominant arm was entered to level of the axilla into a climatic chamber with an ambient temperature of-20°C,-40°C or-60°C for up to 60 min. Conditions were chosen based on winter conditions reported by Environment Canada for Resolute Bay, Nunavut and Whitehorse, Yukon. The protocol included 20 min of no wind followed by a 40 km·h-1 wind for 20 min on the anterior side and 20 min on posterior side of the limb. Whole body DEXA scans were employed for assessment of body composition. The study was approved by the SFU Office of Research Ethics.

RESULTS

For the-40°C condition, the duration endured was 41:54 ± 11:16 mm:ss, with only one participant reaching 60 min. Mean microclimate temperature decreased from a pre-cooling temperature of ~26.0°C for both sides of the hand to a low of 12.4 ± 5.5°C on the anterior hand to a low of 9.7 ± 3.2°C on the posterior hand. Mean TSK reached 22.6 ± 2.0°C on the anterior and 24.1±2.1°C on posterior side of the hand when one of the 16 TSK measurements reached the lower limit of 10°C.

CONCLUSIONS

The Canadian military winter kit mitten provided varied and insufficient thermal protection against these typical arctic conditions.

OPERATIONAL RELEVANCE

Cold-induced decrements in manual tasks remains an ongoing problem with debilitating frostbite on the hands evident in the Canadian Military troops as recently as January 2019. These results support the thermal protection of the current Canadian military winter kit mitten is insufficient. The operational relevance is the design and production of improved thermal protection the hand is needed to allow troops in these arctic conditions to have more effective deployments with reduced cold injuries.

AUTHORS

Elizabeth A Gnatiuk (1)
Jacob MT Cartwright1 (2)
Clara V Etter (2)
Andrew S Perrotta (2
Himani Boury (2)
Emily J Heaps (3)
Matthew D White (2)

(1) Laboratory for Exercise and Environmental Physiology (Burnaby, Canada); (2) Laboratory for Exercise and Environmental Physiology, Department of Biomedical Physiology and Kinesiology, Simon Fraser University (Burnaby, BC, Canada); (3) Wilson School of Design, Kwantlen Polytechique University (Richmond, BC, Canada)

ESTIMATED ENERGY EXPENDITURE AND MACRONUTRIENT REQUIREMENTS OF SKINNING & BREAKING TRAIL DURING SPECIAL OPERATIONS SKI MOUNTAINEERING: A PILOT STUDY

PURPOSE

The conduct of Special Operations Ski Mountaineering (SOSM) includes traversing complex avalanche terrain lacking defined trails. Backcountry ski touring is the primary mode of travel in these conditions, which involves the use of skins on the bottom of touring skis to provide traction, also known as skinning. Skinning in the lead position of a group involves establishing a trail through the snow, known as breaking trail. This task is generally regarded as more physically demanding than skinning. To help inform Operators conducting these tasks on physiological and energy demands, estimates of energy expenditure (EE) and associated macronutrient fuel selection needed to be quantified. The purpose of this pilot study was to estimate the EE and macronutrient requirements of performing skinning and breaking trail during SOSM.

METHODS

Verified subject matter experts developed a series of mission profile work samples, which included skinning and breaking trail while carrying operational loads. Operators who volunteered to participate were equipped with a portable metabolic measurement system and instructed to perform the tasks at a self-selected, operationally relevant pace, while rotating lead position at self-determined intervals. Work samples took place over two days in mountainous terrain above 2,000m elevation.

RESULTS

Three participants performed skinning and breaking trail during one work sample. Participants carried a mean weight of 18.3 (±3.6) kg and dragged a toboggan with a mean weight of 38.4 (±0.5) kg. The mean duration of skinning was 28:10 (±2:01) min:sec, during which time the mean volume of oxygen consumed (VO2) was 30.0 (±2.2) mL·kg-1·min-1, mean EE was 655 (±73) kcal·hr-1, and mean macronutrient breakdown was 52 (±19)% carbohydrates and 48 (±19)% fats. Mean duration of breaking trail was 32:45 (±13:52) min:sec, during which time the mean VO2 was 33.1 (±6.5) mL·kg-1·min-1, mean EE was 763 (±205) kcal·hr-1, and mean macronutrient breakdown was 65 (±26)% carbohydrates and 35 (±26)% fats.

CONCLUSIONS

Results support that breaking trail is more aerobically demanding than skinning, resulting in a higher estimated EE and higher carbohydrate metabolism. Additional research with various scenarios should be conducted to confirm and more accurately determine EE and macronutrient requirements of SOSM tasks.

OPERATIONAL RELEVANCE

Providing Operators with relevant data such as the physical demands, energy requirements and macronutrient breakdown of high intensity tasks allows them to plan, prepare and operate more effectively. It also provides operational commanders with scientific evidence to tactically deploy individuals and support their operational requirements.

AUTHORS

Kyle Gordon (1)
Sylvie Fortier (1)
Anna Smyth (1)
Mark Carlson (1)

(1) Canadian Forces Morale and Welfare Service (Ottawa, Canada)

1.2 OPTIMIZING THE WINTER SOLDIER

#ABS027

FEBRUARY 11, 2020

PHYSICAL AND PHYSIOLOGICAL EFFECTS OF A SUB-ARCTIC UNDERSEA TRAINING OPERATION

PURPOSE

To determine the physiological and physical performance effects of Arctic diving among Norwegian Marinejegerkommandoen divers.

METHODS

Nine male Norwegian Marinejegerkommandoen (age: 32.3 ± 1.2 yr; ht: 180.9 ± 2.6 cm; wt: 86.4 ± 3.9 kg; body fat: 11.4 ± 2.5%) engaged in Arctic dive operations were recruited to participate in this study. Operators conducted a brief 35-min Arctic training dive in Rasmund, Norway (ambient air temperature:-5.1°C, water temperature: 3.3°C). Participants wore dry suits with woolen undergarments. All participants were provided a core temperature (Tc) pill to swallow and skin temperature (Tsk) patches, which were affixed to the right side of the participant at four locations: arm (lateral deltoid), chest, thigh, and calf. Tc and Tsk readings were collected prior to and immediately after the dive, along with measures of hand grip strength, blood glucose, ketones, total testosterone, cortisol, dehydroepiandrosterone (DHEA), insulin-like growth factor-1 (IGF-1), and leptin. Mean Tsk was calculated using the Ramanathan (1964) equation: Tsk = 0.3(Tchest +Tarm)+0.2(Tthigh + Tcalf). All data are represented as mean ± standard error.

RESULTS

There were no differences between pre-and post-dive Tc (37.7 ± 0.2 vs. 37.3 ± 0.4°C; P>0.05); however, there was a significant decrease in mean Tsk pre-to post-dive (32.6 ± 0.4 vs. 26.9 ± 0.7°C; P<0.05). There were significant decreases observed pre-to post-dive for total testosterone (416.6 ± 20.6 vs. 339.6 ± 31.3 ng·dL-1; P<0.05), DHEA (1.68 ± 0.32 vs. 1.08 ± 0.11 µg·dL-1; P<0.05), and leptin (2.6 ± 0.8 vs. 1.7 ± 0.6 ng·mL-1; P<0.05). There were no differences pre-to post-dive for glucose, ketones, cortisol, or IGF-1 (P>0.05). Despite a significant decrease in mean Tsk, there was no difference in pre-to post-dive hand grip strength (56.6 ± 3.7 vs. 56.0 ± 2.7 kg; P>0.05).

CONCLUSIONS

These findings demonstrate that during short-duration Arctic dives, operators can maintain their Tc and physical strength despite decreases in Tsk; and that there are alterations in the hypothalamic-pituitary-gonadal axis hormones.

OPERATIONAL RELEVANCE

These data demonstrate that short-duration missions and operations in Arctic climates are sustainable without decrements in physical performance. Further work needs to be done to determine the effects of long duration and repeated Arctic dives on performance and hormonal balance.

AUTHORS

Andrew Jensen (1)
Laura Arrington (1)
Jake Bernards (1)
Paul Solberg (2)
Karen Kelly (1)

(1) Naval Health Research Center (San Diego, United States); (2) Norwegian Naval Special Operations Command (Bergen, Norway)

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1.2 OPTIMIZING THE WINTER SOLDIER

#ABS170
POSTER PRESENTATION

ESTIMATION OF ENERGY EXPENDITURE DURING CANADIAN HIGH ARCTIC MILITARY OPERATIONS

PURPOSE

The extreme weather conditions faced in the Canadian High Arctic make even basic survival a challenge for the soldier. The purpose of this study was to examine the energy expenditure of Canadian Armed Forces (CAF) members while operating in the Arctic.

METHODS

48 CAF members (mean ± SD: Age=24.42 ± 3.6 years; Weight=83.4 ± 13.94kg; resting metabolic rate (RMR) =1930.7 ± 200.8 kcals/day) wore activity monitors (ActiGraph wGT3X-BT, ActiGraph, Pensacola, FL) while deployed on field exercises in Resolute, Nunavut, in 2018 and 2019. Daily tasks included snowmobile patrols, shelter construction, and basic military duties. Weight was measured before and after the five-day exercises. Total daily energy expenditure (TDEE) was estimated using ActiGraph software in conjunction with the Harris-Benedict estimation of RMR [1].

RESULTS

The mean TDEE across all participants was 3833.8 ± 482.2 kcals per day. Participants lost a mean of 1.51 ± 1.6% of their body weight over the 5 days.

CONCLUSIONS

Estimates of daily energy expenditure during Canadian High Arctic military exercises were found to be similar to typical rates seen in habitually active, non-military males. However, estimates do not account for the added metabolic burden of body temperature maintenance, shivering, and the additional weight of personal protective equipment. Interestingly, estimates are considerably lower than TDEE reported during previous military exercises, both in the extreme cold and elsewhere. This suggests that while the conditions are challenging, actual activity levels may be less taxing due to slower movement and frequent periods of inactivity. The weight loss over five days was not extreme and could be attributed to typical day-to-day fluctuations.

OPERATIONAL RELEVANCE

Ensuring that individual energy requirements are consistently met is crucial for optimization of military performance in the arctic. As the preparation and consumption of food in extreme weather conditions can be challenging, having a basic estimate of energy requirements may help units and individuals make the necessary arrangements to ensure their needs are met.

AUTHORS

Katy Moes (1)

Wendy Sullivan-Kwantes (1)

(1) Defence Research and Development Canada, Toronto Research Centre (Toronto, Canada)

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EFFECT OF A VENTILATION VEST ON THERMOREGULATION DURING EXERCISE IN A WARM ENVIRONMENT FOLLOWED BY STANDING STILL IN A MARKEDLY COLD ENVIRONMENT

PURPOSE

In the arctic and subarctic winter, military personnel may encounter transitions from warm to markedly cold environments without the possibility to change clothes, and may hence wear sweaty garments during the cold exposure. To increase evaporation and reduce the wetness of clothing, a ventilation vest may be used. The purpose was to examine the thermoregulatory responses during transition from a warm to a cold environment, and evaluate the impact of wearing a ventilation vest.

METHODS

Military cadets (9 men, 25±2 yrs, 182±7 cm, 86±4 kg) participated in two trials, wearing a ventilation vest with fans turned on during the treadmill phase = V or no vest = NV. After baseline measurements at ambient temperature 33°C, each subject donned an army winter uniform and walked on a treadmill at 4.5 km/h for 40 min, which induced excessive sweating. This was followed by a transition to a cold chamber (-20°C), where subjects conducted 90-min simulated guard assignment. Rectal, torso and mean skin temperatures were measured continuously. Thermal perception was reported every 15 min.

RESULTS

By the end of exercise, the rectal temperature had increased by 1.0±0.2°C and 0.8±0.3°C in the NV and V conditions (ns), respectively. At the end of the cold exposure, rectal temperature was still elevated by 0.3±0.3°C and 0.1±0.2°C in the NV and V conditions ($p<0.05$), respectively. The torso skin temperature increased throughout exercise in both conditions, yet to a lesser extent in the V condition (NV=35.7±0.4°C, V=35.0±0.3°C, $p<0.05$). At the end of exercise accumulated heat storage was 13% lower ($p<0.05$), and the subjects perceived the torso to be cooler ($p<0.05$), in the V than the NV condition. In the cold, the torso skin cooled at a slower rate in the V condition, and eventually was almost 2°C warmer (NV=29.1±0.9°C, V=30.9±1.0°C, $p<0.05$). Similarly, mean skin temperature was 0.3°C cooler ($p<0.05$) at the end of exercise, and about 1°C warmer ($p<0.05$) at the end of the cold exposure, in the V than the NV condition. The V condition was also perceived warmer during the cold exposure ($p<0.05$).

CONCLUSIONS

The ventilation vest had a positive impact on the temperature response and thermal perception during both the exercise phase, and the cold exposure.

OPERATIONAL RELEVANCE

The results hold promise to use a ventilation vest to improve thermoregulation and thermal comfort in conditions where military personnel need to alternate between warm and markedly cold environments, without being able to change garments.

AUTHORS

Lena Norrbrand (1)
Mikael Grönkvist (1)
Christiano Machado-Moreira (2)
Ola Eiken (1)

(1) KTH Royal Institute of Technology, School of Engineering Sciences in Chemistry, Biotechnology and Health, Div of Environmental Physiology (Solna, Sweden); (2) Federal University of Juiz de Fora, Campus Governador Valadares (Sao Paulo, Brazil)

1.2
OPTIMIZING THE WINTER SOLDIER

#ABS150

FEBRUARY 11, 2020

NEGATIVE ENERGY BALANCE ACTIVATES LIPOLYSIS DURING WINTER SURVIVAL TRAINING

PURPOSE

The aim of this study is to describe the changes in free fatty acids, leptin, body mass and body fat percentage during winter survival training in conscripts.

METHODS

Twenty-three male conscripts (age 19.6±0.8 yrs., height 180±7 cm, body mass 75.8±10.2 kg, BMI 23.2±2.5 kg/m2) volunteered as participants in a winter survival training as a part of their military service. The survival training consisted of strenuous field training period with restricted energy intake, moderate exercise intensity and limited rest. Pre-filled food diaries were used for evaluation of energy intake and heart rate variability measurements for assessment of energy expenditure through the field training. Fasting blood samples for free fatty acids and leptin were conducted three times during training (0d, 5d, 9d). Bioelectrical impedance analysis was used for body composition analyses at the same time points. All data is presented as means±standard deviations. A paired t-test was used to compare the means. Statistical significance was met when $p < 0.05$.

RESULTS

Reported mean energy intake during field training was 740±313 kcal/d and estimated mean energy expenditure 4915±1177 kcal/d, thus the estimated net energy balance was negative (-4349±1341 kcal/d, n=21). Serum free fatty acids increased significantly from 0d (201±133 mmol/L) to 5d (1596±333 mmol/L; $p<0.001$) but then recovered in 9d (272±137 mmol/L; $p=0.096$). Leptin concentration decreased from 3.6±2.5 ng/ml (0d) to 0.4±0.3 ng/ml (5d; $p<0.001$) and 0.9±0.5 ng/ml (9d; $p=0.001$). Body fat percentage decreased from 13.8±4.1% (0d) to 8.9±3.6% (9d; $p<0.001$) and body mass from 75.8±10.2 kg (0d) to 72.7±9.5 kg (9d; $p<0.001$).

CONCLUSION

The increase of free fatty acids and the decrease of leptin concentration were observed during the first five days of strenuous training. Fat utilization for energy substrate contributed to the decrease of body fat percentage. In conclusion, restricted energy intake together with the high energy expenditure activated the lipolysis in the winter survival training.

OPERATIONAL RELEVANCE

In winter survival training, severe energy deprivation diminishes muscle glycogen storages and emphasizes fat oxidation for energy, which impairs optimal performance in soldiers. Therefore, refueling of energy storages is important in preparation and recovery period to maximize the military performance.

AUTHORS

Tarja Nykänen (1)
Tommi Ojanen (2)
Mikael Fogelholm (3)
Heikki Kyröläinen (4)

(1) Army Academy (Lappeenranta, Finland); (2) Finnish Defence Research Agency (Tuusula, Finland); (3) University of Helsinki (Helsinki, Finland); (4) University of Jyväskylä, National Defence University (Jyväskylä, Helsinki, Finland)

HORMONAL CHANGES AND RECOVERY DURING STRENUOUS WINTER SURVIVAL TRAINING IN FINNISH SOLDIERS

PURPOSE

To investigate hormonal changes and effects of a short recovery period during strenuous winter survival training in Finnish soldiers.

METHODS

Forty-five (age 20±1 years, height 180±6 cm, body mass 76.6±9.7 kg) male soldiers voluntary participated in the study. Winter SERE (survival, evasion, resistance and escape) training lasted for 10 days, and consisted of garrison and field training phases. During winter SERE, subjects learn survival skills in the cold environment and are exposed to strenuous physical and psychological stress. The subjects were divided into two groups (RECO, n=20 and EXP, n=25) randomly. RECO group had a 1.5-day rest in the middle of the field training, whereas EXP group continued their training without the recovery period. Body composition, shooting and performance tests as well as serum hormone concentrations were measured four times (PRE, MID1, MID2 and POST) during the study for testosterone (TES), cortisol (COR), sex-hormone binding globulin (SHBG), insulin-like growth factor-1 (IGF-1), leptin (LEP), epinephrine (EPI), norepinephrine (NOR), and creatine kinase (CK). In addition, questionnaires and physical activity (accelerometers and GPS) of the subjects were collected daily.

RESULTS

As expected, significant declines were observed in body and fat mass as well as in the TES, IGF-1 and LEP concentrations in both groups in the beginning of SERE. At the same time, the CK, EPI and NOR values showed significant increases. During the 1.5-day recovery, RECO started to show recovery almost in all of the measured variables, whereas in EXP no recovery was observed. The groups showed no significant changes in maximal isometric strength.

CONCLUSION

Despite the cumulative effects of sleep deprivation, food restriction and strenuous training, the subjects were able to maintain performance in maximal strength. Strenuous winter survival training led to drastic changes in soldiers hormonal concentrations. The 1.5-day rest in the middle of the field training seems to enhance the body to recover and be ready to return to training, but it is not enough for full recovery from the accumulated stress of field training.

OPERATIONAL RELEVANCE

It was important to notice that shooting, especially prone, declined drastically in the EXP group after 5 days of field training. The same was not observed in the RECO group. To fulfill ones mission, it is crucial to get enough recovery even during strenuous winter survival training.

AUTHORS

Tommi Ojanen (1)
Keijo Häkkinen (2)
Heikki Kyröläinen (2)

(1) Finnish Defence Research Agency (Järvenpää, Finland); (2) University of Jyväskylä (Jyväskylä, Finland)

1.2
OPTIMIZING THE WINTER SOLDIER

#ABS293
POSTER PRESENTATION

FEBRUARY 11, 2020

SLEEP DURING AN ARTIC EXPEDITION

PURPOSE

Existing knowledge on sleep in the polar regions reports a decrease in total sleep length and an increase in the incidence and duration of nocturnal awakenings. Many factors have been suggested to explain these disorders such as the permanent day, the temperature of the sleeping set, the body temperature

The objective of our study was to describe the sleep of 12 soldiers in a tent during a fully autonomous raid which took place in the Arctic zone from March 17 to April 8, 2019.

METHODS

Sleep and thermal sensation data was collected using a daily questionnaire in the morning. Temperature measurements were made on the tent (outside and inside) and sleeping set (chest level). The raid was divided into three 1-week periods (W1, W2 and W3). A one-way analysis of variance (week effect) was performed using Sigmaplot software. In case of a significant overall effect, a comparison between each week was made using a Tukey test (significance threshold: $p < 0.05$).

RESULTS

The study subjects were male soldiers (age: 32.3 ± 5.8, weight: 72.7 ± 6.1 kg, height: 1.77 ± 0.07 m, Cooper's test: 3286 ± 112). The average night outside temperature during the raid was 20.8°± 4.0°C and was significantly the warmest during W3. The average night temperature inside the tent was-14.1° ± 3.3°C and was significantly the warmest during W3 (-12.4 ± 0.8°C) versus W2 (-15.7 ± 0.6°C) and W1 (-13.8± 0.8°C). The average temperature inside the sleeping bag at chest level was 28.1 ± 1.9 °C and was significantly the warmest during W3 (+29.0 ± 0.6°C) versus W2 (+28.3 ± 0.9°C) and W1 (+26.6± 1.2°C). The total sleep time (8h35min ± 61min), the number of nocturnal awakenings (2.4 ± 2.1) and their duration (13.3min ± 15.2min) did not vary during the raid. The overall thermal feeling is neutral during the raid. W3 shows a statistically colder overall thermal sensation compared to W1 and W2.

CONCLUSION

A good sleeping set allows to sleep in a tent, without additional heating and with a good sleep quality. Our results in W3 show a paradox: while both the outside night and inside the sleeping bag temperature are warmer, the overall thermal feeling was significantly colder. We hypothesize that global warming in W3 is responsible for a major textile humidity management problem.

OPERATIONAL RELEVANCE

Monitoring work must be carried out on the management of textile humidity in cold climates.

AUTHORS

Cyprien Bourrilhon (1)
Fabien Sauvet (2)
Eleonore Vermeulen (3)
Audrey Bacquart (3)
Camille Famel (3)
Philippe Colin (1)
Keyne Charlot (1)

(1) Département Environnements Opérationnels, Unité de Physiologie de l'Exercice et des Activités en Conditions Extrêmes, Institut de Recherche Biomédicale des Armées, Bretigny-Sur-Orge, France. (France); (2) IRBA (French Armed forces Biomedical Research Institute) (France); (3) école centrale d'électronique (Paris, France)

A NUMERICAL ONE-DIMENSIONAL HAND-GLOVE MODEL FOR PREDICTING FINGER TEMPERATURES IN VARIOUS WORK SETTINGS: DEVELOPMENT AND VALIDATION

Long-hours working in cold environments may greatly endanger human health and safety. Cold injuries could easily be developed in the body extremities such as the hands and feet. Hence, sufficient thermal protection on the hands and feet is highly necessary. A practical and economical way to examine whether the hand/feet thermal protection is sufficient to maintain hand/feet health and safety in any specified cold condition is by numerically predicting local skin temperature during the entire work hour. In this work, we developed a 16-segment numerical hand model, which is comprised of an active system and a passive system. The active system describes the thermoregulation mechanisms including shivering, sweating, vasoconstriction, and vasodilation, which are characterised by warm and cold signals calculated from the temperature difference between each node and its setpoint. The weighted warm and cold skin signals are used as the control variables to regulate physiological reactions. The passive system determines the heat transfer within the hand and between the hand and its thermal environment via mainly radiation, convection, and evaporation. A glove system was coupled with the hand model to simulate the heat exchange process of the hand-glove-environment system. In the glove system, an air layer was introduced in between the hand the glove. Hence, the body heat is transferred from the skin surface to the gloves inner fabric surface through mainly convection, radiation and evaporation. Besides, conduction and diffusion dominate the heat and mass transfer between the inner and outer surface of the gloves fabric layer. The newly established hand-glove model was preliminarily validated against published human trial data of Candas & Dufour. The human trials were performed at a cold and windy environment, where the ambient temperature was 8 °C and the air velocity was 2.5 m/s. The total thermal insulation of the gloves is 1.11 Clo. It was found, however, that numerical skin temperatures at the thumb and the fingers followed the temporal variations of the experimental data and the maximal temperature differences were found was about 4.5 °C. Future directions will include extensive validation and improvement of the hand-glove.

AUTHORS

Faming Wang (1)

Jie Yang (2)

Matthew D White (3)

(1) Department of Architecture, School of Architecture and Art, Central South University (Changsha, China); (2) College of Safety Science and Engineering, Xi'an University of Science and Technology (Xi'an, China); (3) Laboratory for Exercise and Environmental Physiology, Department of Biomedical Physiology and Kinesiology, Simon Fraser University (Burnaby, BC, Canada)

VASCULAR AND NEURAL FUNCTION IN SOLDIERS WITH NON-FREEZING COLD INJURY

PURPOSE

The pathogenesis and pathophysiology of non-freezing cold injury (NFCI) is poorly understood and therefore its prevention, diagnosis/assessment and treatment is probably sub-optimal. This study investigated both the vascular and neural function of soldiers with NFCI compared to matched controls with similar military experience and cold exposure.

METHODS

15 soldiers diagnosed with NFCI in their feet (age 29 [4] years, mass 76.5 [6.8] kg, height 1.762 [0.064] m, predicted VO2max 68 [8] mL·kg-1·min-1) and 15 matched Controls with similar cold exposure (29 [6] years, 80.6 [11.7] kg, 1.775 [0.079] m, 69 [11] mL·kg-1·min-1) undertook Quantitative Sensory Testing (QST) and a Cold Sensitivity Test (CST). QST included measurement of warm, cold, mechanical and vibration detection thresholds and heat, cold and mechanical pain thresholds on the dorsum of the foot in 24 °C air. CST involved gentle exercise in 30 °C air followed by foot immersion in 15 °C water for 2 minutes and then 10 minutes of spontaneous rewarming. QST elements were analysed using either paired t-tests or Mann-Whitney U tests and the CST was analysed using a split-plot ANOVA.

RESULTS

Warm (M [SD]: 7.7 [3.92] °C v 7.9 [3.0] °C), cold (Med [IQR]: 3.8 [2.7] °C v 3.3 [2.9] °C), mechanical (M [SD]: 20.3 [30.6] mN v 10.3 [5.6] mN) and vibrational (Med [IQR]: 7.5 [2.1] v 7.5 [1.7]) thresholds were similar ($P>0.05$) in the NFCI and Control groups. There were no differences between groups for heat, cold or mechanical pain thresholds ($P>0.05$). Likewise, mean toe skin temperature before immersion and after 5 and 10 minutes of rewarming was similar between groups (M [SD]; NFCI: 31.3 [3.0] °C, 27.9 [2.8] °C and 29.4 [3.1] °C; Control 32.8 [3.2] °C, 30.1 [3.9] °C and 31.1 [3.8] °C, n=13, $P>0.05$).

CONCLUSIONS

Vascular and neural function were similar in patients with NFCI and cold-exposed controls. This suggests that either these parameters are not affected by NFCI, or that cold exposure itself alters the vascular and neural responses to a similar extent, perhaps causing a sub-clinical condition. To investigate this, CST and QST are currently being compared in a matched, non-cold exposed Control group.

OPERATIONAL RELEVANCE

NFCI is a common form of non-battle related injury in cold/temperate environments, resulting in military personnel being medically downgraded and seeking compensation. Therefore, understanding of the pathophysiology of NFCI will aid its prevention, diagnosis and treatment.

AUTHORS

Clare Eglin (1)
Jennifer Wright (1)
Matthew Maley (1)
Jennifer Wright (1)
Sarah Hollis (2)
Michael Tipton (1)

(1) University of Portsmouth (Portsmouth, United Kingdom); (2) Regional Occupational Health Team (Catterick, United Kingdom)

SEARCH, RESCUE AND SURVIVAL TRAINING EFFECTS ON CELL INJURY BIOMARKERS IN MILITARY FIREFIGHTERS CADETS

PURPOSE

As normal military training alters levels of cell injury biomarkers in army personnel, the present study aimed to measure their levels in response to the more extreme search, rescue and survival training (SRST) that firefighter cadets execute to prepare for disaster conditions.

METHODS

45 cadets completed two SRST modules: M1-nine days of restricted sleep along with intense physical expenditure and M2-six days of food restriction without physical demand in a jungle area. Blood samples were collected one week prior (PRE) along with after M1, M2 and seven days of recovery (POST). Using commercial kits (Labtest Diagnóstica – Lagoa Santa, MG, Brazil), creatine kinase (CK), lactate dehydrogenase (LDH), aspartate aminotransferase (AST) and gamma-glutamyltransferase (GGT) were measured. Since the data showed a non-parametric distribution (SPSS, $p<0.05$), data were analyzed by Friedman tests followed by Wilcoxon with Bonferroni correction and are presented as median; first quartile-third quartile.

RESULTS

The levels of GGT were 21.0 U/L (18.0-26.0) for M1 and 21.0 U/L (18.0-25.5) for M2, significantly lower than PRE values (25.0; 20.0-32.2 U/L). After recovery, the levels of GGT were significantly increased (32.0; 24.5-44.5 U/L). AST concentrations were different in the two modules with an increase in M1 (75.0; 60.5-103.5 U/L) and a reduction in M2 (33.0; 38.0-43.0 U/L) that increased in POST (53.0; 39.0-80.5 U/L) without returning to the PRE levels (22.0; 18.0-27.25 and 25.0; 21.0-31.0 U/L). CK in M1 (859.0; 1059.0-1684.7 U/L) increased significantly by ~488.52% of PRE (173.0; 136.0-272.0 U/L). In M2, the levels were 251.0; 167.0-356.0-U/L. POST levels (110.0; 75.0-225.0 U/L) were significantly decreased and lower than baseline. In M1, LDH significantly increased (892.0; 777.5-994.3 U/L) in comparison to baseline (PRE: 385.0; 355.0-428.0 U/L). In M2, LDH was lower, but still significantly gradually reduced at 669.0 (597.8-733.0 U/L). The POST levels (484.0; 426.0-562.0 U/L) suggested incomplete recovery.

CONCLUSIONS

SRST modified cell injury biomarkers in trained, military firefighter personnel that did not return to baseline after an one week recovery period. The unrestricted access to rest, even with a food restriction in the field, did appear to positively influence biomarker level recovery.

OPERATIONAL RELEVANCE

As military SRST can cause cellular injury, care should be taken to minimize the impact on safety due to a loss of physical capacity. Furthermore, the single week of recovery was an insufficient time period for complete recovery and trainees could be at a higher risk for injuring during rapid redeployments or additional training.

AUTHORS

Thiago de Barros Ramos (1)
Thalita Ponce Sobral (2)
Míriam Raquel Meira Mainenti (3)
Verônica Salerno Pinto (2)
Mário Vaisman (4)

(1) Academia de Bombeiro Militar Dom Pedro II (ABMDP II) (Rio de Janeiro, Brazil); (2) Escola de Educação Física e Desportos da Universidade Federal do Rio de Janeiro (EEFD/UFRJ) (Rio de Janeiro, Brazil); (3) Escola de Educação Física do Exército (EsEFEx) (Rio de Janeiro, Brazil); (4) Faculdade de Medicina (Endocrinologia) da Universidade Federal do Rio de Janeiro (UFRJ) (Rio de Janeiro, Brazil)

ASSOCIATION BETWEEN THERMOGRAPHIC EVALUATION AND TRAINING LOAD IN A BRAZILIAN NAVY SPECIAL OPERATIONS COURSE

PURPOSE

To evaluate the association between internal training load (TL) and infrared thermography during the 6-weeks of Brazilian Navy special operations course.

METHODS

Eight male military personnel (28.7±3.8 years, 175±50 cm, 79.0±7.5 kg) participated in the study. Participants performed two sessions (morning and afternoon) five days/week of physical training (consisted of strength training, swimming and running) for six weeks. The TL was daily assessed by session-Rating of Perceived Exertion (RPE). Thermal images were taken before the training sessions on Mondays (D1) and Fridays (D5) with a Flir T420 infrared camera in a room with controlled temperature. A 15-minute acclimation period was provided for participants prior to data collection. Four images were performed (upper and lower anterior and posterior quadrants) with participants positioned 3.4 meters from the camera, with the following regions of interest (ROI): shoulder, elbow, pectoral, abdomen, back, lumbar, thigh, knee and leg. The mean differences of temperature between the right and left sides of each ROI among the participants (Tmean) were analyzed. Pearsons product-moment correlation coefficients were used to verify the association between 1) Tmean of each ROI before the training session D1 and the TL of the previous week; 2) Tmean of each ROI before training session D5 and the TL of the same week. Data were analyzed using the SPSS (version 23.0). The level of significance considered was <0.05.

RESULTS

Tmean was correlated to TL of the same week at D5 in dorsal spine region (r=0.91; 95%CI=0.02-0.98; P=0.012).

CONCLUSION

The TL was correlated with asymmetries obtained by thermographic evaluation in the back and thigh. Swimming (held on Thursdays) and running (held on Fridays) exercises could have promoted this increase. Probably, the trained muscular regions involved in the movement have higher metabolic activity.

OPERATIONAL RELEVANCE

Thermography appears to be useful for detecting thermal asymmetries in response to training load. This strategy can prevent musculoskeletal injuries in special operations courses. Assessments performed on the last day of training of the week appear to be useful for detecting thermal asymmetries in the back. However, because of the small sample size, these results should be generalized with caution and further studies with larger samples must be performed.

AUTHORS

Daniel Alves (1)
Maria Miranda (2)
Allan Inoue (3)
Dádiva Souza (4)
Guilherme Araujo (4)
Lucas Moraes (4)
Pamella Canevello (4)
Priscila Bunn (5)

(1) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science; Operational Human Performance Postgraduate Program, Air Force University (Rio de Janeiro, Brazil); (2) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science (Rio de Janeiro, Brazil); (3) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science; Exercise and Sport Sciences Postgraduate Program, Rio de Janeiro State University; Operational Human Performance Postgraduate Program, Air Force University (Rio de Janeiro, Brazil); (4) Federal University of Rio de Janeiro (Rio de Janeiro, Brazil); (5) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science; Exercise and Sport Sciences Postgraduate Program, Rio de Janeiro State University; Operational Human Performance Postgraduate Program, Air Force University (Rio de Janeiro, Brazil)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS053
POSTER PRESENTATION

FEBRUARY 11, 2020

FITNESS ASSESSMENT AND SCREENING: A TOOL TO SCREEN FOR BIOMECHANICAL DEFICIENCIES AND WEAKNESSES IN OFFICER CADETS

PURPOSE

Fitness Assessment and Screening (FAS) is a comprehensive musculoskeletal and physical performance assessment method used to screen for biomechanical deficiencies and weaknesses, as well as to assess ones potential risk of injury during military training, in officer candidates of the Royal Brunei Armed Forces. The purpose of this study was to determine the musculoskeletal and biomechanical deficiencies of a military cohort prior to the start of a 12-months training programme.

METHODS

Forty-one male and 19 female officer candidates (age:25±1.63years; height:1.65±0.06m; weight:64.5±8.2kg) were listed, and completed the FAS within a period of two days. The FAS consists of questionnaires (past and current musculoskeletal injury, physical activity habits and tobacco use) and physical assessments of various aspects of fitness.

RESULTS

Twenty-nine candidates (48.3%) had a past injury history which could potentially recur during the year-long military training period. The data suggests that candidates have poor hamstring flexibility on both legs with an active straight leg raise mean score of 78.4±11.5° on the left leg and 78.3±9.9° on the right leg. The Obers test was used to test the iliotibial-band flexibility (subjectively assessed by a trained assessor) and 42% of the total limbs assessed were positive, indicating poor iliotibial-band flexibility. 85% of the candidates showed signs of weak gluteus medius during the Trendelenburg test. Asymmetry of greater than 15% difference between limbs of the quadriceps and hamstring muscles are 40% and 30%, respectively, and this may put them at an increased risk of injury. Core strength which consists of sit up, planks and hip bridge, of the candidates is fairly good with a mean of 22±9counts, 2.17±0.76mins and 14.03±4.25mins, respectively.

CONCLUSION

Military trainers should be made aware of the individual and collective risk of injuries of the cohort so that they would be mindful of the training programme design. To minimise hip and knee injuries, targeted lower limb flexibility and strength training programme should be introduced prior to and during the Officer Cadets training period. A holistic core strength training programme should be continued to prevent lower back injuries.

OPERATIONAL RELEVANCE

Knowing the biomechanical deficiencies and weaknesses prior to entering a high intensity military training will help in preventing or minimising the risk of musculoskeletal injuries by altering their training programme in a targeted manner. This, in turn, will reduce the number of training days lost for the military personnel.

AUTHORS

Michelle Basir (1)
Alisa Lau (2)
Nurhayatul Filzah Damit (2)
Nursazwilla Rosdie (2)
Rosmarie Abejo (2)
Noreffendy Ali (2)

(1) Mrs. (Bandar Seri Begawan, Brunei); (2) Performance Optimisation Centre, Royal Brunei Armed Forces (Bandar Seri Begawan, Brunei)

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3.2 PREVENTION/ REDUCTION IN MSKI

#ABS036
POSTER PRESENTATION

FEBRUARY 11, 2020

COMPARISON OF TORSO ACCELERATIONS DURING WALKING ACROSS MULTIPLE LOADS AND ENVIRONMENTS

Recent lightweight sensing technologies, i.e. inertial measurement units (IMUs), acquire laboratory-quality data non-invasively. This allows researchers to observe how individuals adapt to conditions regardless of environment (i.e., laboratory v. field).

PURPOSE

To compare torso accelerations during walking with and without combat relevant loads for U.S. Soldiers both inside and outside of the laboratory.

METHODS

Sixteen male Soldiers walked unloaded and with vest-borne loads of 25 and 55 kg inside the lab and outside on level pavement. Order of events was randomized. 3D torso accelerations were measured during each condition at 500 Hz. Two-way repeated-measures ANOVAs (environment x load) compared mean and SD of tri-axial accelerations (vertical, mediolateral, anterior-posterior) between environments matched over 5 second segments by step count. The Bhattacharyya distance was also used to assess differences between 3D patterns among conditions (i.e., greater distance indicates less similarity).

RESULTS

There were no significant interactions for accelerations (p0.182) or main effects for environment (p0.169). After collapsing across environments, there were increased mediolateral (mean±SD: walk-3.2±0.9 m/s2; 25 kg-2.7±0.8 m/s2; 55 kg-2.9±0.8 m/s2; p=0.003) and anterior-posterior accelerations (walk-0.1±1.0 m/s2; 25 kg-0.4±0.9 m/s2; 55 kg-0.5±1.0 m/s2; p=0.003) as load increased. Mean vertical accelerations were not significantly different as load increased (p=0.132). There were also no significant differences between the patterns inside v. outside for the Bhattacharyya distance (walk 0.036±0.172; 25 kg 0.092±0.253; 55 kg 0.006±0.208; p=0.185).

CONCLUSIONS

There were no differences in torso accelerations between environments while walking unloaded and with 25 or 55 kg loads.

OPERATIONAL RELEVANCE

With new and smaller IMUs, field data are more easily obtainable and allow for more realistic assessment of the movement patterns during common physical activities. The lack of difference between laboratory and field data reported in this study support the use of non-invasive devices to collect field data that is biomechanically relevant to laboratory data. Future studies can expand the outdoor environments to include different terrains (i.e. sand, snow). The ability to collect valid data in training or operational environments enables field studies exploring the relationship between biomechanics, performance and musculoskeletal injuries in military cohorts.

AUTHORS

Victoria Bode (1)
Mark Buller (1)
Joseph Seay (1)
Alvin Korus (1)
Nathaniel Smith (1)
Peter Frykman (1)
Rebecca Fellin (1)

(1) USARIEM (Natick, United States)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS050
POSTER PRESENTATION

FEBRUARY 11, 2020

MAIN RISK FACTORS FOR MUSCULOSKELETAL INJURY IN THE MILITARY: A SYSTEMATIC REVIEW WITH META-ANALYSIS

PURPOSE

Many risk factors are associated with musculoskeletal injuries (MSI) among military personnel. Given the lack of quantitative analysis of such factors, this meta-analysis aimed to consolidate a large number of studies, giving statistically results on the association of different factors and injury risk in the military.

METHODS

The databases MEDLINE, LILACS, Virtual Health Library, CINAHL, Web of Science, Cochrane, SCOPUS, and SPORTDiscus were searched up to December 2018 without language or time filters. The inclusion criteria were prospective studies that have investigated risk factors of MSI in military personnel. In this study, any damage to the musculoskeletal system associated with military training was considered as an injury. In order to strengthen the level of evidence and increase the power of the funnel plots method to detect publication bias, only the risk factors that were analyzed for at least 10 studies were selected for the meta-analysis. For data analysis, RevMan5.3 program was used. Meta-analysis was performed to compare the number of participants with MSI between the groups with high or low risk. The following parameters were selected for the analysis: dichotomous variable, Mantel-Haenszel statistical method, random-effects analysis model (to correct the heterogeneity if I225%), and fixed effect analysis (if I2<25%) and risk ratios (RR) effect with 95% confidence interval (95%CI) for the included studies.

RESULTS

A total of 2,110 studies were identified through databases. Thirty-two studies met the inclusion criteria whose risk factors were evaluated by at least 10 studies, representing 373,434 participants. The groups considered at risk were female (RR = 1.48; [95%CI=1.07-2.04]; I2=99%), older (RR = 1.22; [95%CI=1.06-1.41]; I2=83%), overweight or obese (RR = 1.26; [95%CI=1.04-1.51]; I2=91%), previous injuries (RR = 1.14; [95%CI=1.03-1.26]; I2=68%), and with worse performance in 1.600-3.200m running tests (RR = 1.87; [95%CI=1.28-2.71]; I2=93%). The factors ethnicity white or non-white (RR = 0.90; [95%CI=0.81-1.00]; I2=72%) and previous smoking habits (RR = 1.16; [95%CI=0.93-1.44]; I2=93%) were not associated with injuries.

CONCLUSION

Sex, age, overweight or obesity, previous injuries and worse running performance at 1.600-3.200m tests are significantly associated with increased military injury risk.

OPERATIONAL RELEVANCE

Sex and age are non-modifiable risk factors for MSI. In order to minimize the risk of injuries, and thus, the removal of military personnel from their functions, prevention programs should be directed against modifiable risk factors (overweight, obesity, and poor cardiorespiratory fitness). Such strategies could be employed prior to the start of the specific phases of military training or courses.

AUTHORS

Priscila Bunn (1)
Allan Inoue (1)
Frederico Meirelles (2)
Elirez Silva (2)

(1) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science; Exercise and Sport Sciences Postgraduate Program, Rio de Janeiro State University; Operational Human Performance Postgraduate Program, Air Force University (Rio de Janeiro, Brazil); (2) Exercise and Sport Sciences Postgraduate Program, Rio de Janeiro State University (Rio de Janeiro, Brazil)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS118
POSTER PRESENTATION

FEBRUARY 11, 2020

ASSOCIATION BETWEEN ORGANIZED PHYSICAL ACTIVITY OR SPORT PARTICIPATION DURING HIGH SCHOOL AND ODDS OF SELF-REPORTED MUSCULOSKELETAL INJURY OR PAIN DURING U.S. MILITARY ENTRY-LEVEL TRAINING

PURPOSE

The relationship between organized team sports or physical activity programs (OPA) during high school (HS) and risk of musculoskeletal injury (MSK-I) or pain (MSK-P) during U.S. Military entry level training (ELT) is unknown. The purpose of this study was to assess whether individuals who participated in OPA during their last year of HS have a lower odds of MSK-I/MSK-P during subsequent ELT than individuals who did not participate in OPA during their last year of HS.

METHODS

Enlisted male U.S. Military personnel (n=470, age=19.3±1.8 years) were surveyed after completion of ELT as part of a larger study upon entry to secondary training. Questions included OPA participation in their last year of HS, and presence of MSK-I/MSK-P during ELT. Participants were categorized as non-athletes (no OPA participation) or athletes (participant in OPA). Chi-square and odds ratios (OR) assessed likelihood of reporting MSK-I/MSK-P during ELT among athletes compared to non-athletes. Statistical significance was determined a priori at $p<0.05$.

RESULTS

The majority of enlistees 70.0% (n=329/470) reported participating in OPA. Among those, 14% (n=66/470) reported suffering MSK-I during ELT and 31.9% (n=150/470) reported experiencing MSK-P during ELT. Odds of MSK-I (OR=0.71, 95% confidence interval [CI]=0.41-1.23, p=0.25) or MSK-P (OR=0.73, 95%CI=0.48-1.10, p=0.13) during ELT were not lower among athletes compared to non-athletes. Further, odds of MSK-I (OR=0.78, 95%CI=0.41-1.50, p=0.51) or MSK-P (OR=0.74, 95%CI=0.46-1.18, p=0.23) during ELT were not lower among individuals who participated in multiple OPA compared to single-OPA athletes.

CONCLUSIONS

OPA may not be associated with a reduced odds of MSK-I/MSK-P during ELT in male enlistees. MSK-I/MSK-P during ELT are multifactorial and OPA participation may not have a large enough effect on their likelihood to independently predict MSK-I/MSK-P. However, since 70% of our surveyed sample reported OPA participation, we cannot rule out the effects of selection bias. Also, our study sample only included male individuals who completed ELT and therefore may not fully represent the true ELT population.

OPERATIONAL RELEVANCE

Poor physical fitness is a proposed risk factor for MSK-I during training and individuals who do not participate in OPA may have poorer physical fitness than those who do. Understanding relationships between prior OPA and risk of MSK-I/MSK-P during ELT may provide support developing fitness programs tailored to non-athletes that can be completed prior to training. These programs may help ensure non-athletes have the necessary physical fitness to complete training successfully and safely.

AUTHORS

Daniel Clifton (1)
Carolyn Dartt (1)
Sarah de la Motte (2)

(1) Henry M. Jackson Foundation for the Advancement of Military Medicine; Consortium for Health and Military Performance, Department of Military & Emergency Medicine, F Edward Hébert School of Medicine, Uniformed Services University (Bethesda, United States); (2) Consortium for Health and Military Performance, Department of Military & Emergency Medicine, F Edward Hébert School of Medicine, Uniformed Services University (Bethesda, United States)

USE OF A MODIFIED LOAD CARRIAGE PREDICTIVE EQUATION TO IDENTIFY SPECIALIST POLICE CANDIDATES AT GREATER RISK OF INJURY AND SELECTION FAILURE

PURPOSE

Tactical personnel are required to carry external loads as part of their everyday occupation. This load carriage can come with increased risk of injury or degradation of individual performance. To ensure these risks are minimized tactical personnel are routinely required to meet strict aerobic and anaerobic requirements. The aim of this study was to investigate the predictive relationship between a variety of fitness parameters and load carriage performance utilizing a modified predictive equation.

METHODS

Retrospective data were collected from 18 specialist tactical police officer candidates attending a selection course within an Australian law enforcement agency (mean body weight=89.4 ± 8.5 kg). Baseline data were provided for 20-meter Multi-Stage Fitness Test (20m-MSFT) level (converted to est. VO2 max), time to complete a 10 km pack march carrying a load of 25 kg in a backpack and 3.5 kg in the hands, and terrain type and grade and speed of march during the 10 km pack march, and pass or fail on a specialist tactical police selection course. Baseline data were then entered into a load carriage energy cost equation, modified to account for loads in the hands and on the feet, to determine the% of VO2max work effort (M = 1.5 W + 2.0 (W + L)(L/W)2 + (W + L)[1.5 V2 + 0.35 VG]+ V2(0.015LH2+0.064LF2)) and scored on a risk matrix for load carriage.

RESULTS

Seven out of the 18 participants failed the selection course with one participant self-withdrawing. Seven participants work efforts exceeded a predicted work effort of 60% VO2max and of these seven, five failed the selection course. Likewise, 71% of those who were considered to be at moderate risk or higher were injured.

CONCLUSIONS

Modified load carriage equations may be of use in identifying specialist candidates at a greater risk of physical injury and subsequent selection course failure.

OPERATIONAL RELEVANCE

Modified load carriage equations, like the one proposed in this program of research, may augment initial selection processes to identify specialist candidates at a greater risk of injury and selection failure.

AUTHORS

Bradley Dennien (1)
Ben Schram (2)
Jeremy Robinson (3)
Robin Orr (2)

(1) Faculty of Health Sciences & Medicine, Bond University (Robina, Australia); (2) Tactical Research Unit, Bond University (Robina, Australia); (3) Australian Federal Police (Canberra, Australia)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS294
POSTER PRESENTATION

FEBRUARY 11, 2020

PROFILING INJURIES SUSTAINED BY LAW ENFORCEMENT DRILL INSTRUCTORS

PURPOSE

While recruit injury studies are common, there have been few injury studies on the specialized drill instructors (DIs) who are responsible for recruit physical training. These studies are important, as DIs are needed to properly train high volumes of recruits and are themselves a high value asset costing approximately $500,000 USD to train. This aim of this study was to profile injuries sustained by DIs responsible for training recruits at a law enforcement academy in the United States.

METHODS

Archived departmental DI injury data from one of the largest US law enforcement academies was analyzed. Sex, age at time of injury, years assigned to recruit training at time of injury, and type of injury were analyzed descriptively with relative risk per 1,000 person-hours calculated.

RESULTS

Fourteen male and seven female DIs reported 45 total injuries over a 6-year period. Average age at which injury occurred was 40.22 (+5.79: range = 32.67 to 55.11) years. Average time between assignment to recruit training unit and occurrence of training related injury was 4.90 (+5.32: range = 0.18 to 21.24) years.

All injuries reported by DIs resulted in an injury rate of.167 per 1000 person-hours. Total lost/light duty days of 659 days were reported leading to an average of 14.97 (+46.64) lost/light duty days per injury. Bodily sites of injury were categorized as spine/back (11.11%), and lower (57.78%) or upper extremity (31.11%). Over 67% of injuries were muscular skeletal in nature and classified as cumulative overuse injuries.

CONCLUSIONS

A vast majority of injuries observed were muscular skeletal and classified as cumulative overuse with high running volume as a factor. As DIs train with recruits, they were subject to the same types and volumes of exercise. Academy training for this agency often featured high volumes of running. Historical research has indicated this form of training can increase the risk of injury in military and law enforcement populations. The data in this study indicates that DIs are subject to the same injury risks as recruits.

OPERATIONAL RELEVANCE

As DIs need to train with recruits, in addition to providing a standard of fitness for their academy classes, their health and physical performance are paramount. Reducing running volume, increasing resistance training, and focusing on periodization of programming and recovery in both personal and training with recruits could assist in mitigating injuries and increasing operational readiness.

AUTHORS

Joseph Dulla (1)
Ben Schram (2)
Robin Orr (2)
Robert Lockie (3)
Jay Dawes (4)

(1) Los Angeles County Sheriff/Bond University (Los Angeles, United States); (2) Faculty of Health Sciences and Medicine, Bond Institute of Health and Sport, Tactical Research Unit, Bond University, Gold Coast QLD 4229, Australia (Gold Coast, Australia); (3) Faculty, Department of Kinesiology, California State University, Fullerton, Fullerton, USA (Fullerton, United States); (4) Faculty, College of Health, Education, and Aviation, Oklahoma State University, Stillwater, Oklahoma, USA (Stillwater, United States)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS087
POSTER PRESENTATION

FEBRUARY 11, 2020

INFLUENCE OF GENDER ON FUNCTIONAL MOVEMENT SCREEN (FMS) VALUES IN OFFICER CADET CANDIDATES

PURPOSE

Officer cadets, regardless of gender, undergo the same type, intensity and frequency of training throughout their course. Data from studies suggest that female cadets have a higher risk of musculoskeletal injury as compared to male cadets during training. The Functional Movement Screen (FMS) is an assessment designed to identify individuals with biomechanical deficiencies and compromised movement patterns that may put them at risk of injury. Therefore, the aim of this study is to assess the differences in gender with regards to their movement competencies for Officer Cadet candidates using FMS assessment.

METHOD

Sixty-one male candidates (age:25±1.48, height:1.7±0.05m, weight:64.5±7.24kg) and 22 female candidates (age:26±1.14, height:1.57±0.04m, weight:55.3±6.03kg) were recruited. FMS assessment consists of seven stations: Deep Squat (DS), Hurdle Step (HS), Inline Lunge (IL), Shoulder Mobility (SM), Active Straight Leg Raised (ASLR), Trunk Stability Push Up (TSPU) and Rotary Stability (RS). Candidates were scored 0-3 by certified assessors based on their ability to perform each test. A maximum score of 21 can be achieved and a score of less than 14 indicates a higher risk of injury. A two-sample t-test and chi-square test were used to analyse the differences of scores between gender using Microsoft Excel. Significance was set at $p<0.05$.

RESULTS

Total score for FMS indicated no significant difference between gender (male=15±1.77, female=16±1.87, p=0.36). The majority of candidates scored between 14 and 16 (63.1%, male=39, female=14), and 13 candidates scored less than 14 (15.7%, male=11, female=2). There were significant differences seen in both gender for IL (male=2.1, female=2.4, p=0.033), SM (male=2.3, female=2.8, p<0.001), ASLR (male=2.1, female=2.4, p=0.033) and TSPU (male=2.8, female=2, p<0.001).

CONCLUSION

The data suggests that about 16% of the cohort had general movement incompetency that may put them at a high risk of musculoskeletal injury. Poor flexibility, strength and motor control may increase the risk of injury during military training. Female candidates performed significantly better on IL, ASLR and SM which suggest greater flexibility, while male candidates scored significantly higher in TPSU, suggesting greater upper body strength.

OPERATIONAL RELEVANCE

This study provides input for planners to include corrective exercises in their training programme focusing on flexibility, especially for male candidates, in order to reduce the risk of musculoskeletal injury. Furthermore, FMS can potentially be part of a screening tool to assess the risk of injury for potential Officer Cadets.

AUTHORS

Amalina A'liah Gapor (1)
Alisa Lau (1)
Nurhayatul Filzah Damit (1)
Michelle Charlene Basir (1)
Noreffendy Ali (1)

(1) Performance Optimisation Centre,Royal Brunei Armed Forces (Brunei muara, Brunei)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS428

FEBRUARY 11, 2020

SEVERITY AND OUTCOMES OF BATTLE AND NON-BATTLE INJURY AMONG CANADIAN ARMED FORCES IN AFGHANISTAN

PURPOSE

The Canadian Armed Forces (CAF) combat mission in Afghanistan (2006-2011) presented a substantial challenge to the health and readiness of Canadas military. The introduction of modern communications permitted the digital capture of battle injuries (BI) and non-battle injuries (NBI) for deployed CAF personnel in the theatre of war. However, the severity and outcomes of these injuries has not been previously described, nor has the impact on the operational readiness of the CAF.

METHODS

Four primary sources of medical data were combined: a) a clinical database curated by the CAF Directorate of Health Services Operations, b) a registry of CAF trauma patients treated in U.S. Armed Forces field hospitals, c) a database of CAF equipment failures and related casualties, and d) a database of air medical evacuations from Afghanistan.

Medical and occupational outcomes (i.e. duty limitations, hospitalizations, aeromedical evacuations, in-theatre mortality) were recorded along with the mechanism of injury (e.g., improvised explosive device (IED), gunshot wound, motor vehicle collision (MVC), falls), and tabulated for BI and NBI events. Person-days in theatre were computed using CAF administrative records that also provided demographic, occupational and organizational information.

RESULTS

1,320 serious injury events were documented during the CAF combat rotations in Afghanistan, including 798 BI and 522 NBI. The proportion of injured personnel returning to duty was similar across injury events (BI = 50.9%; NBI = 55.2%), but a greater proportion of fatalities was observed among those who suffered a BI (16.4% deceased) versus NBI (2.3% deceased). Conversely, medical evacuation was more common for NBI injuries (42.5%) than BI (32.7%). IEDs caused 75.5% of serious BI, followed by fragmentation devices (18.9%) and gunshots (4.3%). Falls (24.8%) and MVAs (15.8%) were the leading cause of NBI. Lower extremity and pelvic injuries were twice as common among wounded personnel as those who were killed in action.

CONCLUSIONS

The health of deployed personnel is significantly impacted by the risk of injury in operational environments. The occurrence of BI and NBI has implications for the deployment of public health and safety officers to theatres of war, and underscores the importance of multidisciplinary combat medical teams. Future opportunities and threats to battlefield medicine will be discussed.

OPERATIONAL RELEVANCE

This research identifies the mechanisms and outcomes of injury among CAF personnel in a theatre of war, and supports the development of personal protective equipment, battlefield medicine, health resource planning and occupational risk mitigation.

AUTHORS

Robert Alexander Hawes (1)

FL Thériault (1)

DJ Lu (1)

(1) Directorate of Force Health Protection, Canadian Forces Health Services Group (Canada)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS011
POSTER PRESENTATION

FEBRUARY 11, 2020

USING 3-DIMENSIONAL MOTION ANALYSIS TO EVALUATE THE EFFECTS OF A NOVEL, WEARABLE CORRECTIVE TRAINING DEVICE ON BIOMECHANICAL MOBILITY, STABILITY, ASYMMETRY, AND VULNERABILITY TO MUSCULOSKELETAL INJURY

PURPOSE

The Neuropak is a wearable, user-defined corrective training device that applies continuous resistance to the users body in order to accelerate critical skills training and conditioning. We hypothesize that the device produces a potentiation effect on user biomechanics that could be leveraged to improve warfighter physical performance and longevity. As such, this study analyzes the biomechanical effects of the Neuropak in a comparative evaluation using a validated markerless motion analysis system.

METHODS

A standardized movement protocol was performed sequentially (baseline, Neuropak, retest) in the DARI Motion markerless motion capture system (Scientific Analytics Inc., Overland Park, KS) to compare baseline measures to potentiation effect at retest. The subject was a trained athlete, well-practiced in the motion protocol which consisted of 15 dynamic movements. Kinematic and kinetic data analyzed consisted of 142 unique datapoints per session, measuring primary plane mobility, secondary planar deviations, kinematic and kinetic asymmetry, performance metrics, and aggregate scoring. The inter-session changes in these datapoints were calculated in unit-change and as percent-change from baseline.

RESULTS

Primary plane improvements were found overall at the shoulders (6.94%), spine (22.18%), hips (0.79%), knees (4.43%), and ankles (7.91%).

Reductions in secondary planar deviations were found in the spine (-5.94%), and knees (-0.17%), while increases in secondary planar deviation were noted in the shoulders (39.02%), hips (11.52%), and ankles (47.92%)

Reductions in asymmetry at the joint level were found in the shoulders (-35.77%), spine (-36.74%), and knees (-0.17%), while increases in asymmetry were noted at the hips (40.81%) and ankles (78.15%).

Performance improved by 8.23% on average, with average increase of 0.87 inches to squat depths and jump heights.

CONCLUSIONS

67 of 142 data points exhibited improvement relative to baseline, and Neuropak produced on average a 30.25% clinically-relevant improvement in mobility, performance, stability, and global quality scores. No clinically relevant detriment was documented.

OPERATIONAL RELEVANCE

Improvements in biomechanics, performance, and conditioning directly benefit warfighter physical performance and are associated with a reduction in vulnerability to injury in athletic populations and the US Air Force (1,2). Therefore, the preliminary data suggests that the Neuropak may improve the quality of user biomechanics and warrants further study in warfighter populations.

AUTHORS

Joel Hungate (1)

(1) Scientific Analytics/DARI Motion, Overland Park, KS USA (Indianapolis, United States)

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2. CMSgt Joshua Smith, USAF, Lackland JBSA: Integration of Technology into the Daily Training of a Battlefield Airman Candidate, TSAC, Norfolk, VA, 2018

HIGH PHYSICAL EXPOSURE DURING FEMALE SOLDIERS BASIC MILITARY TRAINING LED TO A NOVEL MODEL FOR PROGRESSIVE SYSTEMATIC AND INDIVIDUAL INCREASE IN WEIGHT LOAD CARRIED

PURPOSE

Todays soldiers are heavily burdened. Historically, a rule of thumb recommendation on carried weight load is 23 kg (50 pounds), which should equal one-third of bodyweight. There is, however, a risk for overloading female soldiers as women might weigh less than 69 kg. Further, previous research indicate that increase in loading is unstructured during Basic Military Training (BMT). Thus, the purpose was to evaluate self-reported physical exposure during BMT among female soldiers in order to develop a model for load increase.

METHODS

All 144 females who completed a three-month BMT at 19 regiments in Sweden during the autumn 2016 were asked to answer the Swedish Arm Forces standardized follow-up questionnaire the last week of BMT. The questionnaire focused on physical performance including questions on physical loading and exposure during the training period. Descriptive statistics were used to present data.

RESULTS

The mean age (sd) was 22 (3) years, ranging from 18 to 32 years. The mean (sd) weight was 66.6 (7.0) kg, ranging from 49 to 85 kg, and the mean (sd) body mass index was 23.3 (2.0) kg/m2 with a range from 17.9 to 27.8 kg/m2.

The reported longest march in a day ranged from 2.5 to 55 km, with a mean (sd) of 27.9 (9,6) km. The carried weight during these marches in absolute values ranged from 10 to 50 kg with a mean (sd) 30 (7.1) kg. If expressed in relative values, i.e. in relation to the female soldiers bodyweight, the carried load ranged from 18 to 83% with a mean (sd) of 45 (12)%.

Fifty-four (38%) female soldiers reported that their physical capacity had at times been insufficient to perform their tasks in an adequate way. Further, 79% reported complaints or injuries (i.e. musculoskeletal disorders) during BMT, whereof 83% reported their work ability to be impaired.

Based on findings from the survey, the literature and knowledge in exercise physiology and ergonomics, a novel model based on bodyweight for how to systematically and individually increase weight loads during BMT was developed.

CONCLUSION

The physical load during BMT was high relative to bodyweight and a model for progressive increase in carried weight based on percentage of bodyweight is therefore proposed.

OPERATIONAL RELEVANCE

The model for progressive increase of carried weight load during BMT should lower the risk and frequency of musculoskeletal disorders in female soldiers.

AUTHORS

Marie Kierkegaard (1)

Matthias Tegern (2)

Helena Larsson (3)

(1) Department of Neurobiology, Care Sciences and Society, Division of Physiotherapy, Karolinska Institutet, Stockholm, Sweden (Huddinge, Sweden); (2) Department of Community Medicine and Rehabilitation, Umeå University, Umeå, Sweden and Department of Neurobiology, Care Sciences and Society, Division of Physiotherapy, Karolinska Institutet, Stockholm, Sweden. (Umeå, Sweden); (3) Department of Neurobiology, Care Sciences and Society, Division of Physiotherapy, Karolinska Institutet, Stockholm, Sweden, and Swedish Armed Forces, Headquarters, Medical Services, Stockholm, Sweden (Stockholm, Sweden)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS347
POSTER PRESENTATION

FEBRUARY 11, 2020

PREVENTION OF STRESS FRACTURES WITH RECRUITS A PRACTICAL LIST!

PURPOSE

Stress fractures are a concern among military recruits as they are known to have a high incidence in this population, especially among female candidates. They also can be disabling and are often associated with attrition. The objective of this project was to highlight evidence-based practices that have been used by different military organizations to reduce the incidence of stress fractures in recruits.

METHODS

An electronic literature search was completed using PubMed and SUMSEARCH2 to retrieve articles addressing stress fracture prevention (published between 2008 to May 2018). The search was supplemented with a manual search to examine articles that specifically addressed the effectiveness of targeted prevention interventions.

RESULTS

Two quasi-experimental, two cohort, two observational and one series of prospective studies were selected to prepare a list of training strategies found to be effective in reducing the incidence of stress fractures in recruit populations. A list of effective military fitness training strategies was then generated to provide a quick reference guide to assist recruit training centres in assessing training activities. Similarly, another list was generated to highlight interventions having a negative impact or no impact on the occurrence of stress fractures among recruits.

CONCLUSIONS

This project allowed the creation of quick reference list of evidence-based strategies that have been shown to reduce the incidence of stress fractures. Making such a reference list available to key stakeholders such as recruit training leaders, platoon instructors, fitness and health care professionals may reduce the incidence of these costly injuries and improve the overall level of recruit physical performance.

OPERATIONAL RELEVANCE

Providing this practical list of scientifically proven strategies to reduce stress fractures in a recruit training environment, can assist defence personnel in making evidence-based decisions regarding training that will reduce the potential for injuries and improve operational readiness of recruits.

AUTHORS

Lucie Laferriere (1)
Darrell Menard (2)
Maureen Carew (3)

(1) Department of National Defence Canada, Health Services Group, HQ (Ottawa, Canada); (2) Department of National Defence, Health Services Group, HQ (Ottawa, Canada); (3) Department of National Defence, Health Services Group HQ (Ottawa, Canada)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS202

FEBRUARY 11, 2020

SEX AND OCCUPATION ARE SALIENT RISK FACTORS FOR LATERAL ANKLE SPRAIN AMONG MILITARY TACTICAL ATHLETES

PURPOSE

The purpose of this epidemiological cohort study was to assess sex and military occupation as risk factors for lateral ankle sprain (LAS). A secondary aim was to provide an updated assessment of injury burden due to LAS in the US Armed Forces, 20062015.

METHODS

The Defense Medical Epidemiology Database was queried for the number of patients diagnosed with LAS associated with ICD-9 diagnosis codes 845.00 (sprain of ankle, unspecified site) and 845.02 (sprain of calcaneofibular ligament of ankle) on their initial medical encounter between 2006 and 2015. Using male sex and enlisted Infantry/Ground and Surface Combat officer contrasts, relative risk (RR) point estimates, attributable risk (AR), number needed to harm (NNH), and chi-square statistics were calculated in the assessment of sex and occupational category.

RESULTS

272,970 male enlisted (13.9 per 1,000 person-years), 56,732 female enlisted (17.3 per 1,000 person-years), 24,534 male officers (6.3 per 1,000 person-years), and 6,020 female officers (8.2 per 1,000 person-years) incurred LAS. Enlisted females in all occupational groups were at significantly higher risk for LAS than their male counterparts (RR: 1.091.68; AR: 8.3%40.4%; NNH: 104834; p<.001), with the exception of Engineers (p=.15). Female officers also had consistently higher risk for LAS in all occupational groups (RR: 1.104.77; AR: 8.8%79.0%; NNH: 381,652; p<.001) than male officers, except Ground/Naval Gunfire (p=0.25). Compared with Infantry, enlisted service members in the Special Operations Forces, Mechanized/Armor, Aviation, Maintenance, and Maritime/ Naval Specialties were at lower risk (RR: 0.400.97; AR: 3.1% to 79.0%; NNH: 128 to 2,614; p<.001) and Artillery, Engineers, Administration, Intelligence, Communication, and Logistics Specialties were at higher risk (RR: 1.041.18; AR: 4.1%14.9%; NNH: 4411,824; p<.001). Compared with Ground/Naval Gunfire officers, Aviation and Service officers were at significantly lower risk (RR: 0.750.98; AR: 2.3% to 33.2%; NNH: 640 to 7,121; p<.001) and Engineers, Maintenance, Administration, Operations/Intelligence, and Logistics officers were at higher risk (RR: 1.081.21; AR: 7.5%17.0%; NNH: 7761,964; p<.002). There were no other significant findings.

CONCLUSIONS

Female sex and military occupation were salient factors in LAS risk. LAS continues to be ubiquitous among military tactical athletes and is a substantial threat to operational readiness and lethality. These findings are likely attributed to differences in sex-related musculoskeletal structure and function, occupational hazard exposure, physical fitness, and health care access and utilization.

OPERATIONAL RELEVANCE

Sex-specific factors and occupational hazards are salient factors in LAS risk in the military and should be considered when developing and implementing risk-mitigating strategies in clinical practice and policy.

AUTHORS

John J. Fraser (1)
Andrew MacGregor (2)
Andrew MacGregor (2)
Camille P Ryans (3)
Daniel S. Rhon (4)

(1) Warfighter Performance Department, Naval Health Research Center (San Diego, United States); (2) Medical Modeling, Simulation & Mission Support Department, Naval Health Research Center (San Diego, United States); (3) Musculoskeletal Department, Naval Branch Health Clinic Mayport (Mayport, United States); (4) Center for the Intrepid, Brooke Army Medical Center (Joint Base Sam Houston, United States)

DISTRIBUTION OF MUSCLE MASS IN THE LOWER LIMBS AS A POTENTIAL INJURY FACTOR

PURPOSE

The objective of this study was to analyze body composition in the context of the muscle mass distribution in the lower limbs as a potential factor for injuries.

METHODS

The study group consisted of 88 male students of Military Academy in Poland with an average age of 21,8 ± 1,65 that were. All subjects were examined with the Tanita MC-780MA multi-frequency bioelectrical impedance body analyzer.

RESULTS

Only 11.4% of investigated students population can be consider symmetrical in lower limbs muscle weight (no difference in muscle between right and left limb). Some degree of an asymmetric stature was observed in 63.6% of investigated population with muscle differences between left and right limb of 100 to 200 g. Difference of around 500 g represents a true asymmetry and this was observed in 25% of student population. Student t test was used to compare parameters such as BMI, fat percent, fat visceral index and water percent between asymmetric and symmetric groups. In the asymmetric population a numerically lower BMI (24,7±2.91 vis 25.5±2,80), fat percent (15.4±4.96 vis 17,8±4.32) and visceral index (2.8 ±2.08 vis 3.5±2.14) were noted, while numerically higher water percentage was observed in symmetrical population (61.4±3.84 vis 59.8±3.24), however these differences were not significant.

CONCLUSIONS

According to Jeon et al. (J Phys. Ther. Sci. 2016, 28(4):12891293) muscle asymmetry can be a potential cause of injury because they can affect the position of the joint at rest and change its path of motion during movement, both of which are potential causes of injury especially during stress and fatigue (Holsgaard-Larsen, The Knee, 2014, (21) 1:(66-73)). Most of the subjects were physically active, therefore reason for asymmetry could be inappropriate training and/or earlier injuries, however reason for limbs muscle asymmetry cannot be assigned to particular task or sport.

OPERATIONAL RELEVANCE

The practical benefit of our investigation was the fact that the students were informed about their results and received advice how to train to correct their muscles distribution to avoid injury. Health education is necessary and studies such this described above should become routine for military personnel minimizing risks of injuries.

AUTHORS

Ewelina Maculewicz (1)
Ewa Szarska (1)
Paweł Paweł (1)
Ryszard Puchała (1)
Bożena Antkowiak (2)
Oktawiusz Antkowiak (2)
Marek Brytan (2)
Jerzy Bertrandt (3)

(1) Department of Applied Physiology, Military Institute of Hygiene and Epidemiology (Warsaw, Poland) (Warsaw, Poland); (2) Department of Pharmacology and Toxicology, Military Institute of Hygiene and Epidemiology (Warsaw, Poland) (Warsaw, Poland); (3) Laboratory of Food and Nutrition Hygiene, Military Institute of Hygiene and Epidemiology (Warsaw, Poland) (Warsaw, Poland)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS052

FEBRUARY 11, 2020

MUSCULOSKELETAL INJURY SURVEILLANCE SYSTEM: A TOOL TO SYSTEMATICALLY QUANTIFY THE BURDEN OF MUSCULOSKELETAL INJURIES IN FEMALE RECRUITS

PURPOSE

Soldiers routinely perform intensive training and demanding tasks in unpredictable environment, which can lead to musculoskeletal injuries. Injuries can affect operational readiness and capability due to days lost from work or deployment. Thus, the aim of this study is to investigate the musculoskeletal injury burden in the Royal Brunei Armed Forces (RBAF) female recruits by quantifying its incidence, activity associated with musculoskeletal injury, distribution, characteristics and impact, in terms of training days lost.

METHODS

A cohort of sixty-three female recruits were listed into this prospective study, which commenced on 18 September 2017. Data was collected throughout the course until the recruits commissioned on 12 January 2018. Data on musculoskeletal injuries were collected via customised forms designed for the study. Injury incidences (%) were calculated as the number of recruits with one injury/ the total number of recruits x 100%. Descriptive analyses were performed using Microsoft Excel.

RESULTS

The total injury incidence of the female recruits throughout the course was 58.7%. Of those injuries reported, 46.2% were sustained during fitness training modules (such as endurance runs and loaded marches) and 16.7% were due to military training modules (such as military drills and navigation). Injuries classified as non-training related activities (such as falls and sports outside training programme) were reported as high as 34.6%. The location of injury reported were mostly at the lower limb (knee: 43.5%, ankle: 35.3% and shin: 17.6%). The types of musculoskeletal injury reported were joint sprain (55.3%), muscle strain (27.2%) and stress fracture (1.9%), where 87.2% were acute, 7.4% were chronic and 5.3% were acute-on-chronic. Most of the injured recruits were given limited duty days (1-3 days: 71%, 4-7 days: 23% and >8 days: 6%).

CONCLUSION

The results suggest that more than half of the cohort has sustained injuries during the course and a majority occurs in the lower limbs. This data provides useful insight into the musculoskeletal injury burden of the RBAF female recruits and highlights the need to modify their training programme to reduce musculoskeletal injuries.

OPERATIONAL RELEVANCE

The musculoskeletal injury surveillance system established in this study can serve to inform and improve future surveillance efforts for the RBAF and could be implemented in different military cohorts such as male recruits, officer cadets and specific units, battalions or vocations. Understanding the musculoskeletal injury incidence, distribution, characteristics and associated activities will allow military trainers to review training programmes in a targeted manner

AUTHORS

Nursazwilla Rosdie (1)
Nurhayatul Filzah Damit (1)
Michelle Charlene Basir (1)
Amalina A'liah Gapor (1)
Noreffendy Ali (1)

(1) Performance Optimisation Centre, Royal Brunei Armed Forces (Brunei)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS312
POSTER PRESENTATION

FEBRUARY 11, 2020

A PROFILE OF ANKLE INJURIES IN AUSTRALIAN ARMY SOLDIERS

PURPOSE

Injuries in the military are associated with interruptions in service, detract from capability and present a high financial and resource burden. Prior to injury prevention strategies being implemented, research is needed to further understand the circumstances of these injuries. The aim of this investigation was to profile ankle injuries suffered by both full time and part time Army personnel over a two-year period.

METHODS

Data from a two-year period 2012-2014 was obtained from the Department of Defence, detailing the locations, activities, natures and mechanisms of ankle injuries. Minor Personal Injuries (MPI) were injuries which did not require immediate hospitalization, whereas Serious Personal Injuries (SPI) did. Descriptive analyses were performed to determine the lead contributors of these types to ankle injuries, and ankle injury rates were calculated for each service type relative to days of exposure.

RESULTS

A total of 1315 ankle injuries were reported, giving an incident rate of 2.1 recorded ankle injuries per 100 soldier years of service. Of these injuries, 1291 were deemed Minor Personal Injuries (MPI) and 24 as Serious Personal Injuries (SPI). MPIs were most commonly trauma to the ankle joint and ligaments (n=693), soft tissue (n=491) or due to fractures (n=54), with the ankle injuries most commonly occurring in Physical Training (n=457), Combat Training (n=267) or while walking (n=109). Ankle injuries were commonly due to Falls (n=832), gradual onset muscular stress (n=284) and muscular stress from handling objects (n=45). SPIs affecting the ankle were primarily fractures (n=10), soft tissue injuries (n=6) or dislocations (n=4), and occurred during Physical Training (n=4), while playing touch football (n=3) or while walking (n=3), due primarily to falls (n=12), contact with objects (n=4), or cumulative muscular stress (n=3).

CONCLUSIONS

Targeted approaches to minimizing these ankle injuries should focus on reducing risks of slips, trips and falls during both Physical Training and Combat Training. Previous ankle injuries need to be rehabilitated completely so they do not contribute to re-injury.

OPERATIONAL RELEVANCE

Injuries to the ankle are common in tactical environments and recurrence rates are the highest of all lower limb musculoskeletal injuries. Attempts should be made to identify causes and minimize first time occurrences where possible.

AUTHORS

Ben Schram (1)
Robin Orr (1)
Rodney Pope (1)

(1) Tactical Research Unit, Bond University (Robina, Australia)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS022

FEBRUARY 11, 2020

RISK FACTORS FOR MUSCULOSKELETAL INJURY AMONG SOLDIERS IN U.S. ARMY BAND UNITS

PURPOSE

To investigate risk factors for injuries among U.S. Army Band Soldiers who have unique musculoskeletal injury (MSKI) risks resulting from occupational activities such as standing and marching with instruments for extended periods, and repetitive motions while playing instruments for many hours each day throughout their careers.

METHODS

An electronic survey was administered to three premier U.S. Army Band units in late 2018 to assess recent injuries (12 months prior to survey administration), fitness, health behaviors, band-related tasks, and occupational exposures. This self-reported data was linked to individuals medical records and Army Physical Fitness Test scores. Descriptive statistics were calculated to characterize the health status and occupational exposures of Army Band members, and univariate and multivariable regression were used to identify MSKI risk factors.

RESULTS

More than three quarters (77%) of U.S. Army Band Soldiers in the identified units (n=465) had a recent injury, based on their medical record and survey responses. Most injuries were cumulative micro-traumatic overuse MSKI (71%) to the lower extremities (35%), upper extremities (29%), and back (26%). Frequently reported activities associated with injury were running (21%), repetitive movements associated with playing an instrument (11%), and standing while practicing, rehearsing, or performing (11%). Adjusted risk factors for any injury include: lower physical fitness (fewer sit-ups and slower run time, $0.04 < p < 0.07$), marching more than one hour per day for rehearsal or performances ($p<0.01$), participating in sports or recreational activities for more than ~1 hour per week ($p<0.01$), and replacing footwear worn for performances and rehearsals less often than once per year ($p<0.01$). Separate multivariable regression models were also produced to specifically idenitfy risk factors for for MSKI, band-related injuries, and injuries by unit; results were similar for each model.

CONCLUSIONS

Some observed MSKI risk factors are comparable to those reported in prior studies of military populations, while others are unique to the specific occupational tasks within the Band population. Recommendations to improve modifiable risk factors will be emphasized. Possible interventions include ergonomic enhancements and utilization of Army Wellness Center services.

OPERATIONAL RELEVANCE

As a highly visible sub-population of military members who rely heavily on membership continuity, it is important to identify ways to reduce MSKI and improve medical readiness within Band units. Understanding MSKI risk factors will inform injury prevention strategies that may be extended to other military and non-military musician populations.

AUTHORS

Anna Schuh-Renner (1)
Catherine Rappole (1)
Tyson Grier (1)
Michelle Canham-Chervak (1)
T. Renee Johnson (2)
Bruce Jones (2)

(1) U.S. Army Public Health Center, Injury Prevention Program (Aberdeen Proving Ground, United States); (2) U.S. Army Public Health Center, Health Promotion and Wellness Directorate in support of the Military District of Washington/National Capital Region (Washington, DC, United States)

USING FUNCTIONAL MOVEMENT SCREEN AS A MUSCULOSKELETAL INJURY PREDICTION TOOL IN OFFICER CADETS IN THE SINGAPORE ARMED FORCE (SAF)

INTRODUCTION

The Functional Movement Screen (FMS) is a well established screening tool used for assessing the risk of musculoskeletal (MSK) injuries. With the SAF being a conscript army, it is essential that we place heavy emphasis on manpower preservation, ensuring that we do not lose the soldiers training time as a result of MSK injuries sustained during peacetime training. The SAF Physiotherapy Centre (SPC) embarked on a pilot trial to find out whether a screening and intervention approach using FMS would impact MSK injury rate of the cadets in the Officer Cadet School.

METHOD

A total of three screening sessions were administered across the 9 months Officer Cadet Course at week 1, week 7 and week 36. A questionnaire about their past and present MSK injuries was administered to all cadets at baseline, as it was known that a past history of injury significantly increases the risk of a new or recurrent injury. Short physiotherapy consultations were made available on-the-spot for those with existing injuries, low FMS scores, as well as those who needed advice and simple strategies for injury management. On completion of the 38-week course we used multivariable logistic regression to model the odds of injury using baseline FMS scores and pre-existing MSK injury.

RESULTS

In the sample of 474 cadets, we recorded 98 injury encounters in the camp clinic. Regression analysis showed that low scores on FMS (below 15) were not associated with higher injury risk. However, pre-existing injury at baseline was associated with a 2.6 times (95% CI 1.5 to 4.4) higher risk of a new injury.

CONCLUSION

While the FMS was perceived to be beneficial by commanders and cadets, it has been shown through this study that a screening strategy aimed at pre-existing injuries may in fact be more clinically relevant to the overall effort in reducing injury risk. Physiotherapy treatment and advice could be provided at time of screening, and again at regular intervals to create opportunities for early intervention.

AUTHORS

Denise Seow (1)

(1) Singapore Armed Forces (Singapore)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS025

FEBRUARY 11, 2020

RELATIONSHIP BETWEEN THE OCCUPATIONAL PHYSICAL ASSESSMENT TEST (OPAT) AND 2-YEAR ATTRITION FROM THE U.S. ARM

PURPOSE

The U.S. Army uses the OPAT to screen recruits into jobs they should be physically capable of performing by the end of Initial Entry Training (IET). The four events include the interval aerobic run (IAR), seated power throw (SPT), deadlift, and standing long jump. Army jobs are categorized into physical demands categories (PDC) labelled Heavy (highest demand), Significant, Moderate, or Unprepared (not fit enough to begin IET). To qualify, Soldiers must achieve the required score in the job PDC for all four events. Although not designed to do so, it is hoped OPAT screening will reduce attrition. This study examined whether OPAT screening is associated with reduced attrition during the first 2 years of service.

METHODS

651 men entering combat arms jobs and 124 women entering physically demanding jobs performed the OPAT for the first time at the beginning of IET. Discharge for any reason (attrition) was tracked prospectively for 2 years. Cox regressions with sex adjustment were used to determine if performance on the OPAT events was associated with attrition.

RESULTS

24% of men (n=155) and 30% of women (n=37) attritted during their first two years of service. Soldiers in the Significant PDC for IAR were 1.6 times more likely to attrit than those in the Heavy PDC (HR: 1.63; 95% CI: 1.05-2.52; $p<0.03$). Soldiers in the Moderate and Unprepared PDCs for SPT were 2.7 times (HR: 2.71; 95% CI: 1.66-6.89; $p<0.04$) and 3.0 times (HR: 3.00; 95% CI: 1.05-8.61; $p<0.04$) more likely to attrit, respectively, than Soldiers in the Heavy PDC ($p<0.05$). Standing long jump and deadlift were not associated with two year attrition.

CONCLUSIONS

We have previously shown that lower OPAT scores are associated with increased attrition during the first 10 weeks of IET. In this study, lower scores on the IAR and SPT events were associated with increased attrition during the first two years of service.

OPERATIONAL RELEVANCE

The OPAT was designed to predict Soldier physical performance at the end of IET and lower scores are associated with increased attrition during IET. Soldiers who are physically capable upon entering the Army, specifically those with higher aerobic capacity and upper-body power, are less likely to attrit during the first two years of service.

AUTHORS

Marilyn Sharp (1)
Keith Hauret (2)
Maria Canino (1)
Jan Redmond (1)
Bruce Cohen (1)
Stephen Foulis (1)

(1) U.S. Army Research Institute of Environmental Medicine (Natick, United States); (2) U.S. Army Public Health Center (Aberdeen Proving Ground, United States)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS072
POSTER PRESENTATION

FEBRUARY 11, 2020

REMAP: DECREASING MUSCULOSKELETAL SPECIALIST WAIT TIMES FOR CANADIAN ARMED FORCES PERSONNEL

PURPOSE

The Rehabilitation Medicine Access Program (ReMAP) was created and implemented at Canadian Forces Health Services Centre Atlantic (CF H Svcs C(A)) for the purpose of decreasing wait times for patients requiring referral to a specific on-site musculoskeletal (MSK) specialist (physiatrist). ReMAP provides a clearly defined referral pathway, standardized inclusion and exclusion criteria, recommendations for minor procedures, and a consistent screening process.

METHODS

The number of referrals for the on-site physiatrist as well as patient wait times until initial consult were tracked from January 2019 until April 2019. Complete data for the full year from January 2019 to January 2020 will also be reported.

RESULTS

A total of 38 referrals to ReMAP were received, of which 32 were appropriate to be seen by the physiatrist (working at 0.2 full time equivalent), averaging eight assessments per month. This average is similar to the number of new intakes seen by on-site physiatry at Canadian Forces Health Services Centre Ottawa, when corrected for full time equivalent. The remaining referred patients were screened out based on the application of the inclusion and exclusion criteria, and were seen by physiotherapists in the Physical Rehabilitation Section instead. Current wait times at CF H Svcs C(A) for a consult with physiatry is one to two weeks for patients referred into ReMAP and deemed appropriate.

CONCLUSION

ReMAP has successfully decreased patient wait times for certain on-site MSK specialist referrals at CF H Svcs C(A). It is hypothesized that the referrals received at CF H Svcs C(A) benefit from the criteria disseminated to the referral sources as well as the standardized screening process, thus ensuring that extraneous referrals are minimized and the specialists time maximized. It is recommended that the ReMAP process be applied to other on-site MSK specialists in the future, and expanded to other large Health Services Centres in the CAF.

OPERATIONAL RELEVANCE

Long wait times for MSK specialist consults increase the time CAF personnel are at reduced function while awaiting appropriate treatment. ReMAP optimizes patient access to care by ensuring that referrals are appropriate, thus minimizing wait times and promoting a faster return to operational readiness.

AUTHORS

Boriana (Bonnie) Stefanov (1)
Markus Besemann (2)
Edwin Hanada (1)
Eric Fagan (1)
Adam Hannaford (3)
Daniel Trudel (1)

(1) Canadian Armed Forces, Halifax, Canada (Halifax, Canada); (2) Canadian Armed Forces, Ottawa, Canada (Ottawa, Canada); (3) Canadian Armed Forces, Edmonton, Canada (Edmonton, Canada)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS353

FEBRUARY 11, 2020

NECK PAIN AND ASSOCIATED IMPAIRMENTS IN FIGHTER PILOTS

PURPOSE

It is necessary to reduce the high rates of neck pain in fighter pilots. The aim of this study was to describe the clinical presentation of fighter pilots pain experiences and to evaluate their neck functional performance, as a first step in developing preventive strategies.

METHODS

This cross-sectional study included 36 Swedish Air Force fighter pilots from one air wing with mean (SD) age, height, weight of 35 (±7) years, 1.82 (±.06) m and 80 (±7) kg). All pilots performed tests of isometric maximal neck flexor and extensor muscle strength (torque, Nm), neck flexor and extensor muscle endurance (seconds, at 50% of maximal force) and active range of motion (ROM, degrees). Pilots reporting pain were also examined by a physical therapist in order to describe examination findings associated with the pilots pain experiences.

RESULTS

The neck flexors produced (median (25th-75th percentile) 28.6 Nm (24.3-34.5) and the extensors 41.8 Nm (35.2-46.8). The submaximal endurance was 54s (46-65) for flexors and 88s (65-106) for extensors. Neck flexion ROM was 55 (51-65), extension 69 (61-75), left rotation 70 (62-71), right rotation 63 (59-70), left lateral flexion 40 (35-45), and right lateral flexion 40 (36-45). 14% of the fighter pilots reported ongoing neck pain (Median Numerical Pain Rating: 6/10). The Mann-Whitney test showed that those with pain were older (p=.032), had less rotation and left lateral flexion ROM (p=.047 and.012, respectively).

The physical therapy examinations of the pilots showed impaired control of movements in the upper and mid cervical spine and/or cervicothoracic junction. They reported that activities such as sorties with high Gz, movements such as twisting the neck during sorties and maintained postural habits such as prolonged sitting were associated with their pain experiences. During the exam, it was found that the pilots habitual postures and movement patterns were closely related to their pain experience, suggesting that nociceptive mechanical pain is their dominating pain mechanism.

CONCLUSIONS

Age and neck rotation and lateral flexion ROM, but not neck muscle strength nor endurance differed between pilots with and without neck pain. A pattern of mechanical neck pain affecting different parts of the neck was found. Thus, analysis of posture and tests of pilots ability to control movements seems relevant to include in future examination of fighter pilots.

OPERATIONAL RELEVANCE

This study is the first step to develop preventive strategies, including monitoring systems of neck functional performance, in order to limit neck pain in fighter pilots.

AUTHORS

Matthias Tegern (1)

Ulrika Aasa (2)

Helena Larsson (3)

(1) 1.Department of Community Medicine and Rehabilitation, Division of Physiotherapy, Umeå University. 2. Department of Neurobiology, Care Sciences and Society, Division of Physiotherapy, Karolinska Institutet (Umeå, Sweden); (2) Department of Community Medicine and Rehabilitation, Division of Physiotherapy, Umeå University (Umeå, Sweden); (3) 1.Department of Neurobiology, Care Sciences and Society, Division of Physiotherapy, Karolinska Institutet. 2. Swedish Armed Forces, Head Quarter. (Stockholm, Sweden)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS113

FEBRUARY 11, 2020

DEVELOPING A TOOL FOR THE PROSPECTIVE MONITORING AND SURVEILLANCE OF MUSCULOSKELETAL COMPLAINTS AMONGST FAST JET AIRCREW

PURPOSE

Fast jet aircrew (FJA) commonly suffer from musculoskeletal (MSK) complaints, particularly neck and back pain, which reduce performance and operational capability. Within the current FJA literature, there is variability in definitions used to discriminate recordable MSK complaints or injuries, and inconsistency as to what domains should be considered when determining overall severity. The objective was to develop an appropriate tool that could be used for the monitoring and surveillance of MSK complaints among FJA.

METHODS

For part one of the study, 18 international experts were invited to participate in a modified Delphi study. Participants who volunteered were asked to put forward (round 1) and then agree upon (rounds 2-3): the words/descriptors of what constituted a MSK complaint; which definitions of recordable injury should be captured; and what domains are important for determining the overall severity of a MSK complaint in FJA. Consensus was considered achieved when agreement was >75%. Part two of the study involved developing the surveillance and monitoring tool based upon the consensus reached by the experts. Part three involved seeking feedback from a variety of FJA regarding the usability and comprehension of the tool.

RESULTS

Eleven experts from 8 nations responded to round one, and 9 responded to rounds two and three. Consensus was achieved for: 8 words/descriptors that defined what constitutes a MSK complaint; 6 separate definitions of a recordable injury; and 14 domains important for determining the overall severity of a MSK complaint. A new tool was developed based on these consenses, and feedback on the tool was sought from 10 FJA of varying experience and rank, which shaped final refinements.

CONCLUSIONS

The results of this study have allowed for the robust development of a tool used for the monitoring and surveillance of MSK complaints among FJA. Future work will involve a prospective study for: validation, evaluation of psychometric properties, and item reduction.

OPERATIONAL RELEVANCE

Both surveillance and monitoring are vital in keeping FJA in the air, and minimising operational impact due to injury. This tool is important for future high-quality research including: establishing the size and severity of the problem, identifying risk factors for MSK complaints associated with flying fast jets (particularly neck and back pain which they commonly suffer), and, evaluating the effectiveness of interventions aimed at reducing FJA MSK complaints. Furthermore, this tool will facilitate early identification of MSK complaints/injuries, allowing early intervention, minimising performance decrement and maximising operational capability.

AUTHORS

James Wallace (1)
Phil Newman (2)
Wayne Spratford (2)
Peter Osmotherly (3)
Tim Gabbett (4)

(1) Royal Australian Air Force Institute of Aviation Medicine; University of Canberra Research Institute for Sport and Exercise. (Williamtown, Australia); (2) University of Canberra Research Institute for Sport and Exercise (Canberra, Australia); (3) University of Newcastle (Newcastle, Australia); (4) Gabbett Performance Solutions (Brisbane, Australia)

4.1
IMPLEMENTATION-SCIENCE TO PRACTICE

#ABS215
POSTER PRESENTATION

FEBRUARY 11, 2020

QUALIFYING FITNESS STAFF TO ADMINISTER A PHYSICAL FITNESS SCREENING EVALUATION FOR CANADIAN SPECIAL OPERATIONS FORCES COMMAND APPLICANTS

PURPOSE

The Canadian Special Operations Forces Command (CANSOFCOM) Human Performance Research and Development (HPR&D) Team researched and developed new Physical Fitness Screening Evaluations (PFSEs) and standards for applicants to the Special Forces Operator and Chemical, Biological, Radiological and Nuclear Operator occupations. The purpose of this paper is to describe the collaborative process undertaken to qualify Personnel Support Programs (PSP) fitness staff to safely, reliably and competently administer the PFSEs to CANSOFCOM applicants.

METHODS

In conjunction with the PSP National Training Centre (NTC) and key stakeholders, a qualification standard and training plan that outlines the required individual training and education for fitness staff was established. In order to achieve the qualification standard for current fitness staff, a 1-day workshop comprised of theoretical and practical sessions was developed. The workshops were offered through regional training clinics held across Canada. Subsequently, the PSP NTC developed and implemented: (i) an online theoretical course; (ii) an online test; and (iii) an on-the-job training package for new fitness staff and those that did not receive the in-person training.

RESULTS

A total of 14 regional training clinics were delivered by the HPR&D Team over a period of 3 months, to PSP fitness staff from 31 different locations (Bases/Wings). A total of 89 PSP fitness staff attended the training, resulting in 84 qualified to administer the PFSE. Following initial implementation, an additional 12 fitness staff were subsequently qualified through the PSP NTC online and practical evaluation method. Additionally, a fitness coordinator at each location has now been trained to administer the qualification standard to new employees and to re-qualify existing personnel every 2-years.

CONCLUSIONS

The steps taken by the HPR&D Team and the PSP NTC demonstrate both short and long term processes to ensure that PSP fitness staff across Canada are qualified and supported in administering the newly established PFSEs. The processes employed by the PSP NTC and HPR&D Team were successful in meeting the requirements of their respective organizations.

OPERATIONAL RELEVANCE

Once a physical fitness standard and/or evaluation has been researched, developed and implemented, it is critical to ensure that the fitness staff administering the evaluation are appropriately qualified to do so. An educated, qualified and supported fitness staff ensures that the evaluations are being conducted reliably and the standards are being applied appropriately. This in turn ensures that applicants who achieve the PFSE standard can move forward in the selection process for CANSOFCOM.

AUTHORS

Mark Carlson (1)
Aaron Grainge (2)
Conor MacDonald (1)
Sylvie Fortier (1)

(1) Canadian Forces Morale and Welfare Service (Ottawa, Canada); (2) Canadian Forces Morale and Welfare Service, National PSP Training Centre (Borden, Canada)

CH148 HOIST SIMULATION TRAINING AND PERFORMANCE OBJECTIVES

PURPOSE

Bluedrop Training and Simulation has developed a fully immersive virtual training device for mission-specific hoisting operations with real-time rendering of detailed visual and haptic cues. To determine the cost and safety benefits of simulation, analytic rigor is required to quantify operational performance, both in the simulator and in the air. We aimed to quantify and differentiate hoist performance and gaze behavior (safety scanning) for experienced search and rescue (SAR) and novice hoist operators in a CH148 Hoist Simulator and to determine if simulator training impacted check ride performance in a training mission in a real CH148 Cyclone helicopter.

METHODS

Experienced (8 military veteran and current commercial SAR hoist operators) and novice (n = 7) individuals performed two hoisting missions in a CH148 Hoist Simulator. Hoist time, cable hand positioning, cable tension, and cable displacement were measured. In a separate project, in-flight CH148 performance was compared for a group (n = 7) that received additional training on the simulator along with a traditional training program, to a group that received only the traditional training program (n=6). In-flight performance of a) target hoist alignment and b) safety scanning and situational awareness was evaluated on a 4 point scale.

RESULTS

ANOVAs demonstrated experienced individuals had faster performance times (122s vs 149s) and they grasped the cable lower (.56m vs.74m from floor). This resulted in less tension on the cable but greater cable displacement at the point of the hand compared to novices. Experienced individuals produced a consistent triangular gaze pattern as they scanned the hoist, rear rotor and nose of the aircraft. Novices were more irregular with scanning patterns, spending less time scanning and more time fixated on the load than experts (60% vs 30%).

The in-flight check ride showed a 24% improvement of the hoist alignment for the simulation trained group compared to the traditionally trained group. However, there was not a similar advantage of simulation training for safety scanning.

CONCLUSIONS

In the simulator, experienced individuals demonstrate hoisting technique that differ from novices. Simulation training improves in-flight hoist performance, but not safety scanning, perhaps due to little perceived need to be scanning during controlled training exercise. It is recommended that threats to safety be introduced into the simulation scenarios so that learners will develop better scanning techniques and a heightened situation awareness.

OPERATIONAL RELEVANCE

Simulation training can improve in-flight performance, resulting in more effective use of in-flight training opportunities and reducing risk.

AUTHORS

Heather Carnahan (1)
Michael King (1)
Elizabeth Elliott (1)
Derek Rogers (2)
Stephen Lenser (3)

(1) Marine Institute, Memorial University (St. John's, Canada); (2) Total Response Solutions (Halifax, Canada); (3) Bluedrop Training and Simulation (Halifax, Canada)

4.1
IMPLEMENTATION-SCIENCE TO PRACTICE

#ABS239
POSTER PRESENTATION

INCREMENTAL FIRE AND MOVEMENT ASSESSMENT: A NOVEL TEST OF ARMY SPECIFIC FITNESS

PURPOSE

Continuous running (2.4 3.2 km) and the 20-m Shuttle Run Test (20m-SRT) are commonly used cardiorespiratory fitness assessments for military personnel that do not necessarily reflect job-specific physical demands. In contrast, the Australian All-Corps-Soldier Fire and Movement assessment (FMA) requires 12 bounds of 6 m in 5 s, with a 15 s prone firing (rest) period, while carrying 22 kg, tests a soldiers capacity to perform an assault. The purpose of this investigation was to develop an Incremental Fire and Movement (IFM) version of the validated FMA and explore what underpins performance.

METHODS

The study consisted of two phases. Phase one, protocol design, utilised three male infantry soldiers (age 29.7±0.6 y, height 1.72±0.09 m, mass 79.8±13.2 kg) over four days to develop evenly-stepped increments in physical demand, using the FMA as the initial step, then incrementally reducing bound and rest times. Phase two, physical performance testing with combat and non-combat soldiers, 19 male and six female (age 26.0±5.5 y, height 1.74±0.07 m, mass 78.0±13.3 kg) were assessed on the IFM and generic fitness assessments (20m-SRT, push-ups, standing broad-jump). Paired t-tests were used to compare 20m-SRT to IFM. Coefficient of determination was calculated for the generic test and IFM performance.

RESULTS

Phase One: The protocol consisted of eight levels, with levels 2 to 8 completed in 127±9 s, requiring 8 to 24 bounds. Time to complete a bound, and rest periods, decreased from 5 to 3 s and 15 to 2 s respectively, total protocol duration 18 m 46 s. Phase Two: Participants obtained 45.0±5.7 mL.kg-1. min-1 for the 20m-SRT, 55.1±21.4 push-ups, 205.9±27.8 cm standing broad-jump and completed 50.4±12.8 (Level 5) bounds in the IFM. Peak heart rate was similar (p=0.74) for the 20m-SRT (192±8 b.min-1) and IFM (191±7 b.min-1). The IFM (712±95 s) was longer (p<.001) than the 20m-SRT (570±101 s). Participants rated the IFM 76.6±26.5 mm on a 100-mm visual analogue scale for relevance to military. Cardiorespiratory fitness (20m-SRT, r2=0.64) was more closely related to IFM than upper limb muscle endurance (push-ups, r2=0.51) or leg power (standing broad-jump, r2=0.37).

CONCLUSION

A military specific test of soldier functional fitness to volitional failure was developed that soldiers found relevant to military service.

OPERATIONAL RELEVANCE

The IFM may have the ability to evaluate a soldiers physical capacity to engage with the enemy and could be used to detect changes in combat fitness that may not be reflected in generic predictive tests.

AUTHORS

Greg Carstairs (1)
Daniel Billing (2)
Liana Taylor (2)
Angus Pike (3)
Scott Michael (3)
Herbert Groeller (3)

(1) Defence Science and Technology (Melbourne, Australia); (2) Defence Science and Technology (Melbourne, Australia); (3) University of Wollongong (Wollongong, Australia)

COMPLIANCE OR SAFETY? THE IMPORTANCE OF EVALUATING PERSONAL OR TACTICAL FLOTATION DEVICES UNDER OPERATIONALLY RELEVANT SITUATIONS

PURPOSE

Understanding the functionality of military equipment and how each part of an ensemble performs in an integrated system is key to maximising war-fighter operability and enhancing safety. Personal or Tactical Flotation Devices (P/TFDs) are a critical piece of life-saving apparatus (LSA) used across a range of maritime operations. International Standards provide a performance benchmark for commercial PFDs but cannot cover the full variety of military tasks and equipment ensembles. It is therefore incumbent upon military units to assess the performance of such LSA items, to determine their adequacy under conditions which are operationally relevant.

METHODS

From September 2016 to January 2019, evaluations of the in-water performance of six P/TFDs were conducted as part of various acquisition projects; a multi-chamber PFD (Navy), an Armoured Life Preserver (Air Force), three varieties of integrated TFD/plate carrier and a multi-chamber PFD (all Army). The aim was to assess each systems suitability for use within the relevant military context. The testing methodology was based upon that outlined in ISO 12402, adapted to reflect operationally relevant scenarios (e.g. correct clothing ensembles, representative loads, body armour, helmets, and equipment configurations). Freeboard, self-righting ability, resistance-to-roll and recovery ability (self and assisted) were assessed.

RESULTS

Some common trends across all evaluations were observed. In a number of cases, aspects of the clothing ensemble or equipment configuration impacted the ability of the P/TFD to function optimally. In 63% and 45% of assessments, P/TFDs did not achieve the ISO criterion for freeboard and self-righting respectively. Self-recovery to a platform or liferaft also proved difficult when participants donned an operational load-out.

CONCLUSIONS

Relying solely on LSA compliance with an International Standard does not necessarily satisfy the performance and safety requirements of an operator. Understanding the in-water performance of P/TFDs in operationally relevant situations allows informed decision making around suitability for a given task. Standards provide a useful benchmark, but identifying areas in which P/TFDs perform poorly provides information which has relevance for both SOPs and procurement. This knowledge is crucial in situations where there are competing priorities, e.g. where effectiveness needs to be balanced with safety.

OPERATIONAL RELEVANCE

P/TFDs form an integral part of the war-fighter ensemble. It is imperative that due consideration is given to the in-water performance of any P/TFD, under conditions which accurately represent operational contexts. A robust testing process highlights potential issues and helps determine appropriate safety measures to mitigate drowning risk as far as is reasonably practicable.

AUTHORS

Adam Dooley (1)

(1) Defence Technology Agency, New Zealand Defence Force (New Zealand)

4.1
IMPLEMENTATION-SCIENCE TO PRACTICE

#ABS153
POSTER PRESENTATION

FEBRUARY 11, 2020

MILITARY TRAINING IN COLD OR MODERATE CLIMATES: THE OFTEN UNKNOWN OR UNDERESTIMATED HAZARDS OF EXERTIONAL HEAT ILLNESS

PURPOSE

It is well-known that soldiers are exposed to higher risks of suffering heat stress as well as exertional heat illness (EHI) during missions in hot climates. Substantially less attention has been paid to potential heat stress/EHI during physically demanding training in temperate or even cold climates. This paper focusses on the influence factors and the presence of heat stress/EHI in cold or temperate climates.

METHODS

A selective literature research was conducted in PubMed including current guidelines, guidance sets and recommendations.

RESULTS

Body heat balance depends on conversant influence factors (workload, clothing insulation, heat exchange, physical fitness, fluid balance etc.) with different impacts in divergent climates. However, no prerequisite protecting acclimatisation is developed in cold/temperate climates. Hence, compensation of heat stress is impaired.

Work in the cold (-25°C) with high clothing insulation (e.g., CRBNE) can boost body heat content up to a considerable heat stress level (Trect>38.0°C). High workload of military patrol skiing (-8°C) also occasionally increases Trec>38.0°C (Rintamäki, Rissanen 2006).

In the British Army 66.5% of 361 reported cases of EHI (2007-2014) occurred in temperate climates or during colder months (Stacey et al. 2015).

Only little further information on heat stress/EHI outside hot climates could be identified, although soldiers´ physical performance combined with prolonged high workload (>425W) often results in a remarkable thermal burden due to the restricted heat exchange by high insulation of protective clothing (>1.5clo, e.g., body armour).

CONCLUSION

With the experience of heat stress in the cold and the intense physical performance demands, the risk of EHI in temperate climates may be frequently underreported and underestimated. This is contributed by the appropriate guidelines and guidance sets, which were initially designed for acclimatized persons in warmer climates [e.g., NATO (TR-HFM-187, 2013): >25°C WBGT]. There is a necessity to enlarge the climatic range of these recommendations [e.g., UK (JSP-539, 2017): 20°C WBGT] to prevent an excessive body heat storage in cold or temperate climates under specific military challenges.

OPERATIONAL RELEVANCE

Awareness for heat stress and EHI beyond hot climates should be promoted in instructors and military leaders: Before performing hard physical work even in cold or temperate climates a risk assessment is required with the objective of a flexible adjustment of workload and thermal insulation of clothing. This applies particularly to the military training of inexperienced recruits with a lower physical fitness level.

AUTHORS

Karl Jochen Glitz (1)
Ulrich Rohde (1)
Kai Nestler (2)
Emanuel Vits (2)
Claus Piekarski (3)
Dieter Leyk (4)

(1) Bundeswehr Institute for Preventive Medicine (Andernach, Germany); (2) Bundeswehr Central Hospital (Koblenz, Germany); (3) University of Cologne – Institute & Policlinic for Occupational Health, Environmental Medicine & Prevention Research (Cologne, Germany); (4) 1. Bundeswehr Institute for Preventive Medicine, 2. German Sport University Cologne – Research Group Epidemiology of Performance, Institute for Physiology and Anatomy (Andernach, Germany)

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-Stacey et al. (bmjopensem 2015)
-TR-HFM-187 (2013)

TRANSLATION OF PATROL PATHFINDER COURSE DEMANDS AND KEY PERFORMANCE INDICATORS: APPLIED SPORTS (MILITARY) SCIENCE INTO PRACTICE

PURPOSE

Previous research identifying the characteristics related to attrition and success during the 11-week Canadian Army (CA) Patrol Pathfinder (PPF) course led to the development of a 1-year Performance Readiness Track. This Track aims to better prepare candidates and help reduce the historically high course attrition rates (70%) primarily due to injuries. The development and national implementation of this Performance Readiness Track will be presented.

METHODS

The Performance Readiness Track provides applicants with physical, mental and technical aspects for preparation, and daily applicant monitoring (Mujika et al., 2018, Saw et al., 2015). This strategy represents current best practices in applied sport science and is framed by the CA Mission Ready Performance Strategy. The content is anchored in the previous research; key performance indicators identified from pre-course preparation and post-course perceptions questionnaires, physical demands analysis (movements, loads, distances and metabolic demands), and review of applicant physical fitness and military qualifications screening at CA bases. Applicants will benefit from earlier awareness of course demands and key performance indicators that were identified as being associated with success (consistent and relevant physical training, subject matter expert guidance and support, and specific military skills refresher). These elements need to be managed over a considerable amount of time, preferably with support to help prioritize these with the realities of work-life demands.

RESULTS

A 1-year PPF Performance Readiness Track was developed to guide the applicants in their preparation; including: 1) awareness and education poster with physical performance and personal readiness self-assessment, 2) physical fitness training program, available via web or mobile app, 3) daily applicant monitoring of session RPE, sleep quality, fatigue, and soreness via mobile app, 4) base integrated support network (PPF, fitness, reconditioning, health promotion), 5) how to guidelines for applicants and support network, 6) communication strategies to direct applicants to Performance Readiness Track (posters, Candidate Selection and Preparation message to base units, CA social media), and 7) ongoing communication with CA leadership and base support network.

CONCLUSION

The Performance Readiness Track uses key applied sport science practices and represents a novel approach to course readiness in the CA. Attrition rates, candidate preparation, resources developed and implementation will be monitored annually. Early implementation evaluation outcomes will be presented.

OPERATIONAL RELEVANCE

For physically and mentally demanding courses with high attrition rates, using this type of preparation performance could result in an increase in course success and thus operational capacity.

AUTHORS

Jacqueline Laframboise (1)
Jacqueline Laframboise (1)
Michael Stolberg (1)

(1) Canadian Armed Forces, Human Performance Research and Development Directorate of Fitness (Canada)

4.1
IMPLEMENTATION-SCIENCE TO PRACTICE

#ABS012

FEBRUARY 11, 2020

FROM CONCEPT TO RESEARCH TO IMPLEMENTATION: CHALLENGES OF FORCE-WIDE IMPLEMENTATION OF THE UNITED STATES ARMY COMBAT FITNESS TEST

PURPOSE

A practical review and analysis of the challenges in moving scientific research from conclusions in a research study to fielding and implementation on a national scale.

METHODS

The presentation will be based on the actual case experiences based upon the fielding of the US Armys new physical fitness test, the Army Combat Fitness Test.

RESULTS

Under estimation of the challenges, cost and timelines continues to be a challenge for large scale implementation of empirical research. There is also the gap between scientific findings and practical application

CONCLUSIONS

Operationalizing evidenced-based research findings is vital to make systemic changes to organizations and systems; in this case improving Soldier readiness and changing organizational culture.

OPERATIONAL RELEVANCE

The US Army fitness test is directly related to a Soldiers ability to perform operational tasks, and win on the battlefield. We must capture and share the lessons learned in operationalizing the study into the Army Combat Fitness Test.

ABSTRACT

Background:

Numerous publications, works and books are written on the scientific methodologies of test design and conducting the empirical research in general. Although we are competent in conducting human performance research, in many settings we often fall short in moving our research from the theoretical to practice, especially when it pertains to large-scale organizational changes. Presentation will detail the development of the Army Combat Fitness Test (ACFT), from research design to data collection and analysis through the decision-making process to field testing and full implementation across an enterprise with over 1,000,000 Soldiers. We will discuss the development of a criterion-reference performance test, the selection criteria and the selection of final test events. We describe the decision process for final test event. Five major obstacles in the decision-making process: (1) cost, availability, and maintenance of equipment, (2) time requirements for training and testing, (3) development of standardized scores (specifically norm-vs. criterion-referenced standards), (4) administrative procedures, and (5) implementation strategies. Present the challenges of testing locations, for geographically dispersed troops; equipment funding/maintenance; and changes polices and regulations. Significant issues related to leader and stakeholder buy-in and Congressional oversight. We discuss the implementation plan that was designed to reduce personal and unit turbulence, iterative scoring scales, and the use of media and public affairs to keep stakeholders informed and reduce knowledge gaps. This presentation will address the many political, social, economic, and cultural challenges that often prevent evidenced-based research from achieving full operational capability.

AUTHORS

Michael McGurk (1)
Whitfield East (2)
David Feltwell (3)

(1) US Army (Fort Eustis, United States); (2) Exercise Physiologist and lead scientist (Fort Eustis, United States); (3) Physical Therapist and Lead Doctrine writer – Physical Fitness (Fort Eustis, United States)

4.1
IMPLEMENTATION-SCIENCE TO PRACTICE

#ABS328

FEBRUARY 11, 2020

ELABORATION OF A SPECIFIC PHYSICAL PERFORMANCE TEST FOR AN URBAN POLICE CANINE UNIT

PURPOSE

Most large urban police departments use physical activity requirement (PAR) tests to assess their officers for different operational units. Although, as all special units have very different physical tasks and demands, the canine (K9) unit may warrant a specific physical performance assessment test that best represents their field job tasks. Thus, the aim was to create a PAR test specific to tasks encountered in a large urban setting for a Police K9 unit as a part of the police officers selection process.

METHODS

A working group (WG) was formed for an analysis of the physical work demands of the job. Afterwards, an obstacle course prototype was created and presented within the WG. A validation of the course with nine employed K9 officers (women and men of various seniority on the job) was performed and oxygen consumption (VO2), heart rate (HR) and metabolic equivalents (METS) data was taken on a subgroup of two officers. The K9 officers were instructed to run continuously the course a total of 8 times. Data are presented as means±SD. A cut-off time point for succeeding was established at the 20th percentile. Analysis was performed with SPSS (ver. 21).

RESULTS

The average HR, VO2 and METS during the test was 183.5±0.7 bpm, 51.0±1.4 ml*kg* 1min 1, and 14.5±0.7, respectively. The cut off time point was calculated at 8min30s. The overall success rate spanning two selection process competitions (April and December 2018) was ~ 69% (11/16).

CONCLUSIONS

Using a specific performance test for the K9 units selection process permitted to recruit police officers that have the physical job task capacity. The rationale being that the new K9 recruits will be less likely to suffer physical injuries for the incoming physical field work tasks.

OPERATIONAL RELEVANCE

Similar protocols have been implemented for other special units of this Urban Police Department, including the nautical and cavalry squads, in the aim to create physical performance tests specific to each units job tasks. Thus, each unit would benefit of having specific tests in order to search for particular physical attributes, and, mostly, reduce the risk of drop-off during the training process or injuries once hired. Undoubtedly, the same should apply to soldiers, as they also have different divisions, with different tasks (ex., manual material handling tasks).

AUTHORS

Fanie St-Jean Miron (1)
Patrick Cobello (1)
Alain Steve Comtois (1)

(1) University of Quebec in Montreal (Montreal, Canada)

4.1
IMPLEMENTATION-SCIENCE TO PRACTICE

#ABS169

FEBRUARY 11, 2020

INDEX FINGER STRENGTH AND MUSCLE FATIGUE DURING REPEATED PISTOL FIRING

PURPOSE

Repeated firing (e.g. in prolonged engagements) may entail muscle-fatigue in the index-finger, potentially decreasing the ability for repeated trigger-pulling, and ultimately the inability to pull the trigger due to reduced index-finger strength. Limited information is available on the relationship of finger-strength, muscle-fatigue and trigger pulling ability. Aim of this study was to analyze effects of repeated firing on maximal index-finger strength (MFS) during standardized exercises of close combat marksmanship training.

METHODS

30 soldiers (15m/15f, in field uniform, ballistic vest and helmet) fired 60 rounds with the standard issue sidearm (HK P8, mean trigger pull weight: double-action (DA): 58.8 N, single-action (SA): 26.3 N in three consecutive blocks with 6-minute intermissions between blocks. Blocks consisted of four standardized SA and DA exercises (5 shots each) at ranges of 5m or 10m. Total exercise time (3 blocks + 2 breaks) was approximately 30 minutes. Maximal isometric finger strength (MFS) was measured immediately before (t1, t3, t5) and after (t2, t4, t6) each block and 30 minutes after shooting (t7).

RESULTS

Repeated shooting significantly decreased MFS in male (145.8 ± 21.7 N (t1) to 112.7 ± 26.6 N (t6); p<.001) and female (88.2 ± 15.8 N (t1) to 67.3 ± 17.7 N (t6); p<.001) soldiers.

Mean MFS in males decreased after each block to 94.2 ± 10.5% (t2), 83.8 ± 8.8% (t4), and 76.7 ± 9.7% (t6) while MFS in females decreased to 84.7 ± 12.1% (t2), 77.0 ± 14.5% (t4), and 75.9 ± 13.4% (t6) respectively.

23 of 30 participants (8m/15f) were unable to fire all 60 shots of the training exercise. Higher initial MFS was positively correlated to lesser chance of failure (r=0.73: p<.001) and longer time to failure (r=0.82; p<.001). Participants with lower initial MFS reached critical strength levels earlier. 6-minute breaks between blocks were insufficient for significant recovery of MFS:

MFS returned to approximately pre block 3 values (t5) 30 minutes post exercise (t7).

CONCLUSION

Repeated shooting at given trigger loads lead to muscle fatigue and ultimately failure to complete the exercise. Six minutes of rest were insufficient for MFS recovery. Besides adequate physical strength for locomotion and load-handling (leg extensors, arm flexors, trunk flexors/extensors and hand-grip), sufficient strength in the index-finger is a fundamental requirement for marksmanship and thus another integral prerequisite for military fitness.

OPERATIONAL RELEVANCE

Inadequate trigger weights may lead to individual inability to operate the standard sidearm in the operational setting during prolonged engagements.

AUTHORS

Alexander Sievert (1)
Dieter Leyk (1)
Kai Nestler (2)
Ulrich Rohde (1)

(1) Bundeswehr Institute for Preventive Medicine (Andernach, Germany); (2) Bundeswehr Central Hospital (Koblenz, Germany)

4.1
IMPLEMENTATION-SCIENCE TO PRACTICE

#ABS109
POSTER PRESENTATION

FEBRUARY 11, 2020

PERFORMANCE ON AN ANAEROBIC SPECIALIST TACTICAL POLICE FITNESS TEST: CANDIDATES VERSUS SPECIALIST TACTICAL RESPONSE POLICE OFFICERS

PURPOSE

Specialist tactical response police officers must respond to high threat situations, often resolving these threats in a short explosive event. Candidates wishing to join specialist tactical response police teams are expected to be at a physical level commensurate with the units requirements. The aim of this study was to compare differences in performance between candidates and qualified specialist tactical police officers when completing an occupationally-specific explosive anaerobic task.

METHODS

A retrospective analysis of data from male candidates (n=18) and qualified specialist tactical response police officers (n=34) were provided (see Table 1). Data collected included age, body weight, height, worn equipment weight and Urban Rush (UR) time in minutes and seconds. The dummy weight for both groups was 80.00 kg. Following descriptive analyses, independent samples t-tests were performed to determine if there were any significant differences between candidates and specialist tactical police officers.

RESULTS

There were no significant differences in height, body weight or total loads between groups, however candidates were significantly ($p = 0.002$) younger (candidates = 32.11 ± 4.90 yrs: officers = 37.82 ± 6.64 yrs) and carried significantly ($p < .001$) heavier (candidates =24.02 ± 3.67 kg: officers = 18.97 ± 2.23 kg) occupational loads when compared to the specialist tactical police officers. The UR times of the specialist tactical police officers were generally faster than those of the candidates, with the result approaching significance ($p = 0.087$: candidates =111.73 ± 9.21 secs: officers = 105.10 ± 14.61 secs).

CONCLUSIONS

Often selection courses include intense physical stresses which require the candidates to be exceptionally fit and increases their risk of physical injury during the process. Given the similar total loads moved and UR task times to completion, the results of this study suggest that candidates attempting selection into a specialist tactical police unit may be at a suitable level of fitness on attending selection and that the differences between successful selection and failure could focus on measures other than fitness.

OPERATIONAL RELEVANCE

If candidates are as fit as qualified officers when attending selection, avoiding excessive physically demanding tasks (for the sake of being physically demanding) and focusing on other attributes during selection may mitigate a potential for loss of future specialist personnel due to potential injury in the selection process.

AUTHORS

Jaslyen Singh (1)
Ben Schram (2)
Shane Irving (2)
Jeremy Robinson (3)
Robin Orr (2)

(1) Faculty of Health Sciences & Medicine (Gold Coast, Australia); (2) Tactical Research Unit, Bond University, QLD (Robina, Australia); (3) Australian Federal Police (Canberra, Australia)

4.1
IMPLEMENTATION-SCIENCE TO PRACTICE

#ABS111
POSTER PRESENTATION

FEBRUARY 11, 2020

COMPARING AN OCCUPATIONAL SPECIFIC PHYSICAL ASSESSMENT TO FITNESS MEASURES IN SPECIALIST TACTICAL RESPONSE POLICE CANDIDATES: A RETROSPECTIVE COHORT STUDY

PURPOSE

Specialist tactical response police are required to frequently perform physically demanding tasks at high levels, emphasizing the need for optimal physical fitness in this population. This study aimed to investigate the relationships between select measures of physical fitness and performance on an occupational specific physical assessment (OSPA).

METHODS

A retrospective analysis of data from 18 male specialist tactical response police candidates (mean age = 32.1±5.04 yrs; mean height = 183.72±5.79 cm; mean weight = 89.44±8.56 kg; mean Body Mass Index (BMI) = 26.45±1.58 kg/m2) was conducted. Data comprised of anthropometric measures, fitness measures (1 Repetition Maximum bench press, squat, deadlift, and shoulder press, grip strength, loaded pull ups, 7 stage sit ups, push ups in 60 secs and beep test) and an OSPA (repeated efforts of crawling, adopting kneeling firing positions 80 kg victim dragging, etc) with a 28.43 (0.54) kg load. A stepwise linear regression determined the influence of measured fitness parameters on OSPA performance.

RESULTS

The stepwise linear regression data featured both the 1RM military shoulder press (65.64±9.07 kg) and grip strength of the non-dominant hand (60.17±5.40 kg) as the most significant predictor of performance on the OSPA, accounting for 56.5% of the variance ($p<0.003$). A separate model, exclusively using the 1RM military shoulder press predicted OSPA performance, accounting for 24.0% of the variance in performance. Although both the 1RM shoulder press and grip strength were featured in the regression, the only significant independent factor was the shoulder press ($r=-0.533$, $p=0.023$). Apart from the 1RM shoulder press no correlations were found with other fitness measures and OSPA performance.

CONCLUSIONS

Given that the upper limbs are the leading site of injury in law enforcement personnel, these results emphasize the importance of optimal upper limb musculoskeletal strength on key occupational tasks in specialist tactical response police candidates. The lack of association between cardiovascular fitness and OPSA performance could be due the high level of cardiovascular fitness of the officers and a potential ceiling effect.

OPERATIONAL RELEVANCE

Apart from the need for a generally high level of fitness, specific attention to strength in the upper limbs should inform the bases of strength and conditioning and reconditioning protocols for this population.

AUTHORS

Jessica Strader (1), Jeremy Robinson (2), Ben SChram (3), Shane Irving (4), Robin Orr (4)

(1) Faculty of Health Sciences & Medicine, Bond University (Robina, Australia); (2) Australian Federal Police (Canberra, Australia); (3) Tactical Research Unit, Bond University, QLD (Gold Coast, Australia); (4) Tactical Research Unit, Bond University (Gold Coast, Australia)

4.1
IMPLEMENTATION-SCIENCE TO PRACTICE

#ABS356

FEBRUARY 11, 2020

HEATSTROKE IN TWO SOLDIERS DURING MARCHING, A CASE REPORT

PURPOSE

Soldiers´ physical performance during strenuous, prolonged operations is impaired and, when exposed to hot conditions the risk of heatstroke increases. A new doctrine, consisting of a method to systematically and individually increase the load soldiers are carrying, is under implementation in the Swedish Armed Forces (SwAF). The purpose is to limit injuries due to physical overloading of inexperienced soldiers. This is a well-known problem in SwAF soldiers as well as in other armed forces. The aim of this case report was to describe the challenges arising when implementing methods to optimize the training of soldiers, and to report two serious cases that took place due to overloading.

METHODS

During the final exercise at an SwAF Army units basic training, a prolonged march was carried out to control the soldiers capabilities. Though the current regulation proposes a load less than 50% of body weight for soldiers during this training period, the soldiers wore heavy backpacks and other squad equipment, weighing in at 70 kg (could attain 80-100 kg). This case report describes the context in which they operate when two soldiers developed heatstroke.

RESULTS

The first 24 h hours of the final exercise started with reconnaissance and combat tasks. After relocation with helicopters, the final 50-km march began. The temperature was higher than normal during this time of the year, and extra rest periods were induced (the day temperature was +12-27°C). After marching almost 24 hours, they left their back packs to perform fast marching with combat kit for the last 9 km. The temperature was at that time +27°C. The speed was high and when reaching the end of the march, two soldiers collapsed due to heat stroke and cardiopulmonary resuscitation began at the site.

CONCLUSIONS

The reason given in the units report for these accidents was the hot temperature at the time for the final part of the exercise. From another perspective, the unit did not follow current regulations, and did not control the carried weight. Carrying about 100% of body weight is hazardous.

OPERATIONAL RELEVANCE

Monitoring environmental factors, in this case hot climate, is an essential but not sufficient prerequisite for preventing heatstroke. These two events further stress the importance of a systematic graded load increase as well as the importance to follow the regulations aimed to limit events due to physical overloading during the entire training period.

AUTHORS

Matthias Tegern (1)

Helena Larsson (2)

(1) 1. Department of Neurobiology, Care Sciences and Society, Division of Physiotherapy, Karolinska Institutet. 2. Department of Community Medicine and Rehabilitation, Division of Physiotherapy, Umeå University (Sweden); (2) 1.Department of Neurobiology, Care Sciences and Society, Division of Physiotherapy, Karolinska Institutet 2. Swedish Armed Forces, Head Quarter. (Stockholm, Sweden)

4.3
MILITARY PHYSICAL PERFORMANCE ANALYTICS

#ABS302

FEBRUARY 11, 2020

MODEL FOR CLASSIFYING LARGE NUMBERS OF PHYSICALLY DEMANDING JOBS

PURPOSE

The purpose of the research was to develop models that allowed for classifying large numbers of military jobs based on ergonomic, physiological, work setting, and equipment parameters.

METHODS

Performance of physical work requires multiple physical abilities. The methods used to identify the models by ability included on-site interviews, ergonomic data collection, questionnaires, and past research. Movement categories (MvCat) based on ergonomic and energy expenditure factors (e.g., Hold MvCat: object weight, height, size) described performance in physical jobs (e.g., lift, shovel). Review of 100s of jobs and sub-specialties (e.g., Tactical Aircraft Maintenance: U-2; F-15, F-16), subject matter expert (SME) interviews, and ergonomic data collection provided task performance elements (e.g., lift overhead). SMEs completed the Movement Category Questionnaire (MCQ) that addressed MvCats, equipment, and worksite (e.g., body position) parameters within answer choices.

Analysis of the MCQ data for 113 jobs identified specific MvCats that contributed to classifying jobs. Prominent abilities were muscular strength, muscular endurance, and aerobic capacity. Example MvCats factors associated with muscular strength demand levels were weight, use of assistance, and lift height. Findings for aerobic capacity and muscular endurance included MvCats such as shovel and climb. Each MCQ response within a MvCat (e.g., lift height) received a weighting factor that estimated the relative magnitude of a MvCat parameter based on past research and published data in the areas of ergonomics, physiology, anthropometry, and physical performance. Parameters within a MvCats were combined to form New MvCats (e.g., average object weight *% with assistance). Multiple models were generated using the New MvCats.

RESULTS

Analysis of multiple models found muscular strength best predicted by [(Lift Average Weight * Lift height * With assistance) + (Carry Average Weight * With assistance) + (Hold Average Weight * With Assistance * Height Held)]. The aerobic capacity model was [Climb +Walk + Walk Upstairs No Load + Walk Upstairs with Load + Run + Shovel + Pound]. The model for muscular endurance was not as viable.

CONCLUSIONS

The approach used to stratify job tasks by MvCats and physical abilities provided a platform for categorizing jobs by physical demand for muscular strength and aerobic capacity. The muscular endurance model required further study.

OPERATIONAL RELEVANCE

This approach provides military and civilian organizations with a method to categorize 100s of jobs using a subset of jobs with a questionnaire targeted a parameters of task performance.

AUTHORS

Deborah Gebhardt (1)
Deborah Gebhardt (1)
Todd Baker (1)

(1) HumRRO (Adelphi, United States)

PHYSICAL CHARACTERISTICS OF SOLDIERS SUCCESSFULLY COMPLETING A COMBAT PHYSICAL READINESS COURSE: THE SOLDIER READINESS TEST (SRT)

PURPOSE

To identify physical characteristics that predict successful performance on a combat physical readiness course known as the Soldier Readiness Test (SRT).

METHODS

Personal characteristics and Army Physical Fitness Test scores were obtained by survey from men in U.S. Army Infantry, Armor, Engineer and Stryker Brigade Combat Teams (BCT). Variables were converted into quartiles where applicable. The SRT consisted of three phases performed back to back (the clock did not stop between phases) while wearing a 35 pound armor vest. Phase I to be completed in 2 minutes, consisted of a tire flip (225 lbs, 6 flips), T-Agility drill (40 total yards), and casualty drag (240 lb manikin, 15 meters). Phase II to be completed in 3 minutes, consisted of BCT specific events (sandbag lift and stack, water can carry, sandbag carry and stack or 18 inch step ups). After completing their specific BCT event, a sandbag toss of 10, 40 pound bags over a 7 foot obstacle was completed by all BCTs. Phase III to be completed in 18 minutes, consisted of a 1.5 mile movement that included four 4-foot over/under obstacles. Odds ratios (OR) and 95% confidence intervals (95%CI) were calculated using multivariable logistic regression.

RESULTS

A total of 1,563 Soldiers (24.8±5.5 years) were surveyed and completed a baseline SRT. Overall SRT pass rate was 29%. Soldiers more likely to pass the SRT were older (OR 24-27/21yrs)=1.44, 95%CI 1.17-1.77, (OR 28/21yrs)=1.36, 95%CI 1.10-1.70; taller (OR 68-69/67in) =2.07, 95%CI 1.33-3.05, (OR70-72/67in)=2.01, 95%CI 1.33-3.05, (OR73/67in)=2.85, 95%CI 1.70-4.76; weighed more (OR161-175/160lbs)=1.65, 95%CI 1.11-2.45, (OR176-195/160)=1.72, 95%CI 1.14-2.61, (OR195/160lbs)=1.66, 95%CI 1.02-2.68; had higher muscular endurance (push-ups) (OR57-65/56reps)=1.73, 95%CI 1.14-2.62, (OR66-75/56reps)=1.54, 95%CI 1.01-2.35, (OR76/62reps)=1.69, 95%CI 1.06-2.7, sit-ups (OR78/62reps)=1.83, 95%CI 1.18-2.82 and faster two mile run times (OR13.60/15.48min)=16.33, 95%CI 9.82-27.16, (OR13.61-14.50/15.48min)=6.34, 95%CI 3.91-10.29, (OR14.51-15.47/15.48min)=3.77, 95%CI 2.27-6.27.

CONCLUSION

Soldiers more likely to pass the SRT were older, taller, weighed more and had higher aerobic and muscular endurance. Although muscular strength was not measured, Soldiers who weighed more (assuming they had more muscle and fat mass) were more likely to pass the SRT.

OPERATIONAL RELEVANCE

The SRT is a combat physical readiness test that may be used to predict a Soldiers ability to perform combat tasks while deployed. Higher aerobic and muscular endurance were two of the reported fitness components shown to enhance a Soldiers ability to complete a combat physical readiness course.

AUTHORS

Tyson Grier (1)
Karen Daigle (2)
Catherine Rappole (1)
Eero Dinkeloo (1)
Timothy Benedict (1)
Bruce Jones (1)

(1) U.S. Army Public Health Center (Aberdeen Proving Ground, United States); (2) U.S. Army FORSCOM (Fort Bragg, United States)

4.3
MILITARY PHYSICAL PERFORMANCE ANALYTICS

#ABS193

FEBRUARY 11, 2020

USE OF A MODIFIED FACTORIAL METHOD TO ESTIMATE TOTAL DAILY ENERGY EXPENDITURE ON THE SPECIAL OPERATIONS INSERTION / EXTRACTION COURSE

PURPOSE

The Special Operations Insertion / Extraction (SOIE) Course is 10 days in duration, designed to train Canadian Special Operations Forces Command (CANSOFCOM) members to perform unconventional methods of insertion/extraction, which may be required in support of an assault element. To appropriately inform performance nutrition programming in support of the course, Total Daily Energy Expenditure (TDEE) needed to be estimated. The purpose of this paper is to describe the application of a Modified Factorial Method (FAO/WHO/UNU, 1985) to provide an estimate of TDEE on the most aerobically demanding day on the SOIE Course.

METHODS

The most aerobically demanding day of the SOIE Course was divided into 15 minute intervals, where each interval was assigned a specific task determined by observational notes and the course schedule. When observation outside the course schedule was not possible, anecdotal evidence about activities of daily living were used to fill in the remaining intervals. Each specific task was then assigned an energy expenditure (EE) value, derived either from directly measured field data (via portable metabolic measurement system) or the Compendium of Physical Activities (Ainsworth et al., 2011). Once EE was established for each task, the Thermogenic Effect of Feeding/Food (TEF) was derived based on scientific literature (Westerterp, 2004). The sum of these values provided an estimate of TDEE.

RESULTS

Twenty-one specific tasks were performed during the most aerobically demanding day of the SOIE Course. Estimates of EE for 8 unique insertion/extraction tasks were derived from portable metabolic measurement data, measured on students (n = 7) during the course. These tasks were performed intermittently, for a total duration of 2:45 hr:min. Estimates of EE for the remaining 13 general/low intensity tasks were derived from the Compendium of Physical Activities, applying a mean body mass of 86.5 kg (based on the representative sample [n = 7] from whom the directly measured data was drawn). The resulting TDEE was estimated to be 5,326 kcal.

CONCLUSIONS

The Modified Factorial Method was found to be an easy to use, affordable and customizable method to estimate TDEE. However, additional research should be undertaken to confirm the validity of the Modified Factorial Method for CANSOFCOM courses.

OPERATIONAL RELEVANCE

The Modified Factorial Method may be used to refine estimates of EE for the performance of CANSOFCOM tasks to more precisely inform performance nutrition programming, thus improving the operational effectiveness of CANSOFCOM members.

AUTHORS

Conor MacDonald (1)
Kyle Gordon (1)
Sylvie Fortier (1)
(1) CFMWS/CANSOFCOM (Canada)

ASSOCIATIONS OF PHYSICAL FITNESS AND BODY COMPOSITION WITH A CASUALTY EMERGENCY EVACUATION PERFORMANCE

PURPOSE

Casualty evacuation under enemy fire is one of the most physically demanding military tasks every soldier should be able to perform. The purpose of this study was to develop a test simulating casualty emergency evacuation (CEE) in an operational environment and study how it associates with physical fitness and body composition.

METHODS

25 conscripts (20 men, 5 women) volunteered for measurements of height, weight, waist circumference, body composition, 12-min run test, Wingate test, standing long jump, 1-min sit-ups and push-ups, grip strength, isometric bench and leg press. Evacuation time (ET) was measured in the CEE test, which was developed on an inquiry sent to 200 instructors to describe basic elements of CEE in operational environment. Altogether 74 answers were received. In the CEE test, conscripts wore a combat gear (11.7±1.6 kg) and dragged a doll wearing the combat gear (80.2 kg). At first, they dragged the doll 24 m while crawling (go round two cones, Z-pattern) and 20 m upright (straightforward). Pearson correlation coefficient and regression analysis were used for statistical analyses. Regression model was formed from those variables correlating significantly with ET.

RESULTS

ET lasted on average 87±32 s, and it correlated very strongly with anaerobic capacity (r=-0.84, p0.001), muscle mass (r=-0.78, p0.001), anaerobic power (r=-0.75, p0.001), standing long jump (r=-0.72, p0.001) and isometric bench press (r=-0.72, p0.001). Correlations were strong between ET and isometric leg press (r=-0.69, p0.001), grip strength (r=-0.62, p0.001), height (r=-0.61, p0.001), fat percentage (r=0.61, p0.001) and 12-min run test (r=-0.54, p0.001). Moderate correlation was found between ET and body weight (r=-0.43, p0.05). Anaerobic capacity (=-0.52, p0.001), fat percentage (=0.40, p0.001) and isometric leg press (=-0.25, p=0.062) altogether explained ET significantly (R2=0.87, p0.001).

CONCLUSIONS

CEE requires most importantly anaerobic capacity, lean body mass and strength capabilities, whereas aerobic fitness, although related to CEE, seems to be less important. Concerning strength capabilities, lower body performance might be more relevant. Because CEE is one of the most physically demanding military tasks, soldiers should specifically aim to improve these features by appropriate physical training.

OPERATIONAL RELEVANCE

Strength and power are crucial physical capabilities in various military tasks (Nindl et al. 2015). Therefore, CEE could be used as a simple and familiar work-related field test. Similar tests have also been highly reliable in previous studies (e.g. Spiering et al. 2012).

AUTHORS

Jussi Mussalo (1)
Jani Vaara (2)
Heikki Kyröläinen (3)

(1) Department of Leadership and Military Pedagogy, National Defence University, Helsinki, Finland; Armored Brigade, Finnish Defence Forces, Hämeenlinna, Finland (Hämeenlinna, Finland); (2) Department of Leadership and Military Pedagogy, National Defence University, Helsinki, Finland (Jyväskylä, Finland); (3) Department of Leadership and Military Pedagogy, National Defence University, Helsinki, Finland; Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland (Jyväskylä, Finland)

REFERENCES:

Nindl et al. 2015. J Strength Cond Res.

Spiering et al. 2012. Mil Med.

A WORKLOAD MONITORING SYSTEM THAT CALCULATES NECK FORCES IN FAST JET PILOTS

PURPOSE

Neck pain in fast jet pilots is an international concern. Helmet design, head checks and high G maneuvers are thought to contribute. In order to understand neck pain and neck forces in fast jet pilots, this study sought to build a model to predict the forces acting at the neck and evaluate the efficiency and accuracy of the subsequent algorithm using only head co-ordinates and Gz flight data from helmet mounted inertial sensors.

METHODS

Lab derived model:

Three-dimensional motion data was collected using the VICON camera system from RAAF fast jet pilots performing common head checks whilst seated on an F/A-18A ejection seat. Pilots were modelled wearing 2 helmet types (HGU-55/P and JHMCS). Dynamic graphical models were derived using Opensim software. The OpenSim model calculated forces at each cervical segment for 1-9Gz conditions.

Three ensemble learning algorithms-linear regression, k-nearest neighbours (kNN) and adaptive boosting were deployed and trained 5 times on random stratified samples of 75% of the Opensim model dataset to establish an algorithm that could predict segment moments at C1, C4 and C7 using only head co-ordinates and Gz. The resultant algorithms were tested on the remaining 25% of the OpenSim dataset and the best model identified based on predictive accuracy and efficiency.

Real time flight model:

Head position co-ordinates and Gz values were obtained from helmet-mounted sensors during 42 sorties involving 7 pilots over 7 days. Unfiltered raw data from flight was analysed by the most accurate machine learner and the resultant predicted cervical spine moments collated.

RESULTS

The Adaptive boosting learner performed best (R2=0.994, RMSE=1.129), kNN (R2=0.981, RMSE 2.013), linear regression was least accurate (R2=0.533, RMSE= 9.953). Predictive errors were in the range 0.7-3%. The kNN algorithm was selected for predicting the real flight data to balance efficiency and accuracy. 42 samples from sorties totalling 223 minutes of flight were analysed successfully by the machine learner. Predicted moments at 3 cervical segments, duration, frequency and direction were determined for all flights in less than 5 minutes.

CONCLUSION

The results demonstrate that neck forces can be measured in dynamic flight environments.

OPERATIONAL RELEVANCE

From this system both neck muscle and joint loads can be determined, within a maneuver, within a sortie, within a training week or longer. This technology will enable instructors and health staff to quantify neck workload of pilots, and review head motions in order to better understand flight related neck pain.

AUTHORS

Phil Newman (1)

Wayne Spratford (1)

(1) University of Canberra (Canberra, Australia)

IF THEY ARE NOT FIT THEY RISK INJURY: THE USE OF FITNESS TESTING RESULTS TO PREDICT INJURY IN POLICE RECRUITS

INTRODUCTION

In the conduct of their daily duties, law enforcement officers (LEO) are often required to perform challenging physical tasks with little or no notice, sometimes at maximal levels of exertion. Given these demands, musculoskeletal injuries (MSK-I) are prevalent across tactical professions, and contribute substantially to attrition from training, healthcare costs, and time lost from duty.

PURPOSE

Previous research has demonstrated that physical fitness levels are closely linked with injury incidence and attrition. The aim of this study was to investigate relationships between an existing physical ability test (PAT) and risk of injury during police recruit training.

METHODS

PAT results and trainee injury records were obtained from a National police department and Mann-Whitney U tests were performed to investigate differences between trainees who were, or were not, injured. Additionally, fitness test data were also divided into quintile ranks and assessed for injury incidence differences using Spearman Correlations. Ethics was approved by Bond University Human Research Ethics Committee.

RESULTS

A total of 243 records were analyzed with 68 injuries occurring. Significant differences in PAT performance existed between injured and uninjured groups for the pushup (injured mean 32.94±8.66 reps, uninjured mean 35.67±9.04 reps, p=0.01) and R) grip strength tests (injured mean 49.61±12.51kg, uninjured mean 52.12±11.17kg, p=0.042) regardless of injury type, vertical jump height for lower limb injury (injured mean 51.75±7.54cm, uninjured mean 55.06±8.19cm, p=0.032), and all measures of grip strength for trunk injury.

CONCLUSIONS

A relationship between some measures of the PAT and injury risk during police recruit training were found to exist. Furthermore, some PAT components, namely the 2.4km run, which has previously been reported as an effective predictor, may not play a role in predicting injury within this population due to a ceiling effect. These results do agree with literature investigating similar measures (grip, vertical jump, pushups) in police recruit populations, suggesting that these measures may be directly relevant to training success free of injury or surrogates for an underlying mechanism governing fitness and injury risk.

OPERATIONAL RELEVANCE

For the police training context, our results suggest that the most important fitness measures for predicting injury are grip strength, pushup count and vertical jump. Our results also suggest that run time over a distance may not be as valuable for the purposes of injury prediction in all tactical populations due to either a ceiling effect or low volume of running completed as part of training.

AUTHORS

Colin Tomes (1)
Ben Schram (2)
Rodney Pope (3)
Robin Orr (2)

(1) Faculty of Health Sciences & Medicine, Bond University (Robina, Australia); (2) Tactical Research Unit, Bond University (Gold Coast, Australia); (3) Charles Sturt University, NSW (Albury, Australia)

TS2.
AN INTERNATIONAL PROBLEM AND COLLABORATION TO PREDICTING AND PREVENTING INJURIES IN THE MILITARY
#ABS139

FEBRUARY 11, 2020

ASSESSING AND IMPROVING MOVEMENT QUALITY IN UK MILITARY PERSONNEL CAN A BETTER UNDERSTANDING OF THE PROBLEM INFORM A SIMPLE SOLUTION?

PURPOSE

The high incidence of musculoskeletal injuries (MSKI) in military trainees account for a significant number of working days lost and contribute to training attrition. British trainees have a 1 in 3 chance of sustaining a lower limb MSKI, with females and those of poorer physical fitness at greatest risk. Poor movement quality, carrying military loads and fatigue could compound this risk. Targeted prehabilitation neuromuscular training (NMT) exercise programmes in athletic populations have been associated with up to 35% injury reduction. Thus, studies in UK military cohorts have examined: 1) the relationship between movement ability tests and injury occurrence; 2) the feasibility of conducting a movement quality (i.e. optimal motor control and joint alignment) screening tool pre-and post-military training; and 3) proof of concept of a pre-exercise NMT intervention planned to improve movement quality.

METHODS

The Functional Movement Screen (FMS), and movement tests including the Double-Leg Vertical Drop Jump (DVJ), Hop and Hold (HH) and Single Leg Squat (SLS) have been conducted pre-military training and associations with injury occurrence assessed. The Hip and Lower-Limb Movement Screen (HLLMS), comprising a set of movement control tests focusing upon hip and pelvic control, was conducted pre-and post-military training, in males and females, and with and without military load. The feasibility of administering a 12-week pre-exercise NMT intervention during military training was evaluated relative to organisational and trainee acceptability, and movement quality assessed using the HLLMS pre-and post-intervention.

RESULTS

The FMS, DVJ and SLS were associated with (total) injury occurrence ($P<0.05$) but were neither sensitive nor specific to site or severity of injury, and therefore provided poor prognostic utility for UK military applications. The HLLMS was sensitive to changes in lower-limb movement quality, demonstrating reduced movement quality from pre-to post-military training ($P<0.01$). The NMT intervention was acceptable, and improved movement quality in male and female trainees ($P<0.01$). There was preliminary evidence of a positive dose-response effect with exposure to the NMT intervention.

CONCLUSIONS

The FMS and movement performance tests were associated with MSKI risk but did not provide greater understanding of the nature of that risk. The HLLMS was sensitive to changes in movement quality with training, and with prehabilitation exercises, in military trainees. The association between improved movement quality with NMT warrants further investigation.

OPERATIONAL RELEVANCE

Better understanding of movement control, movement quality and associations with MSKI risk could inform specific movement education and military physical training interventions to mitigate this risk.

AUTHORS

Joanne Fallowfield (1)
Nadine Booysen (2)
Conor Power (2)
Andy Nelstrop (3)
Johanna Gibbs (4)
Russ Coppack (5)
Martin Warner (6)
Maria Stokes (6)

(1) Institute of Naval Medicine, Ministry of Defence (Alverstoke, United Kingdom); (2) Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis, School of Health Sciences, University of Southampton, UK (Southampton, United Kingdom); (3) Joint Medical Group, HMS Drake, Ministry of Defence, Plymouth, UK. (Plymouth, United Kingdom); (4) Institute of Naval Medicine,Ministry of Defence, Alverstoke, UK. (Alverstoke, United Kingdom); (5) Academic Department of Military Rehabilitation, Defence Medical Rehabilitation Centre Stanford Hall, Loughborough, UK (Loughborough, United Kingdom); (6) Centre for Sport, Exercise and Osteoarthritis Research Versus Arthritis, School of Health Sciences, University of Southampton, UK. (Southampton, United Kingdom)

ACCURATE PREDICTION DEPENDS ON ACCURATE ASSESSMENT: SELF-LIMITING BELIEFS AND CULTURAL BARRIERS INFLUENCE MUSCULOSKELETAL INJURY REPORTING

PURPOSE

Accurately identifying musculoskeletal injury (MSKI) risk using movement screening tools requires a precise assessment of all MSKI ultimately sustained. However, fully characterizing MSKI in military populations is often difficult because many Service members (SM) choose not to report or seek care for their MSKI, particularly early in training. A recent study found two-thirds of basic trainees who sustained an MSKI during training report they did not seek care, primarily out of fear of not graduating on time, or to avoid negative perceptions associated with being injured. Understanding these self-limiting beliefs and cultural barriers to MSKI reporting are important for informing effective screening and risk mitigation strategies to optimize health in the military.

METHODS

This presentation will describe ongoing studies assessing self-limiting beliefs influencing MSKI reporting, and cultural stigma surrounding MSKI and seeking care in military secondary training. It will draw from preliminary data obtained from surveys administered before and after secondary training in both enlisted SM and Officers. History of MSKI during previous and current training, why care was/was not sought, and knowledge, attitudes and beliefs about MSKI and its prevention will be discussed.

RESULTS

Approximately 65% of enlisted SM who reported sustaining an MSKI during basic training did not seek care/report their MSKI to a medical provider. Themes for not seeking care included not wanting to be dropped from training, and not believing their MSKI or pain was severe enough to warrant medical attention. The percentage of enlisted SM who sustained an MSKI during secondary training and did not seeking care/report their MSKI was 70%. Conversely, 80% of Officers sustaining an MSKI during secondary training reported seeking medical attention for their MSKI, suggesting this population may not have the same self-limiting beliefs or barriers to seeking care as enlisted SM early in training.

CONCLUSIONS

True MSKI rates during training are likely underestimated, as self-limiting beliefs and cultural barriers undermine MSKI reporting and care-seeking. Until these beliefs and barriers are addressed and MSKI reporting increases, the accuracy of MSKI risk prediction tools will continue to be limited.

OPERATIONAL RELEVANCE

MSKI remains the largest public health issue facing the U.S. military. MSKI reporting and care-seeking by SM should be encouraged, as delayed care is associated with poorer outcomes. Understanding self-limiting beliefs and cultural barriers to seeking care will assist researchers, clinicians and policy makers in designing and utilizing effective screening and risk mitigation strategies to optimize health in the military.

AUTHORS

Sarah de la Motte (1)
Daniel Clifton (1)
Emily Southmayd (1)

(1) Injury Prevention Research Laboratory, Consortium for Health and Military Performance, Uniformed Services University (Bethesda, United States)

SCREENING FOR MUSCULOSKELETAL RISK FACTORS: THE EVOLUTION OF INDIVIDUALIZED RISK CATEGORIES AND SELF-SCREENING

PURPOSE

This presentation will describe the evolution of injury prediction research in sports and the military with a focus on musculoskeletal risk factor identification and categorization. A novel, self-screening process will also be introduced.

METHODS

Injury prevention and prediction efforts started by examining one risk factor for a given single injury and now have expanded to combining multiple risk factors to identify those at greater risk of any time loss injury. By utilizing multiple risk factors, individuals can be placed in an appropriate injury risk category rather than simply identifying the presence of one factor for one single injury. By using a computer-based algorithm to place individuals into risk categories, each factor can be weighted appropriately and the most robust factors, such as previous injury or current pain, can be prioritized. Additionally, research has shown that those individuals who possess more than one known risk factor are indeed at greater risk of injury and this relationship is linear. Accurately categorizing each individual allows for precious resources to be allocated to those who need them the most while still providing the opportunity for improvement for everyone. In addition, performing the required screening and testing to accurately categorize each individual is time consuming. Since musculoskeletal health care is becoming one of the greatest expenses for insurance companies in the private sector, along with the advent of patient centered care, this algorithmic approach has been expanded to begin by having the individual go through a self-screening process.

RESULTS

Previous research that has identified primary risk factor will be explored in depth. The process of musculoskeletal screening will be reviewed. The concept of Self-Screening will be introduced.

CONCLUSION AND OPERATIONAL RELEVANCE

Individuals with multiple risk factors are at greatest risk for subsequent time-loss injuries. Key risk factors can be identified through a self-screening process. The results of the self-musculoskeletal health screen, similar to the full professionally performed process, places individuals into categories that direct their path of care. Often, professional referral is indicated, but when the most appropriate referral is made, improved care and associated cost reduction can occur. Additionally, the self-screening process serves to educate the individual about their musculoskeletal health and the associated corrective strategies and built-in risk factor checks that are prescribed, help to create an autonomous patient environment for long-term musculoskeletal health.

AUTHORS

Kyle Kiesel (1)

(1) Unviersity of Evansivlle (Evansville, United States)

INJURY PREVENTION IN SPORT: WHAT WORKS AND HOW IS THIS RELEVANT TO THE MILITARY?

PURPOSE

Injury prevention in sport is essential for continued athletic participation, performance, team/individual success, and future health. However, the temporal sequence of events leading to injury occurrence in sport is a complex phenomenon. Accordingly, a multifaceted approach involving multiple strategies is imperative to mitigate injury risk. This presentation will discuss two key strategies neuromuscular training (NMT) and load management established for the primary prevention of musculoskeletal (MSK) injuries in youth sport and deliberate on potential applications in the military context.

METHODS

From an epidemiological perspective, MSK injury prevention entails an understanding of the burden and etiology of injuries and subsequent development and implementation of context-specific injury countermeasures. The greatest risk of sport-related injury is in youth and young adults. While a greater proportion of studies have focused on acute injuries in youth athletes, more studies on overuse injuries are emanating. Based on research evidence relating to injury epidemiology, randomized controlled trials and systematic reviews, sport injury prevention experts have developed (cost-)effectiveness NMT warm-up programs for reducing the risk of sport-related acute and overuse injuries in youth and young adults. Similarly, there is a growing body of evidence supporting the effectiveness of training load monitoring and management for sport injury prevention, especially when modeled within an athletes risk profile.

RESULTS

The components of NMT programs and the principles of effective workload monitoring and management will be highlighted. Evidence supporting the effectiveness of both strategies will be examined in detail. The challenge of real-world implementation of these evidence-based interventions will be briefly discussed. Finally, a rapid review of evidence for the two strategies in military settings will be presented.

CONCLUSION

In youth sport, injury prevention strategies in the form of NMT and load management works. Wide-spread implementation of these interventions in community settings is crucial for the greatest public health impact.

OPERATIONAL RELEVANCE

Youth athletes are potential future officers. Previous injury is a strong and consistent predictor of re-injury, chronic joint disorders e.g., post-traumatic osteoarthritis and negative health outcomes. Primary prevention of MSK injuries in youth sport is important to protect current and future health among participants. Neuromuscular training routines and workload management may be explored as additional elements of a multifaceted intervention to reduce physical training-related injuries in military personnel.

AUTHORS

Oluwatoyosi Owoeye (1)

(1) Saint Louis University, USA & University of Calgary, Canada (United States)

TS2.
AN INTERNATIONAL PROBLEM AND COLLABORATION TO PREDICTING AND PREVENTING INJURIES IN THE MILITARY

#ABS090

FEBRUARY 11, 2020

MUSCULOSKELETAL INJURIES: HOW TO EAT THE ELEPHANT IN THE ROOM?

PURPOSE

When do we have enough evidence on the prediction, pre-emption, and prevention of musculoskeletal injuries (MSKI) to move from research, to policy, to action? Musculoskeletal injuries are the leading cause of disability in militaries around the world. Although non-modifiable risk factors are well documented, there is interest to identify modifiable risk factors based on movement screening. This opening presentation will provide the framework for the thematic session by discussing the concepts of MSKI prevention and movement screening tools (MST). Specifically focusing on the following challenges: 1) clarify terminology for MST and MSKI, and scope of existing MST, 2) the need to conduct high quality research to determine which MST are valid and reliable, and 3) decide which MST are appropriate for which purposes. The goals of this thematic session are to discuss: 1. Can MST be used to identify those at increased risk for injury? 2. Can a better understanding of movement control, movement quality, and potential associations with injury risk, inform specific movement education and physical training interventions to mitigate injury risk? 3. How can we best leverage the members of the International Movement Screening and Interventions Group to improve Soldier readiness and lethality by decreasing musculoskeletal injuries?

METHODS

In December 2014, The International Movement Screening and Interventions Group (IMSIG) was established. Currently there are over 70 international members, comprising researchers and clinical academics developing and evaluating MST, and conducting applied research with MST for MSKI risk and exercise interventions. In addition to setting up the presentations during this thematic session, this presentation will use results from the Military Power, Performance, and Prevention (MP3) study that prospectively looked at injury risk based on baseline assessment that included 86 survey questions, functional movement and performance tests, and pain provocation tests. Soldiers were prospectively followed for 1-year to determine those that were not-injured, injured and returned to work, and injured requiring work restrictions.

CONCLUSION

Although there is plenty of room to debate how to best mitigate MSKI risk; the time for action is now. There appears to be enough evidence to placing countermeasures in place to mitigate the disability and cost to readiness associated with MSKI. As a community, there is a need for researchers to help move the current science on prevention of musculoskeletal into practice.

AUTHORS

Deydre Teyhen (1)

(1) Walter Reed Army Institute of Research (Silver Spring, United States)

TS4.
REAL-TIME MONITORING TO PREVENT HEAT INJURY

#ABS388

FEBRUARY 11, 2020

PREDICTING EXERTIONAL HEAT STROKE FROM SIMPLE WEARABLES

PURPOSE

Exertional heat stroke (EHS) is a concern for athletes and military who must train and perform in hot environments. EHS has symptoms of high core body temperatures and truncal ataxia associated with central nervous system (CNS) dysfunction. Algorithms have been developed that (a) estimate core body temperature from heart rate, and (b) detect gait instability using trunk-worn accelerometers. Study question: Can information on heat strain and gait instability, collected by a chest-strap based sensor system hosting these algorithms, be used to predict EHS?

METHODS

Estimated core temperature, heart rate, skin temperature and 3-axis accelerometery data were collected from over 350 U.S. Army Soldiers engaged in four high EHS-risk training activities that included two timed 5-mile runs, and timed 7-mile and 12-mile ruck marches. Soldiers who exhibited an EHS were cooled on-site and evacuated to a military hospital. Four Soldiers were diagnosed with heat stroke and all had rectal temperatures >41 °C when first measured. Estimated core temperature was computed from sequential measures of heart rate via the ECTemp algorithm (Buller et al, Physiol. Meas. 34:7818,2013). Gait instability was computed from 3 axis accelerometery data using features of pattern dispersion and step to step autocorrelation.

RESULTS

The four Soldiers who experienced heat stroke were among the hottest of their respective training events with estimated core temperatures ranging from 39.9-40.5C. Individually learned gait instability measures identified all four heat stroke casualties at least two minutes in advance of collapse, while falsely identifying nine other individuals as possible heat stroke candidates out of 356 subjects with no symptoms. When ECTemp and gait features were combined, 4 out of 4 heat strokes were identified, with three false positives.

CONCLUSIONS

These algorithms provide a real-time assessment of heat stroke risk, with limited incidences of false positives. While these results are encouraging, with the limited number of heat stroke cases, an estimate of the true number of false negatives remains unknown.

OPERATIONAL RELEVANCE

This capability to predict heat stroke in advance of visually obvious symptoms and/or medical intervention using an indication of core body temperature and gait instability provides a training safety tool that can be employed during high risk military training events. It can provide actionable information to trainers to assess individuals who are shown to have a high risk of heat stroke. Use of physiological status monitoring during training will assist prevention of heat stroke or sooner treatment with better prognosis.

AUTHORS

Mark Buller (1)
Rebecca Fellin (1)
Joe Seay (1)
Lara Weed (2)
Beth Beidleman (1)
Meghan Galer (3)
Max Bursey (3)
Jim Williamson (2)
Reed Hoyt (1)

(1) USARIEM (United States); (2) MIT Lincoln Lab (Lincoln, United States); (3) Martin Army Community Hospital (Ft. Benning, United States)

INDIVIDUAL MARKERS & RISK FACTORS OF EXERTIONAL HEAT ILLNESS DURING ARDUOUS MILITARY TRAINING: APPLICATION OF THE FORT BENNING MODEL IN THE UNITED KINGDOM

PURPOSE

A collaborative study has been undertaken at Fort Benning, Georgia between the US Army Research Institute of Environmental Medicine, the Institute of Naval Medicine and Martin Army Community Hospital. The purpose of this study was to identify individual thermal markers and risk factors of personnel conducting rigorous training events that have a high risk of Exertional Heat Illness (EHI) to develop risk profiles for likelihood of Exertional Heat Stroke. It is the intention to further develop this model through a Service Integration Evaluation (SIE), and to apply the model at two military training establishments in the United Kingdom (UK) to identify non-invasive markers and individual risk factors of EHI.

METHODS

Each data collection period will target a high EHI risk, training event. During these training events, and for approximately 24-h prior, volunteers will wear a chest belt physiological status monitor (PSM) to record heart rate, chest skin temperature, and 3-axis accelerometry. Acclimation status, previous heat illness, sleep quality, alcohol intake, prescribed medication and indications of recent inflammatory response will be documented. Anthropometry data will also be collected. Training Team evaluations will be made on the ease of PSM integration into the training environment where, practical use, interpretation of live information, decision making, and dynamic risk assessment will all be evaluated.

RESULTS

The study undertaken at Fort Benning monitored over 1600 personnel and identified six heat stroke casualties admitted to Martin Army Community Hospital. Although it is not expected that the same volume of data will be collected in the UK in the same time-period, it is important that suspected exertional heat exhaustion and heat stroke episodes are captured and aligned with individual risk factors identified by the training team and medical data from clinicians. Together with individual physiological data this collaboration will be the most comprehensive assessment of EHI in the military training environment to date.

CONCLUSIONS

The collaborative study at Fort Benning has identified the spectrum of normal and abnormal thermal responses to exercise during military training. This study will be expanded to include units in the UK to further improve this knowledge base.

OPERATIONAL RELEVANCE

Exertional Heat Illness is a considerable risk held by Commanders and a risk to life during military training. Better understanding of individual markers and risk factors will improve training and survivability.

AUTHORS

Simon Delves (1)

Mark Buller (2)

(1) Environmental Medicine & Science, Institute of Naval Medicine, Alverstoke, Hampshire, United Kingdom (Gosport, United Kingdom); (2) Biophysics and Biomedical Modelling Division, United States Army Research Institute of Environmental Medicine, Natick, USA (Boston, United States)

TS4.
REAL-TIME MONITORING TO PREVENT HEAT INJURY

#ABS199

FEBRUARY 11, 2020

OPTIMISING WORK CAPACITY DURING AIR FORCE OPERATIONS IN EXTREME HEAT

PURPOSE

Australian Defence Force personnel are regularly required to undertake operations in extreme heat where heat casualties are a real risk. To support ongoing operational requirements, the Defence Science and Technology Group provided advice on methods to safely maximise work conducted by aircraft maintainers during operations in extreme heat.

METHODS AND RESULTS

Due to the urgency of the request, the first step was to conduct a desktop analysis. First the current Defence Heat Injury Management policy was reviewed considering the environmental conditions and key aircraft maintainer tasks to identify the level of heat injury risk. Second wearable technologies were explored to reduce the risk and maximise the work capacity. These technologies were cooling vests and individual heat strain monitors. Subsequently, work rates of key tasks were measured at an Air Force base in Australia for modelling.

Several cooling technology options appropriate for aircraft maintainers were identified (e.g. ice-based liquid circulating vests and compressed air vests) and the liquid circulating vests were subsequently implemented. Using the United States Research Institute of Environmental Medicines Heat Strain Decision Aid model [1] the impact of these technologies on body core temperature revealed that they increased safe working times considerably by reducing the rate of body core temperature rise. However, the modelling also highlighted it was still likely that during certain key tasks, the body core temperature of personnel could still reach 38.5°C, which is considered unacceptable.

The military work tables incorporated in the current Defence policy prescribe work and rest ratios to minimise the occurrence of heat casualties. However, these are based upon a risk management model that is designed to protect the weakest link: The individual/s most susceptible to heat injuries. This results in personnel less susceptible to heat illnesses stopping work when they still have considerable capacity to continue. An alternative method to manage personnels heat risk is to monitor each individuals relevant physiological responses (i.e. body core temperature and heart rate) using an individual heat strain monitor, only stopping them if they reach an unacceptable level of physiological strain.

CONCLUSIONS

This project illustrated the potential benefits that two different wearable technologies may have on working in extreme heat and thereby, concurrently enhancing Defence capability whilst managing the health and wellbeing of Defences greatest asset, its people.

AUTHORS

Alison Fogarty (1)
Andrew Hunt (2)
Joanne Caldwell (3)
Mark Patterson (1)

(1) Defence Science and Technology Group (Australia); (2) Queensland University of Technology (Brisbane, Australia); (3) Monash University (Melbourne, Australia)

REFERENCE

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TS4.
REAL-TIME MONITORING TO PREVENT HEAT INJURY

#ABS127

FEBRUARY 11, 2020

THE ARMOR HEAT MONITORVALIDATION AND IMPLEMENTATION OF REAL TIME HEAT STRESS MONITORING IN THE NETHERLANDS ARMY

PURPOSE

The Netherlands Armed Forces recently developed the ARMOR Heat Monitor. This monitor is supporting military instructors in the early detection of exertional heat illness (EHI). It provides live feedback of the heat strain of individual soldiers during physical activities, such as loaded marches. The PSI (Physiological Strain Index; Moran, 1998) is used as the measure for presenting heat strain by combining core temperature and heart rate. Core temperature is estimated from a series of heart rate observations using the ECTemp algorithm (Buller, 2013). Before implementing the system, two studies were conducted to evaluate the validity of; 1) the Polar OH1 heart rate monitor and; 2) the ECTemp algorithm in circumstances where Dutch soldiers operate.

METHODS

In study 1 the Polar OH1 (Polar Electro, Finland), a photoplethysmography sensor worn on the upper arm, was compared to a validated chest belt (EQ02, Hidalgo, UK) by measuring heart rate of 96 soldiers during loaded marches (8-12 km) and speed marches (3 km). In study 2, estimated core temperature was calculated by ECTemp and compared to core temperature measured with a telemetry pill taken at least 6 hours prior to exercise (Vital sense, USA) during loaded marches (3-12 km) in hot (30 °C dry, n=32) and in cooler (10 °C dry, n=40) environments in 72 soldiers. In both studies, the Bland and Altman approach was used to evaluate agreement.

RESULTS

In study 1, a mean difference (systematic bias) of 0.28 b.min-1 (beats per minute) with 95% limits of agreement (LoA) of ±3.5 b.min-1 was found. In study 2, the hot environment, showed a systematic bias of +0.13 °C (ECTemp overestimating measured core temperature) and a LoA of ±0.67 °C. In the cooler circumstances the systematic bias was +0.32 °C, with a LoA of ±0.62 °C. Buller (2013) reported a LoA of ±0.63 °C.

CONCLUSIONS

It was concluded that: 1) the Polar OH1 is a valid heart rate monitoring device during military marching tasks. And 2) the validity of the ECTemp algorithm is comparable to the validity reported by Buller (2013). In cooler circumstances ECTemp showed a systematic bias, which can be corrected for. Based on these results it was felt that using the Polar OH1 and the ECTemp algorithm in the ARMOR heat monitor was appropriate.

OPERATIONAL RELEVANCE

The ARMOR Heat Monitor was implemented in 2019 in the Netherlands Armed Forces. In addition to the regular measures to prevent and to treat heat illness, ARMOR aims to reduce the incidence of EHI.

AUTHORS

Bertil Veenstra (1)
Marijne de Weerd (1)
Mark van Rijswick (1)

(1) Ministry of Defence (Utrecht, Netherlands)

TS4.
REAL-TIME MONITORING TO PREVENT HEAT INJURY

#ABS235

FEBRUARY 11, 2020

MATHEMATICAL MODELS TO ESTIMATE PERSONALISED HEAT STRAIN IN THE SINGAPORE ARMED FORCES

PURPOSE

The body core temperature (Tc) is a primary indicator for exertional heat illness risk. Skin temperature (Tsk), heart rate (HR) and breathing rate (BR) data are useful surrogates of Tc. This paper describes the comparative assessment of three statistical modelling methods for estimating personalised Tc in the Singapore Armed Forces soldiers.

METHODS

Tc, chest Tsk, HR and BR data were collected from three heat strain profiling studies with different experimental protocols (20km fast march, 10km fast march and simulated Infantry assault mission), climatic conditions and soldier volunteers. The extended Kalman filter (EKF), long short term memory (LSTM) network and mixed effects models were developed to map Tsk, HR and BR to Tc in individualised subjects. Model evaluation was conducted via in-sample (20km fast march) and out-of-sample (10km fast march and simulated Infantry assault mission) analyses.

RESULTS

Overall, the mixed effects model conditional on LSTM estimates produced more accurate Tc estimates. Under cross-validation analysis, this model yielded a mean error, root mean square deviation (RMSD) and Bland-Altman limits of agreement (LoA) of 0.01, 0.19 and ±0.37 degree Celsius respectively. Under external validation analysis, the corresponding metrics were-0.02, 0.30, ±0.59 degree Celsius respectively.

CONCLUSIONS

The mixed effects model conditional on LSTM estimates was more accurate in estimating personalised Tc profiles compared to the EKF and LSTM models.

OPERATIONAL RELEVANCE

Mathematical models that can calculate Tc in lieu of the invasive experimental procedures are useful for ambulatory heat strain monitoring and reducing the risk of exertional heat illness in the military. An accurate mathematical model can be plugged into a wearable physiological monitoring system to enable real-time quantification of personalised heat strain, reduce heat injury incidents as well as maximise training and performance outcomes.

AUTHORS

Kok Yong Seng (1)
Ying Chen (2)
Weiping Priscilla Fan (1)
Yue Nie Eunice Teo (1)
Poh Ling Tan (1)
Junxian Ong (1)
Si Hui Maureen Lee (1)

(1) DSO National Laboratories (Singapore); (2) National University of Singapore (Singapore, Singapore)

TS5.
GLOBAL WARMING AND URBANIZATION – IMPLICATIONS ON THE MODERN WARFIGHTERS' PREPARATION AND OPERATION.

#ABS285

FEBRUARY 11, 2020

PSYCHOLOGICAL MANIPULATION TO ENHANCE WARFIGHTER PERFORMANCE IN THE HEAT

Heat reduces performance and impairs cognitive function in warfighters, which can lead to excessive casualties in both training and operations. With increasing urbanization and climate change, warfighters will need multiple strategies beyond a reliance on technological solutions to mitigate the effects of heat strain. The need for rapid deployment may also mean minimal time to prepare for new conditions, such that a near-constant state of heat-readiness will need to be maintained. A strong interaction exists between an individuals thermal perception and their voluntary exercise capacity. Therefore, strategies should aim to decrease the impact of perceptual in addition to physiological heat strain. High aerobic fitness enables longer voluntary tolerance time and maximal core temperatures while exercising in the heat and wearing chemical warfare clothing, with no changes in the rate of heat storage. Furthermore, for the same physiological strain, aerobically fit soldiers had a lower perceived strain. Highly trained adventure racers and warfighters also experience less arousal and distress while maintaining cognitive function in the face of an aversive stimulus. Together, this suggests that maintaining high fitness is a valid long-term strategy to mitigate heat strain. Heat-adapted individuals also have increased physiological tolerance along with reduced perceptual strain. Some evidence also exists for improved performance in temperate environments following heat adaptation. Therefore, a second long-term intervention may be to adopt and maintain a state of heat adaptation throughout the year. Short-term interventions vary in their effectiveness and field-practicality. Deception of either environmental temperatures or core body temperature alters exercise-heat tolerance, but this may not be sustainable long-term and can erode soldier confidence. Psychological training, independent of training or any fitness changes, has increased exercise-heat tolerance and cognitive performance in the heat, and as such is an easily-implemented strategy. Some pharmacological agents notably those enhancing brain dopamine activity also appears to enable higher exercise performance and maximal core temperatures in the heat. This talk will survey the effects of thermal perception on exercise tolerance, evidence of the plasticity of thermal perception, and potential psychophysiological interventions to maintain warfighter readiness for hot-climate operations.

OPERATIONAL RELEVANCE

Heat stress impacts both physiological and perceptual strain, which synergistically interacts to determine performance in hot environments. Manipulating or training perceptual responses to heat can complement technological solutions to maintain warfighter health and performance in an increasingly warming climate.

AUTHORS

Stephen Cheung (1)

(1) Brock University (St. Catharines, Canada)

TS5.
GLOBAL WARMING AND URBANIZATION – IMPLICATIONS ON THE MODERN WARFIGHTERS' PREPARATION AND OPERATION.

#ABS253

FEBRUARY 11, 2020

IMPACTS OF CLIMATE CHANGE ON NATIONAL SECURITY AND WARFIGHTERS' HEALTH

PURPOSE

This symposium talk will analyse the relevance of climate change on the preparation of modern armed forces for the conduct of (i) combat and (ii) non-combat operations.

METHODS

The first topic will be addressed by presenting original data from field studies as well as a non-systematic literature review. The second topic will be addressed by systematic and non-systematic literature reviews.

RESULTS

For combat operations, climate change increases the triggers for conflict (e.g., through land-use changes and resource scarcity) and alters the environments in which conflict takes place, as extreme events become more frequent. In particular, the majority of combat operations during the past decades took place in exceedingly hot and cold environments. For non-combat operations, climate change raises the likelihood of deployment in response to a developing situation by increasing the frequency and intensity of natural disasters and peoples movements through borders. The latter has become a growing crisis which is projected to intensify during the 21st century and armed forces will need to deploy more and more often to support civil authorities in response to migration crises. We recently conducted the first systematic review and meta-analysis on this topic, analysing the migration patterns or attitudes of 1.6 billion people across 200 different countries from 1960 and projecting to 2099 and estimated that 35% of people who migrate or intend to migrate perceive climate change as one of their main reasons for doing so. Of this 35%, seven percentage points are attributed to the direct impacts of climate change (changes in temperature, rainfall, and/or wind), while the remaining 28 percentage points are attributed to indirect impacts (other environmental: 9%; economic: 8%; political: 7%; social: 4%) of climate change. Furthermore, the same meta-analytic work showed that annual migration will be increasing by 1.5% which is equal to 21.9 million people for every degree of increase in climate change until 2099.

CONCLUSIONS

Climate change leads to global instability through increased natural disasters, intensified competition for ever-diminishing food and water resources, amplified socio-economically motivated armed conflicts, and difficulty controlling national borders. As such, armed forces must adapt warfighter preparation as well as current and future operations (both combat and non-combat) to the direct and indirect impacts of climate change and the associated risks to national security.

OPERATIONAL RELEVANCE

To enhance warfighter preparation, it is vital to develop a framework that foresees climate-induced national security risks and implements strategies to address them.

AUTHORS

Andreas Flouris (1)

(1) FAME Laboratory, Department of Exercise Science, University of Thessaly, Greece (Trikala, Greece)

TS5.
GLOBAL WARMING AND URBANIZATION – IMPLICATIONS ON THE MODERN WARFIGHTERS' PREPARATION AND OPERATION.

#ABS321

FEBRUARY 11, 2020

ADVANCED HEAT MANAGEMENT FOR WARFIGHTERS IN THE HEAT

Exercising in the warm and humid often results in an excessive heat strain. Studies have shown that an accelerated increase in heat stain can impair both exercise performance and capacity. New attention on this issue has been created by the ongoing climate change, which in large parts of the world has caused more hot days each year and hotter hot days. Warfighters cannot avoid training and operating in the heat. They therefore have to learn to adapt and perform in these unfavorable environments and whenever possible, incorporate mitigation strategies to counter the negative effects of heat strain to augment performance and safety. Exercise tolerance in the heat can be affected by multiple factors such as the attainment of a high heat strain, cardiovascular insufficiency, metabolic disturbances and reductions in central nervous system drive to skeletal muscle. An excessive heat strain is one of the key limiting factors to exercise tolerance in the heat. The development of hyperthermia has been associated with alterations in self-pacing strategies in exercise performance trials or earlier voluntary termination during exercise capacity. There are various ways to mitigate heat strain, such as aerobic fitness, heat acclimation/acclimatisation, pre-exercise cooling and fluid ingestion. These strategies have shown to be effective in improving exercise tolerance in warm conditions through various processes that include alterations in heat dissipation ability, cardiovascular stability and adaptations and changes to the bodys heat storage capacity. Advanced heat mitigation strategies and important considerations when employing established methods will be presented in this session in hope to augment performance and safety of Warfighters.

OPERATIONAL RELEVANCE

While mitigation strategies are commonly employed to preserve Warfighters performance and safety in the heat, there is scope to harness latest evidence and technology to augment the impact of these strategies. With limited amount of time and resources, an evidence-based approach to quantify the efficacy of various heat mitigation strategies will allow Warfighters to select and prioritize the most effective strategy/ies to optimise performance, safety and health in face of global warming.

AUTHORS

Jason Lee (1)

(1) National University of Singapore (Singapore)

EVIDENCE OF RE-ACTIVATION OF A PREVIOUS FOUR-MONTH HEAT ACCLIMATIZATION MORE THAN SIX MONTHS LATER IN A MILITARY CONTEXT

PURPOSE

While the kinetic of heat acclimation/acclimatization is well described (Périard 2015), the decay is less documented but considered as complete after 6 weeks (Daanen 2018). Nevertheless, a large variability is observed and studies considering decay after 25 days are sparse and inconclusive. Therefore, we evaluate the long-term persistence of physiological and perceptual adaptations acquired during operational heat acclimatization.

METHODS

We compared responses during an early heat stress exercise in a group of soldiers with previous heat acclimatization and a control group. In the past, we performed two sets of studies in United Arab Emirates to evaluate heat acclimatization in French soldiers (Charlot 2017; Malgoyre 2018) and analyzed retrospectively data from 103 among them. 45 males partook in a four-month military mission in hot countries between 6 and 24 months before the study (HA group). The remaining 58 participants were never heat acclimatized (control group). On the second day of their arrival in a desert military base for a new mission, they all performed a heat stress test (HST: 3x8-min runs outdoors at 50% of speed at VO2max at ~40°C and ~20% RH).

RESULTS

Rectal temperature (Trec), heart rate (HR), and thermal discomfort, before and at the end of the HST, and sweat rate and osmolality during the HST were not different between groups. However, the increase of Trec and HR were 22% and 10% lower in the HA than control group ($p = 0.033$ and 0.015, respectively). Perceived exertion was also 20% lower in the HA than control group ($p = 0.023$). Finally, the physiological and perceptual strain index were 17% and 18% ($p = 0.013$ and 0.015, respectively) lower in the HA than control group.

CONCLUSION

Long-term operational heat acclimatization induced adaptations that may persist more than six months later. Comparisons with shorter classical heat acclimation protocols (< 15 days) are required to evaluate the difference in adaptations sustainability between short and long acclimatization approaches.

OPERATIONAL RELEVANCE

Theses results interest all professionals that may be subjected to frequent and repeated heat exposures and also researchers that have to recruit participants for heat acclimation protocols and question the relevant duration of the wash-out period. Whether these results mean residual adaptive responses or early re-induction should be clarified by basic research.

AUTHORS

Alexandra Malgoyre (1)
Pierre-Emmanuel Tardo-Dino (1)
Julien Siracusa (1)
Lepetit Benoit (1)
Nathalie Koulmann (1)
Keyne Charlot (1)

(1) Armed Forces Biomedical Research Institute (Brétigny sur Orge, France)

TS5.
GLOBAL WARMING AND URBANIZATION – IMPLICATIONS ON THE MODERN WARFIGHTERS' PREPARATION AND OPERATION.

#ABS316

CLIMATE CHANGE IMPLICATIONS FOR OPERATIONS: RETHINKING CHRONIC HEAT MANAGEMENT THROUGH THE LENS OF CO-PRODUCTION

PURPOSE

This conceptual paper discusses some of the implications for military preparedness (readiness) and operations resulting from climate change, particularly extreme heat, using the example of the Australian monsoon tropics. It highlights the need for further research in this region and similarly exposed climatic zones.

METHODS

A brief overview of contemporary and projected changes to thermal conditions as a result of climate change is presented. In the context of tensions between physiological limits and operational requirements, we consider how recent insights from theories of social practice re-position heat management as a socio-environmental and socio-technical co-production. This prompts us to critically engage with how the thermal figures or doesnt – in organisational and operational practices. Empirically, we draw on a scoping study for the Australian Department of Defence and several intervention studies with outdoor workers in northern Australia.

RESULTS

Climate change has significantly increased average global temperatures, and the frequency, duration and intensity of heat events. This shifts the thermal terrain in which warfighters prepare for, and conduct, combat operations. In this context, typical risk-mitigation strategies aimed at limited, infrequent events, (predominantly work to rest ratios, avoidance, and adoption of new cooling equipment) may be inadequate. This prompts us to consider more fundamentally how preparedness and operational practices themselves co-produce heat stress (e.g. by shaping exposure and exertion), and what heat management for chronically exposed populations might look like. For example, increasing the frequency of personnel rotation; managing tasks according to individual cumulative levels of exposure/exertion; increasing the use of automation and substitution strategies, such as remote control.

CONCLUSIONS

Climate change already significantly impacts on thermal comfort and physical performance, with implications for preparedness and operations. There is a need to better quantify these impacts and examine how heat-stress is co-produced through the design of operational practices per se to identify opportunities to mitigate negative effects.

OPERATIONAL RELEVANCE

Heat management is often conceptualised as a response to exceptional circumstances rather than more consistent conditions. Militaries typically allow for heat management to be suspended in operational contexts (particularly combat or exercises). This can work in the short term, but may lead to heat causalities and reduce operational capacity and capability over the medium term (for example, affecting personnel deployed over long, hot summer periods). Developing a stronger evidence base and re-conceptualising the problem in terms of practices are two entry-points to identifying and reducing impacts, and contributing to an operational advantage.

AUTHORS

Elspeth Oppermann (1)
Matt Brearley (2)
Jane Holloway (3)

(1) Ludwig Maximilians University (Munich, Germany); (2) Thermal Hyperformance (Howard Springs, Australia); (3) Charles Darwin University (Darwin, Australia)

MEASURING WORKLOAD AND STRESS IN OPERATIONAL VIRTUAL REALITY SETTINGS BY COMBINING ACTIGRAPHY AND HEART RATE

INTRODUCTION

Dealing with high levels of emotional, cognitive and/or physiological stress and workload is an essential skill of soldiers and policemen. The swift development of gaming and virtual reality simulation facilities and tools, miniaturized sensor and monitoring technology represents a great opportunity for advancing performance and resilience of employees that experience high pressure. As the military and police are often operating in dynamical settings, far away from desks and offices, we conducted two feasibility studies to examine the possibility of applying workload and stress measurements during dynamical operational contexts using Virtual Reality environments. To measure the workload and physiological stress response, we used actigraphy in combination with a heart rate (HR) sensor suite. With these measures we exploratively computed the added HR, i.e., the HR over and above the HR associated with by physical activity, where added HR is taken to indicate the mental/cognitive work load of the cardiovascular system to achieve e.g. dynamical reconnaissance and/or surveillance tasks. Added HR was deducted from the complete HR by utilizing the information from actigraphy like standing, walking, running, bending and mental/cognitive workload.

METHODS

25 participants from the Dutch 45th infantry battalion and 50 participants from the Dutch Police Force participated voluntarily in both studies, respectively. For the military we used the BlackSUIT training simulator (ReLiON, Enschede); which is developed for training of military operations in urban terrain. The suit consists of multiple sensors that connect to reference poles to establish positioning in space, leading to a virtualization of the person (https://www.youtube.com/watch?v=bu-J05lOD4w). For the police, we prepared one group with-and one group without VR training to conduct a surveillance tasks during crowded music concerts. All participants wore a small actigraph unit (Shimmer, Ireland) on their hip and the HR team PRO system (POLAR, Finland) around their chest.

RESULTS

Complete results of both studies will be discussed at the 5th ICSPP. Initial analyses showed that added HR is a promising method in classifying soldiers and policemen in high and low responders to perceived pressure in different operational environments.

CONCLUSIONS

Although added HR seems to be a method to measure controllable stress profiles of personnel in dynamic operational contexts, we will discuss whether this method is of added value compared to the interpretation of current HR measurements.

OPERATIONAL RELEVANCE

This research describes the effect of VR training and preparation on operational effectiveness of soldiers and policemen by the application on a new measurement method.

AUTHORS

Olaf Binsch (1)
Jan Ubbo Baardewijk, van (2)
Lotte Linssen (2)
Anne-Marie Brouwer (2)
Nanco Oudejans (3)
Annika Smit (4)
Eric Vermetten (5)

(1) Netherlands Organisation for Applied Scientific Research, Department of Human Factors, Soesterberg, The Netherlands. (Netherlands); (2) Netherlands Organisation for Applied Scientific Research, Department of Human Factors, Soesterberg, The Netherlands (Soesterberg, Netherlands); (3) Dutch National Police, Team Nijmegen-South, The Netherlands (Nijmegen, Netherlands); (4) Police Academy, Department of Knowledge and Research, Apeldoorn, The Netherlands (Apeldoorn, Netherlands); (5) Central Military Hospital, Dutch Ministry of Defence, Utrecht, The Netherlands (Utrecht, Netherlands)

GREATER THAN THE SUM OF ITS PARTS: THE OBJECTIVE ASSESSMENT OF TACTICAL SMALL UNIT PERFORMANCE

BACKGROUND

Defence and Security relies upon the coherent and effective performance of its component parts which, at the tactical level, often comprises Tactical Small Units (TSU) operating as a coordinated team. However, the ability to reliably monitor and objectively assess TSU performance remains an unresolved challenge in the land combat domain despite the emergence of novel technologies used in other areas such as sport. Devices used by sports teams and the military enable the scrutiny of output variables in near real-time such as heart rate and movement patterns. However, analyses of the coordinated contribution of each individual, and the behaviours of the team as a whole, are typically limited to subjective opinion.

PURPOSE

To propose a conceptual framework for the impartial assessment of TSU performance, based upon emergent sensor technologies and Artificial Intelligence (AI).

METHODS

Review of the scientific literature and the developments in AI and emerging sensor technologies was conducted to inform a conceptual framework that was designed to assess TSU performance.

RESULTS

Technology to acquire and rapidly process data continues to advance with the emergence of wearable, implantable and stand-off sensors along with AI-assisted tools. A peer-reviewed, conceptual, interdisciplinary framework for objectively assessing TSU performance has been proposed.

CONCLUSIONS

Analysis of the performance of mission-critical tasks by TSU are typically limited to subjective ratings (and post-hoc reports) despite advances in the available technology. As such, the techniques to objectively assess TSU performance remain to be developed and emerging smart-sensor technologies and AI-assisted analytical tools provide an opportunity to accomplish this.

OPERATIONAL RELEVANCE

The battlefield is complex, non-linear, dynamic and dominated by performance of TSU. Therefore, the progression from simply describing individual performance through the scrutiny of output metrics to understanding the effectiveness of TSU by integration of novel sensors and AI-assisted analytical tools would provide a clear operational benefit. The proposed framework would inform the design and procurement of future soldier systems by reliably determining TSU performance of mission-critical tasks.

AUTHORS

Graham Fordy (1)

Rene Nevola (2)

(1) Fordy Consulting Limited (Raumati Beach, New Zealand); (2) Defence Science Technology Laboratory (Fareham, United Kingdom)

A METHODOLOGY TO MEASURE THE INTERPLAY OF COGNITION AND PHYSICAL PERFORMANCE OF THE INDIVIDUAL SOLDIER DURING A FIELD EXERCISE

PURPOSE

The objective of this research was to establish a test methodology utilizing an operational scenario for assessing the effects of clothing and individual equipment (CIE) on Soldier physical and cognitive performance. The scenario was designed to have Soldiers perform an operationally relevant and fatiguing set of tasks (e.g., movement to an objective, action on an objective, etc.).

METHODS:

A total of 62 male, 11 B Infantry Soldiers participated (24.1 ± 4 years; stature 1.75 ± 0.8 m; weight 81 ± 12 kg; VO2Peak, 49.5 ml/kg/min, body fat 18.9 ± 5%).Test participants performed six events in a 4-hour scenario each day over the course of 3 test days, with a rest day between each day of testing. The scenario sequence of events was as follows: Pre-dynamic rifle marksmanship performance; First 3-mile foot march at 3 mph; Load Effects Assessment Program (LEAP) obstacle course; Military Operations in Urban Terrain (MOUT) exercise; Second 3-mile foot march at 3 miles/hour; and Post-dynamic rifle marksmanship performance.

RESULTS AND DISCUSSION

From a cognitive science perspective, findings suggest that performing a foot march wearing CIE such as the plate carrier body armor and IOTV degrades cognitive control processes, primarily response inhibition. For marksmanship, findings suggest that both static and dynamic marksmanship scenarios are necessary to fully assess the effects of equipment on the marksmanship process in its entirety. These scenarios were found to be sensitive to changes in CIE configuration. The MOUT scenario was only sensitive to configuration changes for measures of mobility, but not lethality or decision making. From a biomechanics perspective, the IMU-derived performance measures generally revealed marked degradations in performance with heavier body-borne loads. This was consistently found during the foot marches and during the LEAP obstacle course.

From the physiologic perspective, practical measurement techniques utilized within this methodology allow for the collection and assessment of important physiologic metrics. These metrics and analysis techniques can be accomplished in the field setting during rigorous Soldier tasks in a non-intrusive manner. This research finds significant outcomes on the detrimental effects of encumbering the Soldier with CIE on physiologic performance during Soldier tasks.

CONCLUSIONS

Together, the results suggest that physical and cognitive indices of Soldier performance change, and often degrade, as a function of CIE, and that the present operationally-relevant scenario is sensitive to detect such changes.

AUTHORS

Leif Hasselquist (1)
Clifford Hancock (2)
Grace Giles (2)
Stephanie Brown (2)
Marianna Eddy (2)

(1) Combat Capabilities Development command (Natick, United States); (2) Combat Capabilities Development Command Soldier Center (Natick, United States)

LESSONS LEARNED FOR MEASURING DISMOUNTED SOLDIER PERFORMANCE AND EFFECTIVENESS UNDER STRESS

PURPOSE

In this panel presentation, lessons learned are described for how we successfully addressed the challenge of developing and applying measures of team (squad) performance and incorporated them in an integrated After Action Review (IAAR).

METHODS

Research has shown that conventionally trained Soldiers lack critical cognitive and socio-emotional skills necessary to reduce avoidable casualties in combat. To address this problem, the SOvM for Tactical Combat Casualty Care (TC3) research program created an integrated training approach (ITA) that implemented classroom, simulation-based training, and live, outdoor exercises based on the principles of stress exposure training.

RESULTS

An experiment with U.S. Soldiers demonstrated the ITA improved soldier and squad knowledge and skills in TC3, advanced situation awareness (ASA), teamwork, and stress management.

CONCLUSIONS

In this section we describe lessons learned for how we successfully addressed the challenge of developing and applying measures of team (squad) performance and incorporated them in an integrated After Action Review (IAAR). We describe how researchers employed an Event-Based Approach to Training (EBAT) method that linked scenario events to observable team behaviors for TC3, ASA, and teamwork. Next we describe how we instrumented Soldiers and their surroundings to enable observations and assessments. We discuss how we generated both static and dynamic assessment tools (e.g., tablet-based) that we used during the live exercises. Finally, we describe how the standard AAR method was revised to integrate these observed assessments to ensure squads could improve their performance over time.

OPERATIONAL RELEVANCE

The submitted research is applicable to Soldier physical performance because it describes lessons learned from an empirically tested training approach for improving Soldier and team performance under stress.

AUTHORS

Joan Johnston (1)

(1) Combat Capabilities Development Command (United States)

MULTI-STAGE SHUTTLE FITNESS TEST PERFORMANCE PREDICTS 2-KM PERFORMANCE IN RECREATIONALLY ACTIVE INDIVIDUALS

PURPOSE

New Physical Employment Standards have recently been introduced for United Kingdoms Armed Forces Ground Close Combat personnel. The resultant new British Army Role Fitness Test (Entry) [RFT(E)] point-of-entry test and in-service, bi-annual Soldier Conditioning Review (SCR) assess aerobic fitness using a 2-km run with the Multistage-Shuttle Fitness Test (MSFT) used as an alternative in cases of inclement weather or restricted access to an outdoor circuit. Therefore, the aim of this study was to quantify the relationship between 2-km run and MSFT performance

METHODS

Twenty-four (15 male, 9 female) participants (mean ± SD; age 27 ± 7 years; stature 1.76 ± 0.08 m; body mass 73.2 ± 9.8 kg) completed a treadmill based assessment of maximal aerobic capacity (VO2max) test, an outdoor 2-km run and gym-based MSFT (minimum 24h apart) in a crossover design. Pearsons correlation coefficient (rp) and Ordinary Least Product regression analyses were used to describe the relationships between a) 2-km run time (min) and the total number of MSFT shuttles completed; b) VO2max and 2-km run time (min); and c) VO2max and MSFT shuttles completed. The standardised residual on Y axis (SResidY) quantified the prediction error of the equation.

RESULTS

2-km run time was extremely largely negatively correlated with MSFT shuttles completed (rp =-0.93, $p < 0.001$). The relationship between average 2-km time and MSFT performance can be described as: average 2-km run time (min) =-0.0628 x number of MSFT shuttles + 13.2063, R2 = 0.86, SResidY = 0.48 min (00:29 min:s). VO2max was also very largely correlated with 2-km run time (rp =-0.85, $p < 0.001$) and MSFT shuttles completed (rp = 0.79, $p < 0.001$).

CONCLUSION

These findings indicate that 2-km run time and MSFT performance are strongly correlated suggesting that the two tests can be used interchangeably, with a small degree of error, to assess an individuals aerobic capacity. In addition, 2-km run and MSFT performance were strongly correlated with VO2max indicating the potential for developing predictive equations for the latter.

OPERATIONAL RELEVANCE

It has been established that a linear regression equation can be used to predict performance between a 2-km run and MSFT, providing assessors the flexibility to use either interchangeably as required. A practical example using this equation is: the British Armys Infantry RFT(E) 2-km run standard is 10:15 min:s which equates to a MSFT score of 47 shuttles, with a SResidY of 0.48 min (00:29 min:s).

AUTHORS

Josh Osofa (1)
Stephen Myers (1)
Oliver Page (1)
Sarah Coakley (1)
Sam Blacker (1)

(1) OPRG – University of Chichester (CHICHESTER, United Kingdom)

CHANGES IN MUSCLE ACTIVITY OF THE MILITARY SIMULATION TEST PERFORMED TWICE DURING THE 6-MONTH MILITARY OPERATION

PURPOSE

The evolution of sensor technology has enabled electromyography (EMG) measurements during dynamic field settings. The present study assessed changes in relative muscle activity during the high-intensity military simulation test (MST), performed in the beginning (PRE) and at the end (POST) of the 6-month crisis-management operation in the Middle East.

METHODS

Maximal force (MVC) of the thigh extensor muscles was measured isometrically (N=58). Simultaneously, EMG (EMG_MVC) of the quadriceps and hamstring muscles was determined by using electrodes embedded inside elastic garment shorts. In addition, EMG was recorded throughout the MST while blood lactate (BLa) and a rating of perceived exertion (RPE) were determined before and after MST. Different phases of MST were identified utilizing video recordings and EMG data. EMG data were normalized to the EMG_MVC value (%EMG_MVC), averaged across the channels and reported as%EMG_MVC (mean±SD).

RESULTS

Mean MST time (PRE 148±22 s) improved by 11±7% ($p<0.001$) during the operation. The relative PRE and POST muscle activities during MST were 90±57 and 116±70% EMG_MVC (67±112%, $p<0.01$), respectively. Similar increases were observed in all phases of MST. PRE and POST BLa values after MST were 10.9±3.6 and 15.8±3.6 mmol/L (63±55%, $p<0.001$), while RPE remained unchanged (18±1).

CONCLUSIONS

Relative muscle activity during MST was close to the level of isometrically measured MVC, and it increased during the operation. The change in EMG suggests increased neuromuscular input during MST after the 6-month military operation, likely leading to faster time and greater lactate levels. High relative EMG values throughout the different phases of MST suggest that despite the anaerobic nature of the test, the soldiers were able to maintain their high voluntary muscle activation until the end of the test. The results must be interpreted cautiously due to high variation in EMG changes and, more detailed (e.g. agonist-antagonist) analyses may be required.

OPERATIONAL RELEVANCE

High muscle activation level was observed during the functional military simulation test. Muscle activity level increased during the 6-month crisis-management operation, obviously as a result of improved physical performance and motor learning. Repeated EMG assessments provide tactical athlete coaches a new non-invasive method to analyze training induced changes in muscle activation during military simulations. More detailed analyses require muscle group specific analyses which are also available with the method used.

AUTHORS

Kai Pihlainen (1)
Arto J. Pesola (2)
Joonas Helén (3)
Tommi Ojanen (4)
Matti Santtila (3)
Keijo Häkkinen (5)
Taija Finni (5)
Heikki Kyröläinen (5)

(1) Defence Command, Training Division, Finnish Defence Forces (Helsinki, Finland); (2) Active Life Lab, South-Eastern Finland University of Applied Sciences (Mikkeli, Finland); (3) National Defence University, Department of Military Pedagogy and Leadership (Helsinki, Finland); (4) Finnish Defence Research Agency, Human Performance Division (Tuusula, Finland); (5) University of Jyväskylä, Neuromuscular Research Center, Faculty of Sport and Health Sciences (Jyväskylä, Finland)

CHARACTERIZING TACTICAL PERFORMANCE DURING SUSTAINED LIVE-FIRE EXERCISES

Tactical success is characterized in terms of four warfighter performance pillars: Shoot, Move, Communicate, and Survive. Mounting research suggests that performance in these areas is nominally influenced by physical, nutritional, health, cognitive, and social-emotional factors. Yet, to date, little work has examined the coalescence of these factors and no research has investigated how individual and group-level (i.e., platoon, team, squad) performance changes as a function of these factors over the course of an extended tactical timeline. To address this knowledge gap, we designed and executed an exploratory field study entitled Monitoring and Assessing Soldier Tactical Readiness and Effectiveness (or, MASTR-E).

MASTR-E was a field study methodology consisting of performance measurements of three platoons of Soldiers (N=46) while they completed a 72-hour dismounted infantry training exercise comprised of a series of simulated field battle drills (conduct an ambush or raid, movement to contact, react to contact, enter and clear a building or bunker, marksmanship under duress, etc.). A comprehensive battery of baseline measurements aimed at quantifying physical and cognitive ability and health and social-emotional status was collected in the days leading up to the field exercise. We additionally tracked performance during the exercise using wearable sensors, biosampling, and intermittent self-report questionnaires. Finally, we evaluated mission recovery by reintroducing a subset of assessments from the baseline battery over the 5 days following the completion of the training exercise. The primary outcome measures of interest included marksmanship performance on a live-fire exercise (Shoot), kinematics during a 6-mile ruck march (Move), physiological responses of acute stress (Survive), and anaerobic capacity during a bounding drill (Survive). Machine learning techniques were applied to identify the collection of baseline measures that best predict each outcome for individuals (using estimation) and platoons (using classification).

We argue that the field study methodology and analytical models provide a framework for down-selecting the readiness traits that meaningfully account for differences in readiness states during essential operational tasks. In addition to discussing operational, technical, and policy implications of this research, we also present lessons learned and areas for refinement for future iterations among new cohorts totaling 150 Soldiers planned over the next 36 months.

AUTHORS

John Ramsay (1)
Erika Hussey (1)
(1) US Army CCDC Soldier Center (Natick, United States)

TS10.
METHODS FOR ASSESSMENT OF SOLDIER PERFORMANCE AND EFFECTIVENESS AT THE INDIVIDUAL AND SMALL UNIT LEVEL
#ABS279

FEBRUARY 11, 2020

DEVELOPMENT OF A FRAMEWORK FOR DISMOUNTED INFANTRY TEAM PERFORMANCE MEASUREMENT

BACKGROUND

Measures of individual soldier performance do not necessarily predict the performance and operational effectiveness of tactical teams (the level at which soldiers are employed). While team effectiveness is often assessed with subjective Subject Matter Expert ratings or simple force-on-force engagement systems, these methods have proven insufficient for objectively demonstrating and comprehending the team effectiveness impact of future soldier system enhancements (e.g., network-enabled communications and situation awareness support technologies).

PURPOSE

To develop a comprehensive model of dismounted small unit effectiveness as a measurement framework, to support objective comparisons of alternative soldier system designs, alternative means of employment of such systems, and future capability development initiatives, in both laboratory and field environments.

METHODS

Three different approaches to measuring mission effectiveness were reviewed for their strengths and limitations. Two workshops were held at the Canadian Infantry School with infantry subject matter experts to review past approaches and to develop a new dismounted soldier system mission effectiveness model (DSS-MOME) that enables a context-driven, more objective team performance scoring or measurement framework.

RESULTS

The developed model applies 150 measurements in order to collect 122 Measures of Performance (MOPs). These MOPs are further aggregated into 73 Measures of Effectiveness (MOEs), which combine into 23 Mission Measures of Effectiveness (MMOEs) in 6 Groupings. Groupings and MMOEs were prioritized according to their importance to mission quality and success, according to each of five different mission types: hasty attack, deliberate attack, deliberate defense, reconnaissance patrol, and cordon & search. Performance effectiveness measurements can be aggregated and summed from the bottom-up, according to the weighted importance of each measurement in each mission context, to arrive at scored Measures of Outcome (MOO). Examples are given in the context of soldier information technology evaluations.

CONCLUSION

The proposed DSS-MOME provides a framework and analytical summation process for aggregating MOPs to produce numeric mission effectiveness and outcome measures or scores, while enabling detailed traceability and diagnosticity to the task and capability levels. The model may be exploited for a range of soldier system interventions (technologies, training, doctrinal changes, changes in tactics techniques and procedures, or personnel interventions).

OPERATIONAL RELEVANCE

The DSS-MOME provides a framework for selection of the most suitable measures likely to demonstrate the impact of a soldier system intervention for a given mission context. This can result in more efficient testing as well as ensure that the objective evidence needed for capability investment planning is captured.

AUTHORS

David Tack (1)
Ed Nakaza (1)
Linda Bossi (2)

(1) HumanSystems Incorporated (Guelph, Canada); (2) Defence R&D Canada (Toronto, Canada)

TS13.
FEMALE SPECIFIC CONSIDERATIONS FOR OPTIMIZING SOLDIER PERFORMANCE THROUGH BETTER CLOTHING AND EQUIPMENT FIT
#ABS247

FEBRUARY 11, 2020

INCIDENCE OF BREAST HEALTH ISSUES IN BRITISH ARMY FEMALE RECRUITS DURING BASIC TRAINING: A PILOT STUDY

PURPOSE

Increasing retention of female recruits throughout Basic Training (BT) is a key priority for the British Army. Excessive breast movement during exercise can cause breast pain, impact physical training adherence, and increase risk of musculoskeletal injury in recreationally active females. Recent unpublished data from British Army female recruits found that 85% experienced bra fit issues and breast health knowledge was poor. The aim of this pilot study was to assess the influence of professionally fitted sports bras on sports bra usage and measures of bra comfort across 14-weeks of BT.

METHODS

Following ethical approval, 33 female recruits undertaking Army BT (age 21 ± 4 years, height 1.6 ± 0.1m, mass 62.6 ± 9.6kg and BMI 22.9 ± 2.4kg/m2) consented to participate. Professionally fitted sports bras were provided to each recruit by BoobyDooTM during week-1 of BT. Validated questionnaires were used to identify the incidence of breast health issues at week-1 (Pre) and week-12 (Post) of BT. Data were analysed descriptively to determine percentages for categorical responses on sports bra usage, incidence and severity of bra comfort. Wilcoxon signed-ranked tests determined statistically significant differences in breast movement and bra comfort pre-post the provision of sports bras.

RESULTS

Pre-questionnaire data indicated only 20% of recruits wore a correctly fitted sports bra. Post-questionnaire data showed that 90% of recruits wore the sports bras provided. Upper body muscle pain reduced by 18%, and self-reported poor posture and excessive breast movement significantly reduced by 50% and 67% respectively ($p < 0.05$). However, the incidence of discomfort from bra straps and underwires digging in increased by 12% and 7%, respectively compared to pre-questionnaire data.

CONCLUSIONS

Some bra fit issues reduced significantly during BT by the provision of professionally fit sports bras. Importantly there was a reduction in self-reported breast movement and poor posture which could negatively impact physical training and musculoskeletal injury risk.

OPERATIONAL RELEVANCE

This pilot study provides training units and the wider Army with important information concerning the feasibility and effectiveness of issuing professionally fitted sports bras to female recruits during BT. Recruits making informed decisions over breast support early in training will reduce the risk of breast tissue damage from excessive breast movement, improve comfort, increase adherence and willingness to exercise and potentially enhance long-term breast health outcomes. As a result of this study the British Army will be issuing all female recruits with professionally fitted sports bras.

AUTHORS

Jenny Burbage (1)
Bethan Moriarty (2)
Louise Corfield (2)
Alex Rawcliffe (2)
Rachel Izard (2)

(1) University of Portsmouth (Portsmouth, United Kingdom); (2) HQ Army Recruiting Initial Training Command, Ministry of Defence, UK (Upavon, United Kingdom)

IS BODY ARMOUR WEAR ASSOCIATED WITH BREAST DISCOMFORT AND BREAST INJURIES AMONG AUSTRALIAN ARMY FEMALE SOLDIERS?

PURPOSE

Anecdotal evidence suggests that female soldiers may be experiencing breast discomfort when wearing the Tiered Body Armour System (TBAS). However, no research has been conducted to confirm this notion. The purpose of the current study was to determine the prevalence of breast discomfort and breast injury among female soldiers as a result of TBAS wear.

METHODS

A custom questionnaire was completed by 147 Australian female soldiers. The 59-item questionnaire included items pertaining to fit and function of TBAS, self-reported bra size, experience of breast discomfort (breast/chest compression and exercise-induced breast discomfort (EIBD)) and prevalence of breast injuries when wearing TBAS. Responses to questions were coded and counted. Participants were divided into two groups (Small breasts and Medium-Large breasts) based on bra size. Chi squared tests determined whether participants with Medium-Large breasts were more likely to report unacceptable levels of breast/chest compression, EIBD or breast injury when wearing TBAS ($p < 0.05$, SPSS v23, USA).

RESULTS

A high prevalence of breast discomfort (breast/chest compression: 75%; EIBD: 49%) was reported, attributed to a lack of space for breasts, as well as ballistic plates pressing into the breasts. Thirty-one percent of participants reported experiencing at least one breast injury when wearing TBAS, with bruising and abrasions the most common types. Injuries were attributed to long periods of wear and impact. Thirty-three percent of participants who reported a breast injury, reported the injury affected soldiering performance (decreased ability to perform tasks, altered technique or experience of discomfort/irritation). Compared to participants with Small breasts, participants with Medium-Large breasts were significantly less likely to rate the breast compression experienced as acceptable (2 (1, n = 147) = 6.583, p = 0.01), were significantly more likely to report experiencing EIBD (2 (1, n = 147) = 12.784, $p < 0.001$), as well as incurring a breast injury when wearing body armour (2 (1, n = 147) = 6.216, p = 0.013).

CONCLUSION

Female soldiers are experiencing breast discomfort and injuries when wearing TBAS and report this affects their soldiering performance. This is amplified in women with larger breast sizes. Breast injuries should be a risk management consideration for military forces. Design of body armour should consider features to minimise breast discomfort and injury.

OPERATIONAL RELEVANCE

In order to enhance female soldiering performance future body armour should investigate how best to incorporate female-specific design features, including features which cater to the breasts.

AUTHORS

Celeste Elizabeth Coltman (1)
Richard Henry Molloy (2)

(1) University of Canberra Research Institute for Sport and Exercise, Faculty of Health, University of Canberra, Australia (Australia); (2) Human Systems Integration, Land Division, Defence Science and Technology Group, Department of Defence, Australia (Melbourne, Australia)

TS13.
FEMALE SPECIFIC CONSIDERATIONS FOR OPTIMIZING SOLDIER PERFORMANCE THROUGH BETTER CLOTHING AND EQUIPMENT FIT
#ABS272

FEBRUARY 11, 2020

IMPACTS ON RANGE OF MOTION IN BODY ARMOR FOR MALES AND FEMALES

Limited research has been done to understand the assessment of clothing and protective equipments impact on mobility for males and females. Previous work has included insufficient numbers of female participants in encumbered range of motion data collections to adequately evaluate sex-based differences. As females begin to enter newly accessible combat job series, understanding mobility differences between males and females and performance degradation related to clothing and equipment is critical.

This study compared the range of motion performance of male and female Soldiers in three clothing configurations (a duty uniform only baseline and two body armor systems (A (vest) and B (plate carrier)), with rifleman kit). Participants completed 12 different movements (neck (2), shoulder/reaches (4), hip (1), lower back (4) and dynamic/whole body (1)) in each configuration.

Sixteen female active duty Soldiers took part in this study (age: 24.6 ± 6.53 years; time in service: 4.6 ± 6.29 years; grade: E2-E8, with 50% E3; MOS: 62% were 31B or K (military police or K9)). Seven (43.8%) participants wore size extra small body armor, six (37.5%) wore small, and three (18.8%) wore medium. Seven male active duty Soldiers took part in the study (all were recent basic training graduates with less than 1 year of time in service; age: 20.6 ± 2.61 years; grade: E1-E2; MOS: 11B). All males wore size small (67%) or medium (33%) body armor.

A mixed-design ANOVA was performed for each movement with sex as a between-subjects variable and three clothing configurations as a within-subjects variable. All movements had a significant (or approaching significance) main effect for configuration, where participants performed worse in each of the body armor configurations than the baseline; however, performance in the two body armor systems was similar. There was a main effect for sex for nine (75%) movements, showing better mobility for males than females. Interestingly, only the shoulder abduction movement had an interaction effect of configuration and sex (approaching significance); with both sexes performing similarly while in the baseline and both experiencing degraded performance, to a greater extent for females, in the body armor configurations.

Sex alone likely does not seem to account for all the differences between male and female Soldiers seen in this study. Anthropometric and demographic characteristics such as age, stature, weight, and percent of body weight may also influences performance. To understand their roles, additional analysis is needed.

AUTHORS

K Blake Mitchell (1)
Todd N Garlie (1)
Hyeg Joo Choi (1)
Jose D Villa (1)
Linda L DeSimone (1)

(1) CCDC Soldier Center (Holliston, United States)

PSYCHOLOGICAL CORRELATES OF COGNITIVE RESILIENCE TO A PHYSICAL CHALLENGE: DOES STRESS MINDSET PROTECT COGNITION?

PURPOSE

Effective cognitive functioning under significant physical stress is often a key determinant of operational success. As a result, it is important for military personnel to display high levels of cognitive resilience, defined as the ability to maintain cognitive performance when faced with stress. One factor that may act to enhance cognitive resilience is ones stress mindset. It is possible that those with a stress-is-enhancing mindset may be more cognitively resilient to the effects of stress than those with a stress-is-debilitating mindset. This study aimed to examine the influence of stress on cognitive performance and whether this potential impact is related to an individuals stress mindset.

METHODS

Participants attended two sessions, presented in a randomised, counterbalanced order. In one session, participants walked on a treadmill for 60 minutes while carrying 30% of their body weight. Speed was adjusted throughout to maintain a perceived exertion of 13 on Borgs 6-20 scale. The second session acted as a control, where participants watched a 60 minute, affectively neutral documentary. An n-back task was used to assess working memory before and after the control and physical stress interventions. Stress mindset was determined using the Stress Mindset Measure. Psychological stress was also measured before and after the control and stress interventions.

RESULTS

Preliminary analysis was conducted on a sample of n = 19. Results indicate that perceived stress ratings were significantly higher following the stress intervention compared to the control. Despite this, there was no significant difference in cognitive performance across the two conditions. Correlational analysis uncovered no significant relationship between stress mindset and the degree of change in cognitive performance in the physical stress condition.

CONCLUSIONS

Preliminary results of the current study indicate that the induction of acute psychological stress following a physically demanding task does not affect cognitive functioning, as assessed in an n-back task. Similarly, stress mindset did not present as a protective factor for the maintenance of cognitive performance under stress. Future research should continue to investigate whether factors, such as stress mindset, act to enhance cognitive resilience across a range of cognitive domains and modes of stress induction.

OPERATIONAL RELEVANCE

The current findings suggest that working memory performance is maintained after a challenging physical task. Despite this, the often-higher physical demands of combat scenarios may threaten cognitive resilience in active military personnel. Whether ones stress mindset acts as a protective factor in these environments requires targeted examination.

AUTHORS

Andrew Flood (1)
Kristy Martin (1)
Ben Rattray (1)
Julien Periard (1)
David Pyne (1)
Andrew McKune (1)
Richard Keegan (1)

(1) University of Canberra Research Institute for Sport and Exercise (Australia)

PHYSIOLOGICAL INTERVENTIONS TO PROMOTE COGNITIVE RESILIENCE

PURPOSE

Military personnel face unique challenges to cognition, including combinations of physical and mental fatigue, anxiety and stress, and environments of unpredictability. Personnel are prepared for and trained to tolerate many of the stressors they may encounter; however, consideration of stressors typically extends only as far as the physical, psychological, and environmental requirements of a given task. The aim of this systematic review was to identify and detail individual physiological states and traits that influence cognition. We will discuss these factors and demonstrate how they may be manipulated to promote resilient cognition.

METHODS

A systematic review of Medline (PubMed), EMBASE (Scopus), PsycINFO, and Web of Science was conducted from inception to January 2019. Eligibility criteria included a healthy military cohort, an outcome of cognition or military task performance, and assessment or manipulation of a physiological state or trait.

RESULTS

The search returned 60,564 records, of which 60 met the inclusion criteria. Factors including increasing age, fatigue arising from sustained military activities, prolonged undernutrition, dehydration, motion sickness, and pregnancy appear detrimental to cognitive performance. Having high visual acuity, high aerobic fitness, and a high DHEAS to cortisol ratio tended to benefit cognitive performance, as did supplementation with carbohydrates and tyrosine during periods of stress. Personnel with low baseline heart rate variability, an exaggerated cortisol response to stress, or a higher number of stress-related biomarkers at baseline are likely more susceptible to performance decline. Among the factors recognized as influencing cognition, a further subset was considered modifiable and include nutrition, hydration, and aerobic fitness.

CONCLUSIONS

Several physiological factors have a positive or negative impact on cognition. Some of these factors are modifiable and should be targeted for interventions in military settings to improve cognitive performance. Increasing or maintaining aerobic fitness impacts cognition directly and improves the ability to accommodate other stressors. Maintaining an adequate diet and hydration status ensures effective brain functioning in regard to neurotransmission. Targeting individuals who recorded a greater physiological response to stress for interventions designed to reduce stress and anxiety may also reduce performance impairment in challenging conditions.

OPERATIONAL RELEVANCE

By identifying the physiological factors that impact cognition, negative influences may be countered or managed where possible, and factors that have a positive effect on cognition promoted and encouraged. This information will assist in the development and evaluation of strategies and training programs to enhance cognitive and military task performance.

AUTHORS

Kristy Martin (1)
Julien Périard (1)
Ben Rattray (1)
David B. Pyne (1)

(1) University of Canberra Research Institute for Sport and Exercise (Canberra, Australia)

TS16.
FACTORS THAT IMPACT AND PREPARE INDIVIDUALS TO BE RESILIENT IN COGNITIVELY DEMANDING ENVIRONMENTS

#ABS136

FEBRUARY 11, 2020

NUTRITIONAL INTERVENTIONS & COGNITION

Exercise will have a positive influence on cognition and it increases the brain-derived neurotrophic factor, an essential neurotrophin. Several dietary components have been identified as having effects on cognitive abilities. In particular, polyphenols have been reported to exert their neuroprotective actions through the potential to protect neurons against injury induced by neurotoxins, an ability to suppress neuroinflammation, and the potential to promote memory, learning, and cognitive function. Dietary factors can affect multiple brain processes by regulating neurotransmitter pathways, synaptic transmission, membrane fluidity, and signal-transduction pathways. Flavonols are part of the flavonoid family that is found in various fruits, cocoa, wine, tea and beans. Although the antioxidant effects of flavonols are well established in vitro, there is general agreement that flavonols have more complex actions in vivo. Several cross-sectional and longitudinal studies have shown that a higher intake of flavonoids from food may be associated with a better cognitive evolution.

Whether this reflects a causal association remains to be elucidated. Several studies have tried to manipulate the brain in order to postpone central fatigue. Most studies have clearly shown that in normal environmental circumstances these interventions are not easy to perform. The use of neurotransmitter precursors has been put forward as a possibility to postpone fatigue during prolonged exercise. Although these studies looked promising, there is no real evidence that the brain, and performance can be manipulated easily. It is clear that caffeine has a positive effect on brain functioning and exercise performance. Carbohydrates as a fuel source seem to influence not only the peripheral fatigue, but there is accumulating evidence that rinsing the mouth with a carbohydrate solution will improve endurance performance.

AUTHORS

Romain Meeusen (1)

Bart Roelands (1)

(1) Vrije Universiteit Brussel (Brussels, Belgium)

CONCEPTUALISING WHAT WE NEED TO CONSIDER TO BETTER STUDY, PLAN FOR, AND IMPROVE COGNITIVE RESILIENCE

PURPOSE

Military personnel are prepared for and trained to tolerate many of the stressors they may encounter; however, consideration of stressors typically extends only as far as the physical, psychological and environmental requirements of a given task. Here we consider these, and wider factors that look to aid operational performance in a military context with a focus on performance under or following cognitively demanding situations.

METHODS

We utilise the cognitive control construct to consider changes in task performance due to its analogous, yet broader, application to cognitive resilience. Cognitive control refers to the processes, or capacity, by which individuals manage goal-orientated behaviours against habitual tendencies or in the face of many choices. In a military context, it is associated with tasks such as target identification in a complex environment, vigilance and maintaining situational awareness, and decisions regarding whether to continue to engage in an action or behaviour. Based on research across military, exercise science, psychological and neuroscience literature, we conceptualise how external and internal factors influence performance.

RESULTS

We highlight examples from the literature where context matters. Factors such as the task, environment, and psychological and emotional traits and states, converge to influence the cognitive control exerted. The task demands of both the cognitive and physical challenge will influence the outcome. Longer durations, higher complexities and less familiarity all contribute to a reduction in performance level. Atmospheric conditions (temperature, humidity, altitude) not only impact the peripheral body, but also cognitive control, as does the social setting. These contexts must be considered with the individual's psychological traits and state to cope with, or physiologically accommodate, the situation. Understanding how cognitive resilience is exerted requires not only the study of these individual factors, but also how they interact. This assists in the understanding of cognitive control and provides insights on how it can be considered in operational planning and augmentation.

CONCLUSIONS

Factors including the demands of the task, the environment, physical demands, and psychological and emotional traits and states, all integrate to influence our capacity and willingness to exert effort. Understanding these relationships are important for understanding changes in performance as well as planning and training for operational success.

OPERATIONAL RELEVANCE

Our recommendations are relevant for improved research on military performance, and inform what should be considered when planning and training for operational effectiveness.

AUTHORS

Ben Rattray (1)
Andrew Flood (1)
Kristy Martin (1)
Richard Keegan (1)

(1) University of Canberra (Australia)

THE EFFECTS OF DIFFERING STRESSORS ON FATIGUE

Fatigue has been described in many ways tiredness, exhaustion, lethargy. It can be defined as a decline in the ability and efficiency of mental and/or physical activities that is caused by excessive mental or physical activities or disease. Fatigue is a very common, multifaceted phenomenon that everybody encounters in their everyday life and/or in a professional setting (such as the military). The ubiquitous presence of fatigue has caused the topic of fatigue to sprout in specific research fields such as sport science, exercise physiology, cognitive psychology, medicine and engineering.

Exercise-induced fatigue is defined as an acute impairment of exercise performance that includes both an increase in the perceived effort necessary to exert a desired force or power output, and the eventual inability to produce that force or power output. It can be approached from different angles. Peripheral fatigue is usually described as an impairment located in the muscle and characterized by a metabolic end point, while central fatigue is defined as a failure of the central nervous system to adequately drive the muscle. Central fatigue can be caused by metabolic, circulatory, neurochemical and/or thermodynamic changes of the cerebral homeostasis.

Mental fatigue is defined as a psychobiological state induced by prolonged exertion that has the potential to reduce performance. It can manifest subjectively, behaviourally and physiologically. Subjectively, increased feelings of tiredness, lack of energy and a decrease in motivation and alertness have been reported. Behaviourally, mental fatigue is recognized as a decline in performance (accuracy and/or reaction time) on a cognitive task. Finally, alterations in brain activity have shown to be a physiological manifestation of mental fatigue. Mental fatigue causes a decline in endurance performance (decreased time to exhaustion and self-selected power output/velocity or increased completion time), associated with a higher than normal perceived exertion. Maximal strength, power, and anaerobic work were however not affected by mental fatigue. This led to the conclusion that duration and intensity of the physical task appear to be important factors in the decrease in physical performance due to mental fatigue. It remains however elusive how mental fatigue originates. Over the recent years several hypotheses have been put forward, such as a depletion of brain energy, an accumulation of adenosine in several brain regions, changes in brain neurotransmitter concentrations. One potential counter measure for mental fatigue appears to be caffeine ingestion or mouth rinsing, but further research is required to substantiate the preliminary research findings.

AUTHORS

Bart Roelands (1)
Romain Meeusen (2)
Jeroen Van Cutsem (1)

(1) Vrije Universiteit Brussel (Belgium); (2) VrijeUniversiteit Brussel (Brussels, Belgium)

TS17.
ANSWERS FROM THE LAB, FIELD, AND FRONTLINES: A HOLISTIC APPROACH TO MAXIMIZING 21ST CENTURY SOLDIER HEALTH AND PERFORMANCE

#ABS114

FEBRUARY 11, 2020

RECOVERY SCIENCE: UTILIZING EMERGING TECHNOLOGIES AND TOOLS TO OPTIMIZE RECOVERY AND ENHANCE SHORT TERM AND LONG TERM TACTICAL PERFORMANCE

Daily demands on the tactical operator include physical, mental, emotional, social, and environmental stressors all of which have both acute and chronic impacts on performance and holistic health and wellness. Traditionally, mainly physical demands are accounted for when balancing training loads and recovery needed for proper adaptation to optimize readiness for the next day, week, or month. Through the recent emergence of physiological monitoring, such as sleep tracking, heart rate / heart rate variability, blood based biomarkers, a deeper level of understand of holistic stress and recovery from that stress is not only possible, but commercially available and scalable. But this is only part of the equation with understanding of the recovery-stress state comes the question, what do we do with that information? This is where Recovery Science fits into the equation, which includes any modality that positively recovers the tactical operator from the from training, operations and life, ranging from simple active recovery to transcranial magnetic stimulation therapy. This session will discuss both common and next-generation recovery modalities, and the intricate link to physiological monitoring with the goal to allow for prescriptive training, nutrition, and recovery for optimized short term and long term performance, health, and wellness.

AUTHORS

Josh Hagen (1)

(1) Rockefeller Neuroscience Institute (United States)

OBJECTIVE AND SUBJECTIVE ASSESSMENTS AND THEIR INFLUENCE ON THE DECISION-MAKING PROCESS.

Today most people are purely leaning on physical outcomes and parameters when making decisions about training for professional soldiers. Several test batteries, work demands, and training models have been developed. Unfortunately, many of these do not consider the variations in exertion and stress the soldiers have in their daily life. As Kiely (2018) stated, most periodization models are based on a stimulus-response model, and that all respond in a similar fashion and sequence to the stimuli. Such models do not consider the soldiers work-schedule, or the individual differences in their physical and mental recovery status. Flexible periodization (FP; Kraemer and Szvivak, 2012) may offer a solution to the problem by allowing the soldier and practioner to determine a training stimulus appropriate to the moment and individual. It is also important to discuss the practicallity of this process and how to leverage technolgy for assistance.

AUTHORS

Rob Hartman (1)

(1) BridgeAthletic (United States)

(*inspired by Paul Solberg Ph.D)

ANCHORING STRENGTH & CONDITIONING PHILOSOPHY WITHIN AN ORGANIZATION

Every day the Royal Netherlands Army contributes to peace, security and freedom. Under all circumstances, day and night. Thats why we continuously work to improve our organization, our knowledge and our material. We push on where others stop and that means that everything must be in perfect condition. This of course also applies to ourselves. How do we ensure that we are in tip-top physical en mental condition?

That is the tasks of the Physical Training and Sports Organization (LO&Sport). The objective of LO&Sport is to prepare every soldier physically & mentally for his or her operational task. And to make sure that everyone remains deployable throughout their military career. Fit for life, fit for function, fit for action.

All Royal Netherlands Army units, both training units and operational units, have their own LO&Sport group, with qualified instructors and first class accommodation. LO&Sport consists of 250 people and is managed from Training Command in Amersfoort. The LO&Sport School is also located there, and is where our sportinstructors receive their initial PT instruction course and specialist courses.

Until 2017, these PT Training Courses were based on an outdated doctrine publication (similar to US Army FM 7-22). That is why we introduced the NSCA literature as our new 'training bible'. This has been the starting point for the implementation of the S&C philosophy within the Dutch Army. The path that we are walking, in anchoring science, can serve as an example for others.

So how do you bridge the gap between science and practice? In science, usually, accuracy prevails over speed. Where the practitioners just want something that works and takes little time, but above all something that does not disturb their daily routine. Can a system be created in which these conflicting interests can go together harmoniously? Ultimately, we all serve the same purpose, a soldier who is physically and mentally in top condition.

AUTHORS

Luuk Nissen (1)

(1) Royal Netherlands Army (Amersfoort, Netherlands)

SIMPLICITY AS THE PLATFORM FOR COMPLEXITY: PRINCIPLE BASED TRAINING INNOVATIONS FOR THE MODERN WARFIGHTER

Ironically, either the presence or #ABSence of advanced training and tracking technology within tactical performance settings can lure coaches toward the abandonment of foundational training principles. These principles include individuality, specificity, overload, progression, diminishing returns, and reversibility. Programming, whether within an environment of technological feast or famine, needs to diminish or eliminate the gap between a soldiers current capabilities and the impending demands of mission critical tasks. The application of timeless principles of strength and conditioning reduces the negative performance effects of fatigue and yields a more physically resilient warfighter who can demonstrate his or her skills more proficiently. A sound approach to training maximizes the advantages of technological advancements and also decreases the disadvantages of limited equipment, space, or adequate coach to athlete ratios. Effective innovation can be as much tactical as it is technological. Resourceful coaches leverage both tactics and technology to assess soldier physicality and physiological requirements of their mission, and successfully train the former to achieve the latter. It is not enough for warfighters to be available. They must evolve along a continuum from available to masterful, and doing so requires a solid physical platform on which to display their skills.

AUTHORS

Nathan Palin (1)

(1) NSCA (Colorado Springs, United States)

PROPOSED STRATEGIES FOR TRANSLATING MULTIMODAL DATA STREAMS IN HUMAN PERFORMANCE

The recent proliferation of the consumer market for wearables has flooded the human performance community, making the collection of inordinate amounts of health and performance data attainable yet cumbersome. Often perceived as a burden in strength and conditioning environments, particularly those with little to no resources (e.g., staffing) available to devote towards data management, alternative strategies must be considered. As such, tactical communities may effectively utilize the wealth of pertinent data available to them. However, deciding not only how to manage that data, but what data to manage and how to present those data to end users is abundantly more important than ensuring your appropriate population is equipped with the newest wearable. Now that data streams are arriving from a multitude of sources external/internal workloads, subjective stress states, nutrition, and recovery to name a few a means of synchronizing and aggregating those data into one centralized location is crucial. What is even more crucial is analyzing and interpreting the data in a timely manner so that end users can effectively apply whatever implications may arise. Consequent to advancements in technology, we no longer operate in a world where health and performance reporting should not be happening immediately subsequent to assessment. At the Rockefeller Neuroscience Institute, we utilize the skills and knowledge of our human performance scientists and data analysts to aggregate and collate subjective and objective data from numerous sources in athletic, military, clinical, and general populations. The vehicle that allows our team to reach our end users (e.g., practitioners, warfighter, athlete) is Smartabase, which we use to not only import virtually any and all data we have access to but also store and visualize multimodal data streams. For the end user, the emphasis when working in this domain must then transition to the visualization strategies as aggregating multimodal data is useless to a coach if a researcher is not able to effectively translate and report any applicable findings. Proper data queries that are dictated by relevant questions posed by our end users are then executed by our team. This methodical approach allows us to collectively make informed decisions in both the larger (e.g., team or squad gross deficiencies) and smaller (e.g., individualized profiling and training) scaled problem spaces, ultimately in an effort to augment human performance and thus organization or team performance.

AUTHORS

Jason Stone (1)
Andrew Thompson (1)
Josh Hagen (2)

(1) WVU Rockefeller Neuroscience Institute (Morgantown, United States); (2) WVU Rockefeller Neuroscience Institute (Cincinnati, United States)

EMBEDDING THE COGNITIVE ELEMENT INTO SOLDIER TRAINING AND TESTING PARADIGMS

Tactical operations often involve intense physical exertion. Traditionally, Soldiers undergo extensive fitness training and testing to prepare for these endeavors; however, many units either neglect the cognitive domain or treat it as a second-tier necessity. From the Warfighters perspective, one could argue major deciding factors across most combat operations rely heavily on the mental domain: from attention and emotion regulation-driven environmental perception to task-relevant information processing/timely decision-making and subsequent cyclic acts of shooting, moving, and communicating. Each of these skills, and the effectiveness/efficiency with which they are executed, are the direct result of neurophysiological integration across the intersection of perception, cognition, and skilled motor actions. Furthermore, each of these aspects can be evaluated to forecast real-world performance; moreover, they can be enhanced through employing validated techniques in applied cognitive neurosciences, sport psychology, and psychophysiological biomonitoring. By disseminating targeted, practical application methods that seek to characterize, predict, monitor, and optimize the operator, this talk addresses an important and commonly-overlooked keystone, the mental side of Soldier performance. Failing to account for the cognitive domain in training and testing can result in an imbalanced force thats ill-prepared to maintain tactical overmatch against near-peer and peer-plus adversaries.

This talk will outline several methodologies for incorporating the cognitive domain into testing and training paradigms. For example, tactical stressors and traditional cognitive tasks can be programmatically selected and intermingled to enhance realism and analytical value, enabling more accurate performance predictions while promoting more positive, real-world operational transfer. Moreover, secondary cognitive task loads can be imposed to assess true motor skill expertise and identify areas in need of improvement. Furthermore, implicit learning paradigms can be utilized to acquire skills that are both more resource efficient and more resilient to operational stressors. Additionally, assessing and tracking subjective and objective psychometrics and biomonitoring markers can provide insight into the modulation of individual and team capacity over time. These examples, along with other valuable techniques and tools, will be elucidated to the audience.

AUTHORS

Andrew G. Thompson (1)

(1) Rockefeller Neuroscience Institute (Morgantown, United States)

LOAD EFFECTS ASSESSMENT PROGRAM MOBILITY, LETHALITY AND SURVIVABILITY (LEAP MLS) VARIANT: INTEGRATION OF LETHALITY AND SURVIVABILITY METRICS INTO A MILITARY OPERATIONAL TEST PLATFORM

Previous research involving the Load Effects Assessment Program (LEAP) tool has provided operationally relevant mobility related timing data, enhancing our understanding of how the equipped Soldier moves. Previous simulated marksmanship performance research showed sensitivity to clothing/equipment encumbrance, threat order exposure and fatigue. However, with Lethality prioritized by the US Army, program offices desired the ability to capture a holistic/integrated measure of lethality and Soldier performance (i.e., mobility, lethality and survivability). To meet this need, a variant of LEAP was developed (LEAP MLS). This study is a first step in developing a methodology that incorporates objective measures of varying types of mission performance and is sensitive to changes in Soldier-system equipment.

Twenty active duty Soldier volunteers executed the course in three levels of encumbrance (unloaded, minimal weight/bulk (rifleman), maximal weight/bulk (grenadier)), during a repeated measures experiment. Volunteers were instructed to transverse the course as quickly as possible, while maintaining tactical discipline in their movements. Mobility tasks include climbing, running, casualty drags and crawls. Completion time was the primary mobility measure. Lethality tasks included static and dynamic integrated shooting engagements, which included cognitive decision-making (go/no-go) and threat discrimination tasks. Lethality measures across the marksmanship process included accuracy, precision, weapon handling stability, acquisition/engagement times, and decision-making. Survivability was assessed via quantification of threat elimination and body exposure during engagements.

Overall course completion time was significantly slower for both the min and max configurations than unloaded ($p < .0001$), but not different from each other. During the static marksmanship task, precision, trigger control, and vertical stability performance was significantly worse in the unloaded configuration ($p<.05$) as compared to the min/max configurations, which were not different from each other. During the integrated dynamic marksmanship, shooting stability was significantly better in the unloaded compare to the min/max configurations at specific obstacles in the course requiring standing unsupported positions ($p<.05$) but the inverse was found for the prone/standing supported positions ($p<.05$). Threat elimination (survivability via correct engagement of threats) was reduced in the max-configuration compared to the other configurations ($p<.05$).

These findings indicate the LEAP tool can be enhanced with supplemental lethality relevant tasks and still keep its benefits as a comprehensive and sensitive mobility test for product assessments. Future analysis efforts will work towards development of a weighted index for each component (i.e. mobility, lethality, and survivability), standardizing performance interpretation during CIE product tradeoff assessments and course metric validation.

AUTHORS

Stephanie A. T. Brown (1)
Blake Mitchell (1)
(1) CCDC Soldier Center (Natick, United States)

TS24.
LOAD EFFECTS ASSESSMENT PROGRAM (LEAP) – ASSESSING DISMOUNTED SOLDIER PHYSICAL PERFORMANCE

#ABS023

ISOLATED AND COMBINED EFFECTS OF MASS, BULK AN STIFFNESS OF CLOTHING AND EQUIPMENT ON LEAP PERFORMANCE USING A NEWLY DEVELOPED CLOTHING & EQUIPMENT CHARACTERISTICS SUIT

PURPOSE

Soldiers, firemen, police officers and other first responders are required to conduct tasks and operations in physically demanding situations. Physically demanding situations require good mobility. Soldiers and first responders mobility can be impaired by any worn personal protective clothing/equipment (PPCE). When assessing the effects of PPCE on mobility, three characteristics of PPCE of importance can be identified: mass, bulk and stiffness.

AIM

The aim is to isolate PPCE characteristics mass, bulk and stiffness and evaluated the effects of these properties on load effects assessment program (LEAP) obstacle course performance using a specifically designed suit that allows isolated alteration of PPCE characteristics.

METHODS

Nine male military subjects performed the LEAP obstacle course while wearing 7 different configurations: control, 10 kg mass, 30 kg mass, 20 liter bulk, stiffness 1, stiffness 2 and a mix of 10 kg mass, 20 liter bulk and stiffness 1. Total LEAP time, completion time per obstacle and heart rate were measured. Prior to LEAP execution range of motion of several joints were measured, while after LEAP execution vertical jump height and rate of perceived exertion (RPE) were assessed. A repeated measures ANOVA was performed to detect differences, followed by LSD post hoc test with an adjusted p-value of 0.01 to identify significant differences.

RESULTS

All configuration resulted in a slower total LEAP time (p value < 0.05) compared to control, except for configuration stiffness 1. Mean course completion time varied between 243.8 s ± 22.0 for the control condition and 366.8 s ± 46.9 for the condition with a load of 30 kg. The objective internal load (heart rate) did not differ significantly between configurations ($p>0.05$), while subjective internal load (RPE) of configurations 10 kg, 30 kg and mix was significantly higher compared to control ($p < 0.05$).

CONCLUSIONS

The results of this study show that it is possible to achieve isolated variation of PPCE characteristics mass, bulk and stiffness using the agility suit. We also show that mass, bulk and stiffness all have an individual negative effect on LEAP performance, but that none of the PPCE characteristics increase the heart rate during performance of the LEAP.

OPERATIONAL RELEVANCE

The results of this study will elucidate the underlying contributions of individual clothing and equipment properties on mobility and physical operational performance. Findings can be used to model and identify interventions in equipment fit and design that positively influence operational performance and effectiveness.

AUTHORS

Kaj Gijsbertse (1)
Lotte Linssen (1)
Arend Woering (1)
Milene Catoire (1)

(1) TNO Human Factors (Soesterberg, Netherlands)

THE EFFECT OF SOFT ARMOUR COVERAGE AND FATIGUE ON SOLDIER PERFORMANCE DURING THE LOAD EFFECTS ASSESSMENT PROGRAM (LEAP)

BACKGROUND/PURPOSE

Increased soft armour coverage may lead to decrements in the performance of military tasks. The study aims to investigate if soft armour coverage affects the performance of Canadian soldiers completing the Load Effects Assessment Program (LEAP) and whether performance is hindered following a fatiguing protocol.

METHODS

A total of 30 male regular force Canadian Armed Forces members with an average (standard deviation) age: 24.5 (±4.5) years; height: 1.78 (±0.1)m; weight: 85.8 (±13.2)kg were recruited. LEAP consists of 10 obstacles including; tunnel and hatch, sprint, stairs and ladder, agility run, casualty drag, windows, bounding rushes, balance beam, crawls, and walls in addition to ancillary and marksmanship tasks. Participants completed 14 LEAP runs; 4 familiarization (Karakolis et al., 2017) and 2 runs for each of 5 armour coverage levels. Each testing run took place before and following a 5 km march on a 400m track carrying a 10kg weighted backpack. Armour conditions included; in-service; in-service+, equivalent coverage to in-service with increased fabric layers; narrow, in-service without side protection; short and wide, in-service without shoulder protection and shorter torso coverage and plate carrier, without side or shoulder protection. Each armour condition was equivalent in weight for the same size of vest. Two way general linear models with repeated measures on armour and fatigue was applied to total LEAP completion time and obstacle time using a significance of =.05.

RESULTS

There was a main effect of fatigue on total time to complete the LEAP course ($p=0.0008$). Participants took an additional 32.0 seconds to complete the LEAP obstacles following the march. There was a main effect of fatigue on 6 obstacle times including, agility, balance beam, casualty drag, crawls, tunnel and hatch and sprint ($p<0.0245$) where participants look longer to complete each obstacle following the 5km march. There was no main effect or interaction effect of armour condition on any dependent variable.

CONCLUSIONS

A fatiguing 5km march reduces LEAP performance while soft armour coverage of equivalent weight and used in conjunction with a load carriage system does not impact LEAP performance.

OPERATIONAL RELEVANCE

Soft armour coverage, normalized by weight and used with a load carriage system with greater coverage than the armour, does not result in a loss of performance in operationally relevant mobility tasks.

AUTHORS

Kristina Gruevski (1)
Ryan Graham (1)
Thomas Karakolis (2)
Andrew Morton (3)
Linda Bossi (2)

(1) University of Ottawa (Canada); (2) Defence Research and Development Canada (Toronto, Canada); (3) HumanSystems Inc. (Guelph, Canada)

REFERENCE

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LOAD WEIGHT, BULK AND STIFFNESS PARAMETERIZATION OF SOLDIER BODY-BORNE EQUIPMENT: EFFECTIVE PREDICTORS OF COMBAT MOBILITY?

Significant knowledge gaps persist with respect to the effect of soldier equipment on operational task performance. Body-borne equipment is often parameterized by three factors: load weight, bulk, and stiffness. Load weight refers to the skin-out weight and load distribution carried by a solider; Bulk is defined as the additional spatial volume of equipment; and Stiffness refers to the malleability or elastic properties of material and/or equipment. These parameters can be difficult to isolate, parameterize, and quantify the effects on combat mobility.

PURPOSE

The objective was to quantify the effects of load weight, bulk, and stiffness measures of body-borne equipment on soldier combat mobility.

METHODS

This analysis uses data from a study conducted on the Canadian Load Effects and Assessment Program (LEAP) combat mobility course. LEAP evaluates decrements in sequential timed mobility tasks to quantify the performance differences due to soldier equipment. Baseline measures of soldier participants and body borne equipment were obtained, including 3D body scans, load weight, and stiffness measures of equipment material. Principal component analysis was conducted to down-sample the potential regressors. Step-wise regression analysis was conducted to quantify relationships between load weight, bulk, and stiffness measures of equipment, participant anthropometric, strength, fitness, and range of motion characteristics, and LEAP performance.

RESULTS

Overall equipment weight and bulk measures were highly correlated across the soldier equipment levels. Higher equipment weight and/or increased bulk metrics were equivalently associated with decrements in LEAP performance. In particular, increased completion times were observed for the overall course and the stairs-ladder, bounding rushes, and crawl obstacles with increasing load weight and bulk metrics. Individual soldier capabilities, specifically, estimated V02 max, maximum jump capability and participant stature, were also important determinants of LEAP performance. Differences in stiffness measures were not found to be related to LEAP performance.

CONCLUSIONS

Measures of equipment weight and bulk were equally predictive of soldier combat mobility. Further investigation is necessary to quantitatively parameterize equipment with sufficient fidelity to effectively differentiate in terms of combat mobility.

OPERATIONAL RELEVANCE

Knowledge from objective measures of encumbrance (equipment weight, bulk) that are sensitive to differences in body-borne equipment and predictive of soldier combat mobility will inform equipment design and evaluation.

AUTHORS

Monica Jones (1)
Linda Bossi (2)
Lois Sy (2)
Alison Kelly (3)
David Tack (3)

(1) University of Michigan (Ann Arbor, United States); (2) Defence Research and Development Canada (DRDC) (Toronto, Canada); (3) Human Systems Inc. (Guelph, Canada)

EFFECT OF LOADED MILITARY OPERATION ON SOLDIERS PHYSICAL PERFORMANCE

PURPOSE

Overloading from load carriage, combined with prolonged duration of foot marches during military operations, can lead to muscular fatigue and musculoskeletal injuries to the trunk and lower extremities. This can inhibit soldiers performance and fighting capability at the frontline1. Therefore, the aim of this study was to investigate the effects of loaded military operation on Royal Brunei Armed Forces (RBAF) infantry soldiers physical performance during a prolonged military activity.

METHODS

Thirty-five male soldiers (age: 23±4years; height: 1.63±0.05m; weight: 62.4±9.51kg) completed a 19 hours planned operation while carrying their individual military load carriage system (load mass: 26.21±3.23kg). The operation was divided into four phases, which included marching on foot in tactical formation to various jungle locations, counter-attacking enemy positions, digging activity to secure a defense area and tactical assault in urban settings. Parameters collected were hand grip (HG), vertical jump (VJ) and plank performance, which were collected prior to the activity (pre-trial), during the activity at two sampling points (SP1 and SP2) and after the activity (post-trial). Data collected at SP1, SP2 and post-trial were compared with the pre-trial data using paired sample t-test.

RESULTS

There was a statistically significant increase in the VJ performance at SP1 (50±8cm vs 49±7cm, $p<0.05$) and a decrease at post trial (46±7cm, $p<0.05$). Compared to pre-trial, plank performance was significantly reduced in each of the three time points (pre-trial: 193±61s, SP1: 127±60, SP2: 152±76s, post-trial: 123±66s, $p<0.05$). No statistically significant changes were seen in HG performance (pre-trial: 36±6kg, SP1: 34±8kg, SP2: 35±9kg, post-trial: 35±8kg).

CONCLUSION

The results suggest that the loaded military activity conducted had induced a general decrease in the physical performance of the soldiers trunk and lower limbs muscular power, strength and endurance. Consequently, the data provides a benchmark for changes in RBAF soldiers physical performance during a prolonged military operation which was not readily available before.

OPERATIONAL RELEVANCE

This study has provided input on the current state of RBAF soldiers physical performance during prolonged loaded military operations. It will also assist military operations planner to plan the sustainability of soldiers performance according to their military activity during operations more effectively in order to maximize their combat performance.

AUTHORS

Dr Dayangku Nurhayatul Filzah Pengiran Damit (1)
Michelle Charlene Basir (1)
Nursazwilla Rosdie (1)
Rosmarie Prabhakaran (1)
Noreffendy Ali (1)

(1) Performance Optimisation Centre, Royal Brunei Armed Forces (Brunei)

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TS24.
LOAD EFFECTS ASSESSMENT PROGRAM (LEAP) – ASSESSING DISMOUNTED SOLDIER PHYSICAL PERFORMANCE

#ABS403

FEBRUARY 11, 2020

IMPACT OF LIGHT-WEIGHT HARD ARMOUR SYSTEMS ON MARINE MOBILITY PERFORMANCE

PURPOSE

The U.S. Marine Corps needed to compare the mobility effects of lighter, less protective hard armor plates to the current Enhanced Small Arms Protective Insert (ESAPI) system to determine if Marines could perform combat mobility tasks faster with the Light Weight Plates (LWP). The results of this study were used as input to a subsequent vulnerability study to determine if Marine survivability is sufficiently improved by the mobility benefits of lighter plates, despite the lower protection levels.

METHODS

Twenty-nine (29) Marines participated in evaluating four levels of armour protection using the Marine Corps Lead Effects Assessment Programs (MCLEAP) instrumented obstacle course and a separate series of maximum capacity sprints based on select obstacles from the LEAP course. Armour conditions, with a standard assault load, included ESAPI (soft armour with ESAPI plates), Light Weight Plates (LWP in place of the ESAPI plates), No Plates (soft armour with no plates), and No Armour (jungle rig with no armour). Mobility testing was performed in two states: fatigued and unfatigued. The fatigued state included a pre-fatiguing protocol that consisted of a four-kilometer hike at patrolling pace while wearing a weighted assault pack with included upper body exercises enroute.

RESULTS

The LWP condition resulted in improved mobility over the ESAPI condition as evidenced by faster times for total MCLEAP course time and select obstacle times in both unfatigued and fatigued states. The general pattern of results was consistent with subjective Marine reporting. The performance detriment of the ESAPI as compared to the LWP is particularly evident in the fatigued state under sustained capability testing. Marines were less affected in their maximum capability performance by the armour conditions and, while there were statistically significant differences, the associated differences in time were small.

CONCLUSIONS

A lighter hard armour plate system improved Marine mobility performance over the in-service, heavier ESAPI plate system. Pre-fatiguing Marines increased the sensitivity of the LEAP course to the effects of the hard armour differences. Marines can overcome load effect differences in very short-burst, high intensity efforts but in sustained effort the equipment configuration has a significant and meaningful impact on performance.

OPERATIONAL RELEVANCE

Marine and soldier mobility performance can be significantly improved by targeted weight reductions in component areas of the combat load, even though those #ABSolute reductions may appear small in relation to total system weight.

AUTHORS

David Tack (1)
Andrew Morton (1)
Edward Nakaza (1)
Mark Richter (2)

(1) Humansystems Incorporated (Guelph, Canada); (2) U.S. Marine Corps, Marine Corps Systems Command (Quantico, United States)

TS30. FEEDING FEMALE SOLDIERS

#ABS242

FEBRUARY 11, 2020

ENERGY AVAILABILITY OF OFFICER CADETS DURING BRITISH ARMY TRAINING

PURPOSE

Optimal energy availability (EA) is when sufficient energy is available after physical activity energy expenditure (PAEE) to support all body functions that underpin health, adaptation to training, and optimal performance. EA is expressed relative to Fat Free Mass (FFM) and can be categorised as reduced EA (30-45 kcal·kgFFM·day-1) or low EA (<30 kcal·kgFFM·day-1). Low EA has been associated with impaired health and performance, through a reduction in Energy Intake (EI) and/or increased Energy Expenditure (EE). The aim of this study was to investigate EA of Officer Cadets during one week on camp and one week on exercise.

METHODS

Eleven Officer Cadets (mean ± SD: age 24 ± 2 years, height 1.80 ± 0.08 m, body mass 77.3 ± 10.3 kg) volunteered to undertake measurements of EI and EE during ten days on camp (CAMP) and five days during a field exercise (FEX). In each setting, tri-axial accelerometers (GENEActiv, UK) were used to estimate Total Daily EE (TDEE) and researcher-led dietary weighing was used to estimate EI. PAEE was calculated by subtracting each participants estimated basal metabolic rate and thermogenic effect of food from their TDEE. EA was calculated using the following equation; EA={EI [PAEE (TDEE PAEE)]}/FFM. Differences in variables between training weeks were compared using paired sample t-tests, with significance set at $p<0.05$.

RESULTS

EA was higher during CAMP compared to FEX (54 ± 10 vs. 25 ± 13 kcal·kgFFM·day-1, $p<0.001$); on average, participants were in optimal EA during CAMP, and were in Low EA during FEX. PAEE and TDEE were higher in FEX compared to CAMP (PAEE: 2964 ± 563 vs 2422 ± 588 kcals·d-1 and TDEE: 4842 ± 721 vs 4493 ± 795 kcals·d-1, $p<0.05$), whereas EI was lower (2632 ± 890 vs 2726 ± 828 kcals·d-1, $p<0.05$).

CONCLUSION

Low EA during a five-day FEX was likely due to higher PAEE and lower EI compared to 10-days in CAMP. During military training, personnel often complete periods of intense exercise leading to high EE that they are unable to match with EI, leading to insufficient EA.

OPERATIONAL RELEVANCE

The importance of identifying low EA, with a view to protecting the health and performance of athletes, is being increasingly recognised. Identifying periods of reduced-and low-EA could inform strategies to improve soldier health, adaptation to training, and performance.

AUTHORS

Victoria Edwards (1)
Sam Blacker (1)
Steve Myers (1)
Andy Siddall (1)
Sarah Needham-Beck (1)
Steve Powell (1)
Sarah Jackson (2)
Julie Greeves (2)
Sophie Wardle (2)
Sam Blacker (1)

(1) Occupational Performance Research Group (Chichester, United Kingdom); (2) Department of Army Health and Physical Performance Research (Andover, United Kingdom)

RELATIVE ENERGY DEFICIENCY IN SOLDIERS: A PERSPECTIVE ON LOW ENERGY AVAILABILITY IN THE MILITARY

PURPOSE

Relative Energy Deficiency in Sport (RED-S) is a syndrome that encompasses the health and performance consequences of low energy availability (energy intake minus exercise energy expenditure) in athletes. We propose that the severe energy restriction experienced by military personnel during combat training and operations may similarly have a negative impact on their endocrine function, and reproductive and bone health. This review summarises the evidence for energy deficit in military training and on operations, and associated effects on health and performance outcomes, which we term Relative Energy Deficiency in Soldiers.

METHODS

Published literature on energy deficiency in, and endocrine responses to, military training and operations were retrieved from PubMEd and Google Scholar databases.

RESULTS

Energy expenditure measured by doubly labelled water reaches ~6500 kcald-1 in men and ~5500 kcald-1 in women during military training. Studies that have also measured energy intake or body composition changes with DXA report severe (up to ~4000 kcald-1) and/or prolonged energy deficits (up to 8 weeks). Arduous military training in energy deficit impairs endocrine and metabolic function (adrenal, thyroid, reproductive and somatotropic hormones), bone turnover, immune function, gastrointestinal health, iron status, mood, and physical and cognitive performance in men. Fewer studies have been performed in service women, but observational studies suggest that military training impairs iron status and disturbs menstrual function; the role of energy deficiency in these outcomes is not clear. Nutritional supplements maintain metabolic, endocrine and immune function, and physical performance.

CONCLUSIONS

Military training and operations can result in periods of severe and/or prolonged energy deficit that likely impair health and performance. More research is required to understand the role of low energy availability in endocrine, metabolic and immune function, and physical performance in soldiers, and how energy availability can be estimated in this free living, multi-stressor environment.

OPERATIONAL RELEVANCE

Energy deficit should be avoided where possible in military training and operations to protect the health and performance of soldiers. Supplementation with additional energy during military training can prevent disturbances in metabolic, endocrine and immune function, and physical performance, but energy deficits can occur even with the provision of adequate energy.

AUTHORS

Julie Greeves (1)

Thomas O'Leary (1)

(1) UK MOD (Andover, United Kingdom)

TS30. FEEDING FEMALE SOLDIERS

#ABS120

FEBRUARY 11, 2020

FEEDING FEMALE SOLDIERS TO OPTIMISE BONE HEALTH AND PHYSICAL PERFORMANCE

PURPOSE

Maintaining bone health and avoiding injuries is paramount for optimizing Warfighter physical performance. Stress fracture, an injury associated with unaccustomed activity and overuse, affects female military personnel at up to four times the frequency of male military personnel during initial military training (IMT). Nutrition is a component of bone health, as recent studies have demonstrated the relationship between dietary intake, nutritional status, and stress fracture incidence. The purpose of this presentation is to review recent studies linking nutrition and bone health in military personnel, with a focus on stress fracture and sex differences in nutrient requirements.

METHODS

Randomized controlled trials exploring the relationship between dietary intake, nutritional status, and stress fracture in military personnel during IMT will be reviewed and presented.

RESULTS

Studies have demonstrated that nutritional status, including iron and vitamin D status, is linked to the incidence of stress fracture. Further, supplemental calcium and vitamin D may protect against stress fracture and optimize bone health during IMT. In the case of some nutrients, such as iron, requirements are different between male and female military personnel.

CONCLUSIONS

Optimal nutrition is critical for the maintenance of bone health and the avoidance of stress fracture during IMT. There are sex differences in the incidence of stress fracture and nutrient requirements during military training.

OPERATIONAL RELEVANCE

Nutrition is a key factor for preventing injury and optimizing Warfighter physical performance. Sex differences in the incidence of injury and nutritional requirements should be considered when forming garrison and operational feeding programs.

AUTHORS

James McClung (1)

(1) US Army Research Institute of Environmental Medicine (Natick, United States)

TS30. FEEDING FEMALE SOLDIERS

#ABS189

FEBRUARY 11, 2020

FEEDING FEMALE SOLDIERS DURING ENERGY DEFICIT

BACKGROUND

Severe energy deficits resulting from increases in energy expenditure and insufficient energy intake are common during military operations. In male Soldiers, energy deficits lead to declines in body and skeletal muscle mass, as well as physical performance. Though responses to energy deficit during military operations have been well characterized in male Soldiers, less is known regarding the impact on female Soldiers.

PURPOSE

Discuss differences in response to energy deficit during military operations between males and females.

METHODS

Review of literature assessing sex differences in response to military operations and energy deficit.

RESULTS

During 54-h US Marine training energy expenditures in males (25.7 ± 0.8 MJ·d-1) were higher ($P < 0.05$) than females (19.9 ± 0.6 MJ·d-1). Similarly, energy intake was higher ($P < 0.05$) in males (6.0 ± 2.0 MJ·d-1) compared to females (4.8 ± 1.8 MJ·d-1). However, there was no difference in energy deficit (~77% total energy needs), nor was there a difference in physical activity level in males (3.4 ± 0.5) compared to females (3.3 ± 0.4). Following a 7-d Norwegian Ranger training, a greater loss in fat-free mass (FFM) was observed in males (-4.0 ± 1.2 kg) compared to females (-2.5 ± 1.1 kg). There was no difference in loss of fat mass between males (-3.5 ± 0.7 kg) compared to females (-3.4 ± 0.2 kg). Despite the lack of difference in losses in fat mass, females oxidized more ($P < 0.05$) fat (7.3 ± 0.5 mg·min-1·kg FFM-1) for fuel during the training operation compare to males (5.2 ± 1.0 mg·min-1·kg FFM-1).

CONCLUSION

Though limited literature is available on sex difference responses to military operations and energy deficit, results from these past studies suggest that males and females experience similar degrees of energy deficit during military operations. Greater fat oxidation in females compared to males may suggest different feeding strategies may be required based on sex.

OPERATIONAL RELEVANCE

Females are becoming more integrated into combat operations. Having a clear understanding of the impact of operational stress females body composition and substrate oxidation is critical in making appropriate fueling recommendations to optimize their physical performance on the battlefield.

AUTHORS

Lee Margolis (1)

Stefan Pasiakos (2)

(1) USARIEM (Natick, United States); (2) c (United Kingdom)

FEEDING FEMALE SOLDIERS TO OPTIMISE MUSCLE MASS AND FUNCTION

Protein feeding and resistance exercise are potent stimuli for muscle protein synthesis, and subsequently muscle remodelling / adaptation, mass and strength. Muscle mass and strength are important for performance of military tasks, including load carriage and lifting and carrying. Women typically have less muscle mass than men which becomes evident following puberty due to differences in hormone levels of estrogen and testosterone. With these known hormonal and anatomical differences between men and women, it is reasonable to question whether feeding strategies to enhance the muscle protein synthetic response, and thus military performance, should differ between sexes.

PURPOSE

To evaluate sex differences in muscle adaptation following protein feeding and / or physical training / exercise.

METHODS

A narrative review of literature evaluating sex differences in muscle adaptation following protein feeding and / or physical training / exercise.

RESULTS

To our knowledge no studies have yet directly compared the muscle protein synthetic response in men and women following protein feeding and / or resistance exercise training, and few studies have studied women. When correcting for lean mass, men and women typically demonstrate similar muscle protein turnover rates in basal conditions and in response to feeding and resistance exercise despite significantly lower levels of testosterone in women. Yet, more recent data suggest that women may require higher protein intakes than men (1.71 g·kg·d-1 vs. 1.20 g·kg·d-1 (1)) following variable intensity exercise to maintain whole body protein balance. Conclusion: Data are limited on sex differences in protein requirements for promoting muscle adaptation, particularly in response to military training. Extant data from studies conducted separately in men and women suggest that women may require higher protein intakes to maintain whole body net protein balance but further studies are required to directly compare sexes and in military relevant contexts.

OPERATIONAL RELEVANCE

With the recent full inclusion of women in all military roles across many Nations, and the known increased energy requirements / physical demands of combat employment, feeding strategies to support women serving effectively in these roles are essential. Understanding sex-specific muscle responses to nutrient intake will be important for the design of feeding strategies to optimise muscle mass and function in military personnel.

AUTHORS

Sophie Wardle (1)

(1) UK MOD (United Kingdom)

(1) Wooding et al. (2017) MSSE

1.1
MENTAL AND PHYSICAL RESILIENCE

#ABS273

FEBRUARY 12, 2020

EFFECTIVENESS OF THE ARMY NATIONAL GUARD (ARNG) RESILIENCE TRAINING

PURPOSE

This evaluation examines the association between ARNG Soldiers receipt of resilience training and levels of subsequent resilience.

METHODS

Levels of resilience and two measures of behavioral health (depression and anxiety) were collected via surveys of Soldiers completing their ARNG recruit sustainment programs (RSPs). RSP attendance is mandatory and introduces recruits with no prior military experience to military environments and the adjustments required for successful completion of basic combat training (BCT). RSP is executed in four phases Red (1st drill weekend), White (1st to final drill weekend), Blue (last day before shipping), and Gold (1st drill after BCT completion). Resilience training, a mandatory component of the program, is delivered during Red and Blue RSP phases.

Surveys were completed either before resilience training (during the Red or Blue Phases) or just before recruits were shipped to their final units (during the Gold Phase), starting in fiscal year 2019. Scores were grouped and compared by RSP phase using chi-square tests of significance and post-hoc tests for corrections.

RESULTS

Overall, 1,405 new recruits completed their first survey during one of the three phases: 39% were in the Red RSP phase; 31% were in the Blue phase; and 30% were in the Gold phase. The majority of respondents were male (75%) with a mean age of 21 years. Survey responses showed the following results:

Resilience: There was a statistically significant difference in the percentage of recruits scoring in the higher resilience quartiles between the baseline and the first drill following completion of BCT ($p = 0.0494$); with higher scores noted by the Gold Phase. A similar result was noted between the time of the drill just before shipping to BCT (Blue Phase) and the Gold Phase ($p = 0.004$).

Depression: The percentage of recruits reporting depression (mild, moderate versus none) was not changed between these time periods ($p > 0.05$).

Anxiety: The percentage of recruits reporting anxiety was statistically different between baseline and the blue phase ($p = 0.0028$) only.

CONCLUSIONS

Situational resilience of ARNG Soldiers can be measured; and notable changes in resilience can be observed following exposure to resilience training conducted during RSP. Depression and anxiety, which may be associated with resilience, were relatively stable.

OPERATIONAL RELEVANCE

Increased resilience positively impacts emotional and physical health, which in turn influences Soldier readiness. This study brings attention to the effectiveness of the ARNG resilience curriculum, which is not currently well documented.

AUTHORS

Marcus Jackson (1)
Shamola Dye (2)
Sequioa Roscoe (3)
Lanna Forrest (2)
Maisha Toussaint (4)
James Moore (5)
Jimmie Lucas (5)
Franklin Wright (5)
Phyon Christopher (2)
John Ambrose (2)

(1) US ARMY NG NGB (United States); (2) Defense Health Agency (United States); (3) ARNG (District of Columbia, United States); (4) Army Public Health Center (Maryland, United States); (5) ARNG (District of Columbia, United States)

1.1
MENTAL AND PHYSICAL RESILIENCE

#ABS269

FEBRUARY 12, 2020

MENTAL SKILLS FITNESS TRAINING FOR PEAK PERFORMANCE

PURPOSE

Army Physical Fitness Test (APFT) failure accounts for 30% of all Active Component Flags with negative impact to military readiness (Godfrey, 2019). Army occupational therapy has developed an evidence-based program integrating mental skills with unit fitness to improve readiness and resilience. Warfighters are trained in skills commonly used by elite athletes such as goal setting, mental imagery, positive self-talk and heart rate control, improving effort, control and focus. Optimal human performance requires a combination of skilled physical and mental training with mindset often providing the wining advantage.

METHODS

A mental skills training program was initiated with Soldiers from a large military treatment facility six weeks prior to the annual Army Physical Fitness Test (APFT). Soldiers trained in the four principles of mental skills for peak performance and given a Quick Reference Card (QRC) to reinforce weekly training. Mental skills training occurred once per week during regularly scheduled unit fitness. APFT scores following the mental skills training were compared to five previous APFTs of the same unit using one-way ANOVA test with post-hoc testing, including pairwise comparisons, using SPSS version 24.

RESULTS

APFT scores following mental skills training were 13-14 points higher than historical averages showing a statistically significant improvement $P=0.001$. Mean score of the post intervention group differed significantly from each of five previous iterations ($P<0.05$). Mental skills fitness training was recognized as quality training by participants with recognized carry over to other aspects of military life and recommendations to introduce this early in military training (Meyer, 2018).

CONCLUSION

Mental skill fitness training encourages physical and psychological fitness on and off the battlefield along with providing resilience skills needed throughout ones career. Easily incorporated into individual and unit-level training, implementation improved readiness standards with widespread acceptance.

OPERATIONAL RELEVANCE

Mental skills fitness training enhances Soldier performance by integrating principles of mental resilience into daily tasks and military culture. Just as elite athletes train mind and body for competition, the warfighter must acquire this skillset for optimal performance.

AUTHORS

Vanessa Meyer (1)

(1) Fort Belvoir Community Hospital, Fort Belvoir, US (Lorton, United States)

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THE PHYSIOLOGICAL EFFECTS OF A FIVE-DAY SPECIALIST POLICE TACTICAL TEAM SELECTION COURSE

PURPOSE

Specialist police tactical teams, like special operations military personnel, are tasked with dangerous, high risk missions which are beyond that of general police and military personnel and consequently, the selection courses for entry into these units are physiologically and psychologically demanding, designed to match the operational requirement of this job role. The aim of this study was to determine the physiological effects of a weeklong, intensive, specialist police selection course.

METHODS

A prospective cohort study was designed where data pertaining to 18 candidates was obtained during a five-day selection course for specialist police selection. Daily measures of weight, grip strength, sit and reach flexibility, vertical jump height and vertical jump power output were performed. Changes in these measures over the course were analyzed with a repeated measures ANOVA.

RESULTS

Eleven candidates finished the selection course. Over the course of the week there were significant ($p=0.006$) decreases in body weight of 2.05kg [95% CI=3.65-0.45], significant ($p<0.001$) decreases in grip strength of 14.48kg [95% CI=21.32-7.64] on the right and 14.27kg [95% CI=21.89-6.66] on the left and a significant ($p<0.001$) decrease of sit and reach flexibility of 6.64cm [95%CI=9.94-3.33] was found. Non-significant decreases in power output and peak jump velocity of 669.77W [95%CI = 1942.92 to 603.39] and 0.28m/s [95%CI=0.69-0.14], were also found with an overall increase in vertical jump height 6.09cm [95%CI =-6.08 to 18.79].

CONCLUSIONS

Significant decreases in body weight, grip strength, lower limb flexibility was observed, while smaller decreases in lower limb power output were evident in a grueling five-day specialist selection course.

OPERATIONAL RELEVANCE

This study highlights the declines in performance may be associated with an increased risk of injury during a five-day selection course. Health professionals working with police who are planning on attending selection courses should plan for these decreases and build redundancy in these areas to minimize their effect to decrease injury risk and maximize chances of success.

AUTHORS

Ben Schram (1)
Robin Orr (2)
Jeremy Robinson (3)

(1) Bond University (Robina, Australia); (2) Tactical Research Unit, Bond University (Robina, Australia); (3) Australian Federal Police, Specialist Response Group – Tactical Response Team (Canberra, Australia)

THE ROLE OF MENTAL RESILIENCE IN THE BIOPSYCHOSOCIAL EXPERIENCE OF PAIN IN MALE AND FEMALE MILITARY OFFICERS

PURPOSE

The biopsychosocial experience of pain could impact Service members abilities to train. As a first step, we compared relationships between mental resilience and pain interference with daily life in male versus female military Officers during secondary training (ST).

METHODS

Military Officers (n=626; male=547 (87.4%); female=79 (12.6%), 25±3 yrs) within two weeks of finishing a six-month ST course completed two items assessing mental resilience: Connor-Davidson Resilience Scale (CD-RISC) and Short Grit Scale (SGS), wherein higher scores indicate greater mental resilience. A modified Defense Veterans Pain Rating Scale (DVPRS) assessed pain during ST on a 0 (no pain) to 10 (as bad as it could be, nothing else matters) scale; pain interference with sleep, mood, activity, and stress were each rated 0 (does not interfere) to 10 (completely interferes) and averaged to calculate total pain interference score (PIS). Mann-Whitney U tests compared between-group differences in CD-RISC and SGS scores, pain, and PIS. Among those that reported pain, sex-specific Spearmans correlation analyses measured associations between PIS and mental resilience (i.e. CD-RISC and SGS scores).

RESULTS

Among Officers, 30% of males (n=166/547) and 32% of females (n=25/79) reported pain in the past six months. Average pain was 5.3±0.1 (range 1-9) and PIS was 3.1±0.2 (range 0-8). Pain was slightly lower in males (5.2±0.1, range 1-9) than females (6.0±0.3, range 1-8) (p=0.04). PIS was lower in males (2.9±0.2, range 0-8) than females (4.2±0.4, range 1-8) (p=0.01). CD-RISC and SGS scores were similar between males (CD-RISC=32.8±0.3, SGS=3.7±0.03) and females (CD-RISC=31.8±0.7, SGS=3.8±0.06) (p>0.05), and between those with pain (CD-RISC=32.6±0.3, SGS=3.7±0.04) and without pain (CD-RISC=32.8±0.4, SGS=3.7±0.04) (p>0.05). PIS and CD-RISC (=-0.20) and PIS and SGS (=-0.29) were significantly correlated in males (p<0.01) but not females (PIS and CD-RISC: =-0.30, p=0.15; PIS and SGS: =-0.01, p=0.96).

CONCLUSIONS

Males and females reported pain levels that interrupt usual activities during ST, and negative correlations of CD-RISC and SGS scores with PIS suggest that mental resilience may further impact the experience of pain during ST. The relatively small female sample size precludes sex-specific conclusions.

OPERATIONAL RELEVANCE

The experience of pain may be moderated by biopsychosocial characteristics, such as mental resilience, which could influence the ability to train during ST. Future studies should aim to identify factors in addition to resilience, such as sleep, nutrition, and stress, that could refine the biopsychosocial experience of pain and evaluate associated interventions to improve readiness.

AUTHORS

Emily Southmayd (1)
Amelia Barrett (1)
John Tra (2)
Carl Goforth (3)
Sarah de la Motte (4)

(1) Consortium for Health and Military performance, Department of Military and Emergency Medicine, F. Hebert School of Medicine, Uniformed Services University, Bethesda, MD, Henry M Jackson Foundation for the Advancement of Military Medicine (Bethesda, United States); (2) Consortium for Health and Military performance, Department of Military and Emergency Medicine, F. Hebert School of Medicine, Uniformed Services University, Bethesda, MD, Henry M Jackson Foundation for the Advancement of Military Medicine (Bethesda, United States); (3) Department of Surgery, F. Hebert School of Medicine, Uniformed Services University, Bethesda, MD, Naval Medical Research Center, Silver Spring, MD (Bethesda, United States); (4) Consortium for Health and Military performance, Department of Military and Emergency Medicine, F. Hebert School of Medicine, Uniformed Services University, Bethesda, MD (Bethesda, United States)

STRESS INOCULATION TRAINING, CAC CONDUCT AFTER CAPTURE TRAINING, CAN WE SUCCESSFULLY CREATE A HIGH STRESS TRAINING ENVIRONMENT? WHEN PARTICIPANTS KNOW IT'S COMING?

PURPOSE

Is CAC, conduct after capture training stressful? This study aim to evaluate biological stress markers and performance measures sensitive to stress, to validate CAC training on its effort to create intense stress on participants.

METHOD

Soldiers undergoing CAC were tested on stress hormone cortisol at baseline and during training. Cognitive performance was measured at baseline and after the exercise. A questionnaire evaluating the exercise was given after completion. Two groups were measured. The first group (A) were both sleep depraved and exhausted when taken capture. For the second group (B) we controlled for sleep and physical strain so they were well rested at CAC onset.

RESULTS

Cortisol, group A showed a high increase of cortisol during the exercise, compared to baseline, values were multiple times as high as expected values. Group B showed elevated levels, but slightly lower than group A. Group B dropped to normal levels during the latter part of the exercise.

Cognitive test, showed no difference either pre-post training or between groups.

The questionnaire targeted the exercise as a whole, but also specific parts. Response profiles were similar for both groups, but group B scored slightly lower on all items (non significant over all items except one).

CONCLUSIONS, AND OPERATIONAL RELEVANCE

The CAC exercise is a stress inoculation exercise, by using specific methods in a realistic stressful situation, its supposed to build experience, self-efficacy and mental preparedness.

Our conclusion is that the exercise is perceived as stressful. Cortisol levels indicate a high stress response during the exercise, as intended. Results form the questionnaire show a response profile around the middle values with low variance. Still one item (being contained in a small box is considered non stressful by almost all participants. Even though no cognitive performance change could be identified, qualitative observation gave at hand that several participants froze in a cognitive sense during the exercise due to stress. That effect was limited to the specific situation and had no carryover or accumulation over the exercise.

Studies like this one are relevant in that we need to evaluate and validate training paradigms in order to develop them further. Operational demands as well as regulations of training might have impact on the intended effects (regulations and limitations) hence constant evaluation is needed when it comes to training that comes at great cost both for the organization but also for the participant.

AUTHORS

Niclas Wisén (1)
Gerry Larsson (2)
Ulf Arborelius (1)

(1) Karolinska Institute (Solna, Sweden); (2) Swedish Defence Academy (Solna, Sweden)

1.4
INNOVATION IN PHYSICAL TRAINING

#ABS391
POSTER PRESENTATION

FEBRUARY 12, 2020

PHYSICAL OPTIMIZATION OF THE PARATROOPERS OPERATIONAL FITNESS

PURPOSE

This study evaluates the impact of a new physical training practice on injuries in paratroopers. Whereas the optimization of the physical condition of the paratroopers responds to operational efficiency and to the application of new doctrines (CNSD, 2011), the various parachute jumping techniques create strong physical and technical constraints. This can result in different types of accidents and injuries (Lafourcade et al., 2018).

METHODS

After acquiring data of sports practices and effects of training on paratroopers, concrete and simple measures were implemented as part of a "renovated physical", military and sports training. Health data were collected from 581 soldiers (age: 20-28 years) and analyzed by a physiotherapist and medical students.

RESULTS

The renovated fitness system allows a marked improvement in sports-related pathologies. The rate of injuries related to sports activity decreased from 65% to 22% in the first-year follow-up. Diseases due to hyper-solicitation, which accounted for 40% of injuries, fell to 1%. The risk of injury after 1-year follow-up decreased from 48% to 16%.

DISCUSSION

The practice of an adapted training must therefore be popularized, as well as the reduction of the weekly mileage running, in accordance with Ressort et al. (2013). Overall, the diversification and personalization of training must be the focus of attention in order to achieve a modernization of physical, military and sports training.

CONCLUSION

The intervention was highly successful in reducing injury rates. However, preventive measures must also be considered individually in order to reduce the risk as much as possible.

OPERATIONAL RELEVANCE

Reducing injuries makes soldiers more available and military units more operationally effective.

AUTHORS

Sophie Garnier (1)
Cyril Vilmant (2)
Pascale Mauriege (3)
Sandra Joffroy (4)

(1) Université Paul Sabatier (Toulouse, France) (TOULOUSE, France); (2) MASTER ISSD diploma (Toulouse, France); (3) Université Laval (Québec, Canada); (4) Université Paul Sabatier (TOULOUSE, France)

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ISOKINETIC STRENGTH OF ROTATORS, FLEXORS AND HIP EXTENSORS IS RELATED TO FRONT KICK IMPACT FORCE IN MILITARY PROFESSIONALS

PURPOSE

Close combat is part of special physical training, and it is focused on increasing the physical and mental readiness of soldiers to perform specialized tasks. To mimic real-life combative environments close combat training usually takes place outside in a field uniform. However, this can be difficult because of climatic conditions, poor visibility, or the presence with military personnel protective equipment and guns. As a result, for greater safety, indoor barefoot training without military equipment is often included in the practice where the importance is on proper performance of all techniques. Specifically for front kick performance, hip flexion, extension, internal rotation, and external rotation are important, but it is unknown whether these movements should be trained to develop maximal strength at slow velocities or explosive strength at high velocities. Therefore, the purpose of this study was to explain which of these most influence front kick impact force during barefoot training.

METHODS

Twenty-five male soldiers (27.7±7.2yr, 83.8±6.1kg, 180.5±6.5cm) performed six individual barefoot front kicks and impact forces (N) were measured on a triaxial force plate. Also, isokinetic concentric and eccentric peak torque of the kicking limb hip flexors and extensors (60, 120, 240 and 300°·s-1), and stance limb hip internal and external rotators (30°·s-1 and 90°·s-1).

RESULTS

The multiple regression showed that concentric hip flexion and extension of the kicking limb at 120°·s-1 could explain 54% of the peak impact force during the barefoot kicks ($R2=0.54$, $p<0.001$). When adding 1) eccentric and concentric hip internal and external rotations at 30°·s-1, 2) internal and external hip rotation ratios at 30°·s-1 on stance limb, and 3) concentric ratio of kicking limb flexion and extension at 300°·s-1, the explained variance of impact force was 75% ($p=0.003$).

CONCLUSIONS

Explosive strength of kicking limb hip flexors and extensors was the main contributor for front kick impact force. The maximum strength of the stance limbs internal and external rotators and the speed strength of the kicking limbs hip flexors and extensors are also important elements of kicking performance, which should be considered for improving front kick impact force.

OPERATIONAL RELEVANCE

During barefoot training in controlled conditions, tactical strength and conditioning specialists working with military personnel who participate in close combat should focus on increasing hip flexor and extensor explosive strength, either should focus on increasing maximum strength of the internal and external hip rotators when aiming to increase front kick impact force.

AUTHORS

Jan Maleček (1)
Michal Vágner (2)
Luboš Tomšovský (3)
Petr Kubový (3)
Petr Šťastný (4)

(1) Department of Physiology and Biochemistry, Faculty of Physical Education and Sport, Charles University, Prague, Czech Republic (Prague, Czech Republic); (2) Department of Military Physical Education, Faculty of Physical Education and Sport, Charles University, Prague, Czech Republic (Prague, Czech Republic); (3) Department of Anatomy and Biomechanics, Faculty of Physical Education and Sport, Charles University, Prague, Czech Republic (Prague, Czech Republic); (4) Department of Sport Games, Faculty of Physical Education and Sport, Charles University, Prague, Czech Republic (Prague, Czech Republic)

1.4
INNOVATION IN PHYSICAL TRAINING

#ABS227
POSTER PRESENTATION

FEBRUARY 12, 2020

PHYSICAL TRAINING IN THE MILITARY: A TELLING HISTORY

PURPOSE

The need to physically train soldiers for combat can be traced back to the tome Epitoma rei militaris, by Flavius Renatus (circa 500 AD). Noting the period over which physical training (PT) has been a focus of military training, the question arises as to how much has changed. The aim of this study was to investigate PT as it has been applied to the Australian military through history.

METHODS

Data were sourced from participating training establishments, Australian Defence Force subject matter experts, previously published reports, and research undertaken by the Research Team at the Australian War Memorial Research Centre.

RESULTS & DISCUSSION

Many types of training undertaken for military PT and still employed today can be found in manuals dating back to 1937. For example, the conduct of specific log exercises is shown in archival photographs spanning 67 years while specific rope obstacle training was found in documents spanning 97 years. Doctrine from 1937 highlights the importance of progressive training, the need for training to be consistent, to consist of six sessions per week of at least 60 minutes, and instructs command staff not to replace PT with other activities. Furthermore, the doctrine states that physical fitness is the only framework upon which solider qualities can be built. Information provided by Physical Training Instructors spanning nearly thirty years indicated there has been a reduction in distance runs and marches and an increase in strength-orientated training, with a shift to a fitness industry model in the early 90s and a sports model in recent years. Considering this, review of a major training unit found a 33% decrease in the number of PT sessions from 63 (1987) to 40 (2018) in the 80-day training program with many sessions lasting only 40 minutes.

CONCLUSIONS

Over a span of around 100 years many training formats and exercises appear to have remained extant although some changes to the non-combat orientated fitness methods (e.g. running and strength training) have occurring in more recent decades. There is evidence that best-practice for physical conditioning of military personnel has been known and documented since the 1930s.

OPERATIONAL RELEVANCE

Given that physical training has largely remained unchanged in nearly a century, and that best practice for military physical training was documented over 80 years ago, the main limitations to best practice for military physical training may be administration and logistic practices as opposed to scientific knowledge of how best to train personnel.

AUTHORS

Robin Orr (1)
Ben Schram (1)
Elisaq Canetti (1)
Rod Pope (2)

(1) Tactical Research Unit, Bond University (Robina, Australia); (2) Charles Sturt University (Albury, Australia)

1.4 INNOVATION IN PHYSICAL TRAINING

#ABS080
POSTER PRESENTATION

FEBRUARY 12, 2020

COMBINING SPORTS AND MILITARY TRAINING: THE BRAZILIAN AIR FORCE´S WING OPERATIONAL EXERCISE

PURPOSE

The Brazilian Air Force (BAF) has sought to develop physical fitness programs based on high-intensity functional training methods. As a way of introducing the disciplines and motivating the military personnel for its systematic practice, coaches of the Aeronautics Sports Commission analyzed the basic operational activities within the BAF personnel and proposed a championship based on the Military Aeronautical Pentathlon and military Crossfit training method to develop multiple physical and psychomotor skills, mental readiness and group cooperation. The aim of this study was to assess the level of the warriors satisfaction during the contest, as a military physical training protocol.

METHODS

144 military personnel (24women) participated in the competition. The events proposed were: C1-300m obstacle course with 9mm pistol assembly and disassembly processes; C2-combined contest of fast orienteering (2-3km), air pistol shooting (10m) and swimming (25m); C3-swimming (50m) with obstacles; C4-climb up and down a 4m high rope preceding a 400 meters sprint equipped with backpack; C5-military operational circuit with 8 functional exercises, including shooting, distributed in 200 meters. The classification considered the group results. After finishing the exercises, each military responded to a satisfaction questionnaire with 21 questions, using the Likert scale, in which 1 indicated “strongly disagree” and 5 “strongly agree”. It was possible to include free comments to justify the answers. The answers were divided into two groups per contest: G1-negative partial index with the sum of the scores 1, 2 and 3; and G2-positive partial index with the sum of scores 4 and 5. The average of the 5 disciplines on G1 and G2 was used to calculate the negative and positive Overall Satisfaction Index (OSI-and OSI+), respectively. Results:125 warriors answered the questionnaires. The OSI-was 18,40% and the OSI+ was 81,64%. The contest C5 was the sole exercise which had a G1>G2. According to the comments, it might be explained by the changes in rules implemented during the competition to adjust unforeseen logistical issues and not by the exercises themselves.

CONCLUSION & OPERATIONAL RELEVANCE

The acceptance of the proposed model encouraged each wing to start practicing the exercises by themselves and led the BAF Preparation Command to consider the competition as one of the yearly operational training exercises of the BAF military personnel. Despite the great acceptance, it is recommended that the exercises go through a process of scientific validation to serve as a basis for a broader assessment process of combat-oriented physical skills.

AUTHORS

Pedro Palermo (1)
Daniele Gabriel-Costa (1)
Grace Guindani (1)
Marcelo Baldanza (1)
André Brand (2)
Renato Massaferri (1)
Alexander Bomfim (1)
Alini Schultz (1)

(1) Brazilian Air Force University (Rio de Janeiro, Brazil); (2) Aeronautical Sports Commission (Rio de Janeiro, Brazil)

ANALYSIS OF THE PERCEPTION OF EFFORT AND RECOVERY OF CADETS OF THE BRAZILIAN AIR FORCE ACADEMY SUBMITTED TO AN OPERATIONAL TRAINING

Physical training is responsible for promoting changes in physical fitness and adaptive responses. In this context, training aims to increase performance in a systematic way, however, one should be concerned about the onset of injuries and overtraining. The objective of this study was to relate training loads and recovery levels through the analysis of the Subjective Perceived Effort (PSE) and the Total Quality of Recovery (TQR) scale of Brazilian Air Force Military personnel submitted to an operational training model. The sample of the present research consisted of 14 male military personnel, aged between 17 and 23 years, volunteers, belonging to the Training Course for Officials given at the Air Force Academy (AFA). The project was approved by the UNIMEP Ethics Committee. The analyzes were made during an eight-week training that consisted of exercises for upper and lower limbs performed as a circuit based on operational functional movements and rustic running on rough terrain. The training load was gradually increased over the course of the macro cycle. Statistical analysis was performed t-test, multivariate analysis of variance with repeated measures, Bonferroni, Shapiro-wilk and Pearson's correlation. SPSS 25 software was used. PSE was applied 30 minutes after the training sessions and the TQR the next day before starting the next training, these analyzes were done for all the training sessions, the averages were presented per week. The training load quantified by PSE ranged from 3 to 5 on the perception scale. The load was higher at weeks 3, 4, 6 and 8 and at week 7 showed the lowest load. The TQR presented values between 12 and 16 on the perception scale, and in week 2 it presented the scale 12, which means that the volunteers felt reasonably recovered, this could have happened due to being the second week of training and the volunteers were in the adaptation phase to the training. The data show that the training program over the weeks, points to intensity from medium to heavy representing assimilation to the program. The TQR pointed out that the training load allowed good recovery to the applied program. Therefore, the use of PSE and TQR are valid instruments to control the periodization and protection against overtraining and maintenance of the physical fitness of military personnel for operational missions.

AUTHORS

Juliana Cristina Viola (1)
Thiago Augusto Rochetti Bezerra (2)
Thiago Augusto Rochetti Bezerra (2)
Maria Imaculada de Lima Montebello (1)
Adriano de Almeida Pereira (1)
Ídico Luiz Pellegrinotti (1)

(1) Piracicaba Methodist University – UNIMEP, Faculty of Health Sciences – FACIS, Piracicaba, São Paulo, Brazil (Araras, Brazil); (2) Air Force Academy, Pirassununga, São Paulo, Brazil (Pirassununga, Brazil)

1.4
INNOVATION IN PHYSICAL TRAINING

#ABS206
POSTER PRESENTATION

FEBRUARY 12, 2020

DESIGNING THE DANISH MILITARY PHYSICAL TRAINING CONCEPT

PURPOSE

The purpose of this presentation is to describe the design process of analyzing the operationel needs and military educational restrictions, determining which physical training to apply and how to effectively prescribe training programs based on testresults and operational physical recommandations. In short: how to design an effective, individualized and applied physical trainingsystem for approx. 20.000 warfighters across all military services.

METHODS

Empirical inquiries was made into the challenges of developing and maintaining operational physical preparedness in the army, navy, airforce and special forces during military training and international operations. Physiological training principles used as scientific basis for the selection of training elements were determined a priori and modalities, exercises and methods were organized into systems of protocols according to principles, operational needs and educational restraints.

RESULTS

The result is a detailed system of strength, endurance and mobility that is prioritzed according to the individual weaknesses and operational needs. The concept is delivered to the operators through a smartphone application and military physical instructors throughout military service.

CONCLUSION

Military Physical Training is an evidence-based and pragmatic training system that is tailored to meet the individual warfighters operational needs within the constraints of daily military service.

OPERATIONAL RELEVANS

The Danish concept of Military Physical Training is the foundation for the physical performance and preparedness in the Danish armed forces. The experience and insights gained from the design proces can extent to military institutions in other countries that wishes to build or adjust a practical physical training concept for their military forces.

AUTHORS

Frank Thøgersen (1)
Frederik Training (1)
Frederik Sevelsted (1)

(1) Danish Armed Forces Health Services, Center for Militay Physical Training (Copenhagen, Denmark)

BIOMECHANICAL EFFECTS AND PERCEIVED COMFORT OF LOAD REDISTRIBUTION BETWEEN THE TRUNK AND PELVIS

PURPOSE

Methods for redistribution of load between the upper and lower body (e.g., hip belts, exoskeletons) have been identified as a means to mitigate the negative effects of torso-borne load carriage, with a primary goal of improving physical comfort of the load carrier. However, the biomechanical consequences of such load redistribution are not well understood. The purpose of this study was to characterize those effects relative to subjective ratings of physical comfort for a fixed load systematically distributed between the trunk and pelvis.

METHOD

Ten male Soldiers (28.6±9.9 years, 175.2±8.7 cm, 83.0±19.8 kg) walked on an instrumented treadmill at 1.34 m/s for 5-minute periods while carrying a fighting load equivalent mass (26.7 kg) split between a plate carrier and combat belt weighted to achieve four levels of load distribution (100%, 75%, 50% and 25% trunk). Spatiotemporal, kinematic, kinetic, and electromyographic variables were quantified over the final minute of treadmill walking for each condition and ratings of musculoskeletal pain, soreness & discomfort (PSD) were recorded following each condition. Main effect of load distribution was evaluated for each variable of interest using repeated measures ANOVA (=0.05).

RESULTS

Ratings of PSD for the shoulder region decreased ($F(3,36)=6.240$, $p<0.01$) with increasing distribution of carried load to the pelvis while those for the hip region ($F(3,36)=6.905$, $p<0.001$) and quadriceps ($F(3,36)=5.604$, $p<0.01$) increased. Post-hoc analyses further indicated that for a given region, PSD ratings for the 75% trunk load condition did not differ significantly from those conditions with the lowest PSD ratings for that region. Biomechanical differences between conditions were not statistically significant, however, trends for reduced magnitudes at one of the intermediary load distributions (75% or 50% trunk) were observed for several of kinetic and muscular variables.

CONCLUSIONS

If appropriately implemented, redistribution of load from the trunk to the pelvis can improve perceptions of comfort without incurring negative biomechanical or neuromuscular effects. A shift of 25% of the load from the trunk to the pelvis may represent an optimal level of load redistribution as evidenced by an observed balance of PSD ratings for the shoulders, hips and lower extremities coupled with trends for reduced musculoskeletal loading and muscular work.

OPERATIONAL RELEVANCE

The results of this study provide insight regarding trade-offs between comfort and physical effects that can inform optimized design and implementation of mitigation strategies to address the mobility, lethality and survivability degradations associated with Soldier-borne load.

AUTHORS

Angela Boynton (1)
Joon-Hyuk Park (1)
Andrew Tweedell (1)

(1) Army Research Laboratory (Aberdeen Proving Ground, United States)

A NEEDS ASSESSMENT FOR THE USE OF DIGITAL HUMAN MODELLING TO ADVANCE THE PREDICTION AND OPTIMIZATION OF SOLDIER-SYSTEM INTEGRATION AND PERFORMANCE

PURPOSE

Digital human modelling (DHM) provides a unique opportunity to simulate soldiers performance of operational tasks virtually and enables proactive trade-off analyses related to soldier-systems integration and performance. To ensure these models have sufficient capability to yield meaningful outcomes, the design of DHM tools must be informed by the end-users. The aim of this study was to conduct a needs assessment to inform a list of design requirements that should be considered within a DHM when used to predict and optimize soldier-system integration and performance.

METHODS

We conducted a needs assessment by combining information from key informant interviews and a scoping review of literature. Interviews were completed over the telephone, spanned one hour in length and were later transcribed for analysis. The scoping review was conducted by searching military and civilian databases for research related to the use of DHM within military applications. Data was extracted where pertinent to the use of DHM to predict and optimize soldier-system integration and performance. Thematic analysis was applied to the two data sources to identify emerging themes.

RESULTS

Five key informant interviews were completed with experts from sectors of Vehicle/Equipment Design, Simulation, and Army Research. A total of 2274 papers were identified and 64 papers were retained for the scoping review. Thematic analysis of the combined data sources revealed six major themes that should inform research and development of DHM for application in a military context: population specificity, visualization, state modelling, ease of use, task modelling and validity. Within those themes, key requirements emerged to support the use of DHM to predict and optimize soldier-system integration and performance. A subset of the requirements included: 1) seamlessly integrate 3D boundary manikins, 2) accurately model the effects of clothing/equipment, 3) model the effects of different states such as fatigue and 4) pre-model operational tasks for simple trade-off analyses of equipment.

CONCLUSIONS

Increased use of DHM will disrupt the status quo of using expensive and time-consuming field trials to evaluate soldier-system integration and performance. Enhancing DHM capabilities to meet the requirements emerging from this work will improve the utility of DHM to the military as required to predict and optimize soldier-system integration and performance.

OPERATIONAL RELEVANCE

Military performance prediction is an important step in understanding and optimizing the physical performance of warfighters. This needs assessment has identified key requirements for DHM to accommodate the military needs and will lead to faster and more cost-effective trade-off analyses.

AUTHORS

Justin Davidson (1)
Steven Fischer (1)
Ryan Graham (2)
Steven Beck (3)
Tim Marler (4)

(1) University of Waterloo (Drayton, Canada); (2) University of Ottawa (Ottawa, Canada); (3) SantosHuman Inc. (Coralville, United States); (4) Santos Human Inc. (Coralville, United States)

EVALUATING THE QUALITY OF PSYCHOEDUCATIONAL CONCUSSION APPS FOR MILITARY MEMBERS WITH MILD TRAUMATIC BRAIN INJURY AND POST-CONCUSSIVE SYMPTOMS

PURPOSE

Military personnel have an elevated risk of sustaining mild traumatic brain injuries (mTBI) and post-concussion symptoms (PCS).1,2,3,4,5 Smartphone apps that provide psychoeducation may assist those with mTBI or PCS to overcome unique barriers that military personnel experience with accessing healthcare resources. The purpose of this presentation is (1) to evaluate the smartphone apps advertised to provide psychoeducation for those who have sustained a mTBI or PCS utilizing the Mobile Application Rating Scale (MARS)6 and; (2) explore the relevance, utility and effectiveness of these apps to facilitate symptom management, return to duty, and overall recovery from mTBIs amongst military personnel.

METHOD

A systematic search for smartphone apps for military members with mTBI or PCS was conducted on June 21, 2019. The Apps Store and Google Play Store were utilized and multiple rounds of exclusions were performed based on specific criteria and search terms. Apps meeting inclusion criteria pps were evaluated further using the MARS and compared to evidence-based materials referencing best-practice management protocols for mTBI and PCS. A literature search was also conducted to identify if these apps had been included in the evidence-based literature.

RESULTS

The search yielded a total of 324 smartphone apps. After applying inclusion/exclusion criteria, 26 apps were subjected to evaluation. One app was endorsed by Veteran Affairs; all others (n= 25) were developed for civilians. Once compared to evidence-based best-practice resources, the majority of the apps did provide adequate psychoeducational content.

CONCLUSION

Psychoeducational interventions have a good evidence-base as a treatment for mTBIs and PCS.5 Utilizing apps for this purpose may be clinically effective, confidential, easily accessible, and cost-effective. The development of military-specific apps researched by military healthcare organizations is also warranted and may increase the effectiveness and relevance of mTBI psychoeducation apps specific to military personnel. Additional research of the currently available apps would aid clinicians in prescribing resources to military personnel who require psychoeducation to facilitate their recovery from mTBI/PCS.

OPERATIONAL RELEVANCE

Maximizing full recovery after mTBI is critical to maintaining a fit, ready military force. Those who have experienced mTBI benefit from interventions that can optimize their physical, mental, and cognitive functioning which is imperative for executing work-related duties as well as maintaining healthy and productive relationships.7 Increased rates of error or unnecessary interpersonal conflicts that arise subsequent to mTBIs are resource intensive and hazardous for members, units, families, and missions.

AUTHORS

Chelsea Jones (1)

Kaitlin O'Toole (2)

Suzette Bremault-Phillips (3)

(1) Heroes in Mind, Advocacy and Research Consortium HiMARC), Faculty of Rehabilitation Medicine, University of Alberta (Edmonton, Canada); (2) Department of Occupational Therapy, Faculty of Rehabilitation Medicine, University of Alberta (Edmonton, Canada); (3) HiMARC, Department of Occupational Therapy, Faculty of Rehabilitation Medicine, University of Alberta (Edmonton, Canada)

EXOSKELETONS, HUMAN-SYSTEMS INTEGRATION AND MOTOR CONTROL: QUESTIONS REGARDING DESIGN AND CONTROL FOR MILITARY APPLICATIONS

PURPOSE

Exoskeleton technology offers a wealth of potential benefits for the military community. From reducing musculoskeletal injuries to the decreasing the metabolic cost of performing various tasks, exoskeletons appear to offer excellent solutions. However, findings from rehabilitation and industrial ergonomics research indicate that the interaction between these devices and the human neuromuscular system is quite variable, especially in relation to the levels of robotic assistance applied and the control mechanisms used. The purpose of this review is to investigate what is known about the effects of lower-limb exoskeleton use on neuromuscular patterning in healthy individuals, and to propose a set of questions that could provide useful guidance for design and testing.

METHODS

A search of the PubMed database was conducted to identify peer-reviewed studies designed to investigate the influence of exoskeleton use on neuromuscular patterning in healthy subjects. Studies were required to compare one or more exoskeleton-assisted conditions with either a free-movement or a "transparent mode" condition. Studies were also required to identify differences in patterning via analysis of motor modules extracted from surface electromyography (EMG) via non-negative matrix factorization. Six studies met all criteria, and four were focused on use of lower-limb exoskeletons. These were selected for this review.

RESULTS

Two of the studies made use of similar ankle-only devices, while the others worked with identical poly-articular (full lower-limb) exoskeletons. Comparison of the ankle studies indicates that the mechanisms and parameters of robotic control could override the influence of the work or torque levels provided by the exoskeleton on muscular activation and timing. All four studies found that the number of motor modules needed to explain the majority of EMG variance remained similar across conditions, yet there were significant indications of fine-tuning within the neuromuscular system. Furthermore, both of the poly-articular studies found at least one condition in which module similarity broke down entirely, indicating that a more detailed analysis of muscular activity is needed to generate appropriate robotic control algorithms.

CONCLUSIONS

These studies demonstrate the importance of continued research into the effects of various exoskeleton designs, assistance levels, and control algorithms, as these elements may have profound effects on neuromuscular response.

OPERATIONAL RELEVANCE

The effects of exoskeleton use on the neuromuscular system must be well understood in order to ensure the safest and most efficient application of the technology in the field, most especially in potential combat scenarios.

AUTHORS

Kim Pribanic (1)

(1) Montana Overland Research Foundation (United States)

METABOLIC EFFECTS OF DISTRIBUTING CARRIED LOAD BETWEEN THE UPPER AND LOWER BODY

PURPOSE

To identify changes in metabolic cost associated with redistributing carried load from the upper body (trunk) to the lower body (pelvis) during self-selected and fixed speed walking. We hypothesis that there is an optimal level of trunk-pelvis load distribution, which requires less metabolic cost than when all the load is carried on the trunk.

METHODS

Thirteen male Soldiers (28.8±8.3 yrs., 88.6±18.8 kg) walked on a treadmill with a 22.67 kg load split between a plate carrier and a hip belt (i.e. no linkage between the load on the hips and the load on the shoulders). Four different load distribution conditions (100, 75, 50 and 25% of the total load on the trunk) were worn while walking for 5 minutes at two different speeds (a fixed speed (1.34 m/s) and a self-selected speed). Oxygen consumption (VO2) was measured using a breath-by-breath cardiopulmonary mask and normalized to each subjects body weight and peak VO2. A repeated measures ANOVA was performed on the VO2 (%) between speeds and load distributions.

RESULTS

There were no main effects between loads, or interaction effects between loads and speeds. There was a main effect for speed on metabolic cost ($F_{1,12}=8.63$, $p<0.02$), with self-selected speeds eliciting a higher metabolic cost (44.5±9.6%) than the fixed speed (40.7±6.9%). Mean self-selected speeds were 1.41±0.36, 1.48±0.34, 1.40±0.41, and 1.46±0.26 m/s for, 25, 50, 75, and 100%, respectively, with no statistical differences between them. When speed was standardized, there was a U-shaped trend with the 75% condition yielding the smallest metabolic cost (39.6±6.7%) compared to the 25, 50, and 100% conditions (41.7±7.3, 40.0±6.2, and 41.4±7.7%, respectively).

CONCLUSIONS

Metabolic cost of loaded walking did not change as carried load was redistributed from the trunk to the pelvis, regardless of speed. However, the Soldiers self-selected speeds were greater than the fixed speed, and elicited higher metabolic costs. When speed was fixed, unloading some of the weight from the shoulders to the hips produced small benefits in metabolic cost. However, this benefit is lost as more of the weight is offloaded. Further research is needed to determine if this trend is enhanced with higher fixed walking speeds or heavier loads.

OPERATIONAL RELEVANCE

To be effective in the field, body-borne Soldier-systems attempting to reduce musculoskeletal injury and increase mobility should not also add physiological burden. Overall, redistributing a trunk-borne load does not appear to affect energy expenditure and thus may be potential solution.

AUTHORS

Andrew Tweedell (1)
Joon-Hyuk Park (2)
Angela Boynton (2)

(1) United States Army Research Laboratory (Aberdeen Proving Ground, United States); (2) United States Army Research Laboratory (Aberdeen Proving Ground, United States)

2.3
EMERGING TECHNOLOGY TO ACHIEVE GOAL

#ABS267
POSTER PRESENTATION

FEBRUARY 12, 2020

PERFORMANCE AND GAIT ADAPTATIONS WHILE WEARING DIFFERENT NIGHT VISION TECHNOLOGIES

PURPOSE

Recent modern conflicts have resulted in an increased reliance on night vision technologies to provide a tactical advantage to the user. Although these technologies allow the user to operate in an environment few others can, they do have limitations including tunnel vision, decreased visual acuity, compromised depth perception, and loss of peripheral vision. These limitations have the potential to decrease tactical performance. The current study investigates how different night vision technologies influence performance during a simulated room clearance task.

METHODS

Twelve trained tactical shooters participated in a simulated room clearance task that consisted of a 25 m approach through a cleared room on their way to an un-cleared (target) room. The approach task was performed under four different conditions: 1) ambient lighting; 2) wearing white phosphor monocular NVGs; 3) wearing white phosphor binocular NVGs, and 4) wearing green phosphor NVGs with dual optical tubes and single intensifier tube. Approach time to the target room and step frequency were compared between experimental conditions using a single factor (NVG) Repeated Measures ANOVA (= 0.05). Tukeys post-hoc test was used to compare means when main effects were found to be significant.

RESULTS

Approach time to the target room was significantly different across all testing conditions. The best times were associated with the ambient lighting condition (9.209±0.356 s), whereas the worst times were associated with use of the green phosphor NVGs (13.095±0.595 s). On average, use of the binocular NVGs resulted in nearly one second better performance than the monocular NVGs (11.044±0.374 vs. 11.934±0.418, respectively) during the approach. Step rate was relatively unaffected during the initial portion of the approach. Upon negotiation of the corners and stairs, all NVG conditions resulted in a decreased step rate when negotiating the ramp to the target room when compared to the ambient lighting condition, with the most significant decrease seen between the ambient lighting and green phosphor condition (0.512 steps/sec).

CONCLUSIONS

NVG technologies appear to influence gait and task performance to varying degrees during room clearance tasks. These changes in performance should be considered when choosing technologies for operational use.

OPERATIONAL RELEVANCE

With an ever increasing reliance on technology and amount of equipment worn by the warfighter, it is important to understand the potential influence this equipment has on soldier performance and survivability. This research establishes a significant difference in task performance while wearing NVGs across a broad range of technologies.

AUTHORS

Brian Higginson (1)

Jemma Coleman (2)

(1) Revision Military (Portsmouth, United States); (2) Defence Science and Technology Group (Melbourne, Australia)

EVALUATING THE QUALITY OF RESILIENCE APPS FOR MILITARY MEMBERS

PURPOSE

Resilience, defined as positively coping and adapting when in adverse circumstances, is integral in ensuring the wellbeing and operational readiness of military personnel. The unique barriers present in military life necessitate targeted interventions which foster resilience that are clinically effective, confidential, available, and cost-effective. Smartphone apps targeting resilience may assist with overcoming these barriers and are increasingly available, however, some apps have been found to have limited involvement from medical professionals and facilitate misleading information. Apps utilized in an evidence-based intervention must be evaluated using a reliable tool to determine their appropriateness. The purpose of this presentation is to: (1) evaluate the smartphone apps available and advertised to foster physical and mental resilience in military personnel utilizing the Mobile Application Rating Scale (MARS) and; (2) explore the potential utility and effectiveness of smartphone apps to contribute to improved physical and operational performance amongst military personnel.

METHODS

A search protocol was developed to examine apps aimed at fostering resilience and executed on November 25, 2018. Two rounds of eliminations were performed based on specific exclusion criteria which resulted in the final selection for further evaluation. Apps were evaluated using the MARS to determine their usability and evidence-based merit.

RESULTS

Eighty-three apps resulted from the search with twelve being selected for further MARS analysis. The resilience strategies offered by the majority of apps were; diaphragmatic breathing, mindfulness practice, sleep, and progressive muscle relaxation. Based on the MARS, eleven apps were deemed, high quality with evidence-based strategies and potential to foster resilience.

CONCLUSIONS

As evolving technology and access to smartphones has increased, apps have become a mainstream option for interactive and engaging information delivery. The analysed apps available are well suited to foster resilience in military personnel offering evidence-based interventions to assist with mental and physical wellness practices through self-regulated interventions and psych education. Crucially, they may also encourage help-seeking behaviours. The development of military-specific apps researched by military healthcare organizations may increase the effectiveness and relevance of resilience apps specific to this population.

OPERATIONAL RELEVANCE

Mental and physical resilience are complementary in facilitating peak operational performance amongst military personnel. For example, the analysed apps recommend strategies to regulate breathing, reduce muscle tightness, increase awareness of ones surroundings, and improve sleep which could be beneficial in reducing performance errors during military tasks and operations. Training in strategies to regulate breathing have also been demonstrated to positively impact physical health after exhaustive exercise

AUTHORS

Kaitlin O'Toole (1)

Chelsea Jones (2)

Cary Brown (3)

(1) Occupational Therapy, Faculty of Rehabilitation Medicine, University of Alberta, MScOT Student (Edmonton, Canada); (2) Heroes in Mind Advocacy and Research Consortium (HiMARC), Faculty of Rehabilitation Medicine, University of Alberta-PhD Student (Edmonton, Canada); (3) Occupational Therapy, Faculty of Rehabilitation Medicine, University of Alberta, PhD (Edmonton, Canada)

UPPER EXTREMITY FATIGUE DEVELOPMENT DURING LIVE-FIRE WITH AND WITHOUT A BODY-BORNE WEAPON MOUNT

PURPOSE

A body-borne prototype weapon mount (Third Arm, 3ARM) has been developed to aid with weapon stabilization, improve marksmanship performance, and attenuate upper extremity fatigue during sustained marksmanship tasks. The purpose of this research was to determine whether 3ARM effectively improves muscular endurance and reduces fatigue of the upper extremities.

METHODS

Seven male military subjects were recruited for participation. Subjects completed a muscular endurance task and a series of live-fire shooting tasks. The endurance task consisted of the subject extending their weapon support arm and holding a 3.6-kg (8 lb) weight as long as possible. An inertial measurement unit (IMU) secured to the upper arm was used to quantify duration of the hold. Electromyography (EMG) sensors positioned over several arm muscles were used to quantify changes in muscle contraction properties over the course of the endurance task. Following a period of rest, subjects completed a paced live-fire task firing a single round every 6 seconds on a 75-meter target with and without the 3ARM system (~3 min duration). Subjects then immediately repeated the muscle endurance task. Endurance time and median power frequency (MF) of weapon support muscles were determined prior to weapon fire (Pre) and following live-fire for each condition (control, 3ARM). Linear mixed-effects models were used to compare between Pre, control, and 3ARM conditions with subject as a random variable.

RESULTS

Mean (SD) endurance time prior to weapon fire was 57.3 (11.1) sec. A main effect of condition was found ($F(2,12)=34.02$, $p<0.001$); mean endurance time was significantly reduced to 37.6 (13.1) sec for the 3ARM condition and 17.8 (5.8) sec for the control condition ($p=0.004$ and $p<0.0001$, respectively). No significant differences were found for changes in MF of support arm muscles, but data trended towards lower MF (greater fatigue) at the initiation of the endurance task following the control condition.

CONCLUSIONS

Sustained target engagement results in a decrease in muscular endurance of the support arm, but this decrease is significantly less with the use of the 3ARM. When target engagement times are held constant, the 3ARM can help reduce fatigue development in the weapon support arm.

OPERATIONAL RELEVANCE

Assistive technologies are being developed to improve Soldier lethality and resilience. Prior to fielding these technologies, research is needed to evaluate their efficacy and consider their potential effects on Soldier performance.

AUTHORS

Courtney Haynes (1)
Michael LaFiandra (2)
Andrew Tweedell (1)
Joon-Hyuk Park (1)
Daniel Baechle (1)

(1) U.S. Army Research Laboratory (Aberdeen Proving Ground, United States); (2) United States Military Academy (United States)

A PILOT ANALYSIS OF EMERGING SURFACE ELECTROMYOGRAPHY WEARABLE TECHNOLOGY: TRAINING LOAD DEMANDS, MUSCLE RATIOS, AND SEX DIFFERENCES IN THE CASUALTY DRAG

PURPOSE

To determine training load (TL) demands, muscle ratios, and sex differences in the tactical task of a casualty drag (CD) using surface electromyography (sEMG) wearable technology.

METHODS

A convenience sample of 36 college-aged participants (=25; =11) performed two trials of a 15-m 123-kg CD. A 91-kg dummy with 32-kg of additional load via a weighted vest was positioned on the ground. Participants grabbed the vest handles and dragged the dummy backwards over the required distance. Time was recorded to calculate CD velocity, with the fastest trial analyzed. Prior to testing, participants were fitted with a compression short or legging embedded with sEMG sensors to measure the quadriceps (QUAD), hamstrings (HAM), and gluteus maximus (GM) of both legs. The sEMG signal for each muscle was measured as a percentage of maximal voluntary contraction to calculate TL (measured as arbitrary units; AU). The variables included: overall TL (sum of all muscles), and QUAD-HAM, GM-HAM, and QUAD-HAM+GM ratios. Independent samples t-tests calculated sex differences between CD velocity and the sEMG variables. Partial correlations controlling for sex calculated relationships between CD velocity and the sEMG variables.

RESULTS

Males completed the CD faster than females (1.48±0.26 m/s vs. 0.83±0.16 m/s; $p < 0.01$). Consequently, females experienced a greater overall TL compared to males (94.73±27.84 AU vs. 56.01±15.30 AU; $p < 0.01$). There were no between-sex differences in the muscle ratios. There was a significant correlation between faster CD velocity and greater QUAD-HAM ratio (greater QUAD contribution relative to the HAM; $r = -0.35$, $p = 0.04$).

CONCLUSIONS

The sEMG wearable technology could be used to indicate the stress associated with soldiering tasks, in this instance a CD. Slower performance increased TL demands, which was notable for the females. This has implications for soldier training, where TL increases have been associated with injury risk. sEMG wearable technology could be used to measure the stress of tasks where TL metrics may be difficult to measure (e.g., lifting and carrying loads, combat simulations). Lastly, greater QUAD contribution, shown through the QUAD-HAM ratio, could contribute to a faster backward CD.

OPERATIONAL RELEVANCE

This study provided a preliminary investigation into how sEMG wearable technology could be integrated into basic training by measuring TL of a specific task. Initial measures indicated greater TL demands with slower CD task performance. sEMG wearable technology could measure soldier TL during basic training, with objectives of enhancing performance and decreasing injury risk via workload monitoring and manipulation.

AUTHORS

Robert Lockie (1)
Matthew Moreno (1)
Spencer Ducheny (1)
Robin Orr (2)
Jay Dawes (3)
Katherine Balfany (1)

(1) California State University, Fullerton (Fullerton, United States); (2) Bond University (Robina, Australia); (3) Oklahoma State University (Stillwater, United States)

PHYSIOLOGICAL MEASUREMENTS IN A GLOVE: CHALLENGE OR REALITY?

PURPOSE

local cold injuries are a common problem of military operations and training in wintertime. Feets and hands are more prone to cold injuries. Wearing a protective glove is the best way of preventing frostbites of the hands. Many laboratory studies have investigated local reactions to cold with a cold water test. We do not have field data and for several hours. The goal of our work is to provide a proof of concept of an integrable electronics glove for the physiological monitoring of the hand.

METHODS

We developed a prototype glove for physiological monitoring in the field for 24 hours. Non-functional requirements: the glove must remain comfortable and can be worn for several hours. In order to meet theses expectations, we developed a monitoring electronic system on flexible substrate, apart from the microcontroller to improve mechanical reliability. Integrated sensors consist of 7 thermistors measuring the skin temperature of the fingers, the thenar eminence and the back of the hand. 1 measurement of skin blood flow and heart rate are implemented at the wrist using the photoplethysmography method. 2 hygrometry sensors are embedded inside and outside the glove. The sampling frequency is 1 point every 5 seconds. The data is stored on a microSD card. First tests show a practical autonomy of 87 hours at room temperature of 25°C.

RESULTS

The first results demonstrate good ergonomics with respect for manual dexterity. Temperature, blood flow, heart rate and humidity sensors are functional. Relevance of temperature and humidity measurements is validated in a controlled environment. Ergonomics of the battery and microcontroller will require improvements.

CONCLUSION

This first prototype allowed the validation of the integration of flexible electronics in a glove. The first field tests will be conducted during winter 2019-2020.

OPERATIONAL RELEVANCE

Integration of flexible electronics inside a glove makes it possible to study local physiological reactions to cold in the field. A monitoring glove is now a reality that should allow us to improve the fabrication of our gloves.

AUTHORS

Roger Delattre (1)
Alexandra Malgoyre (2)
Tomas Barbe (3)
Theo Delaunoy (3)
Arturo Mollinedo (3)
Cedric Gernigon (3)
Florent Katchikian (4)
Cyprien Bourrilhon (5)

(1) Department of Flexible Electronics, Ecole Nationale Supérieure des Mines, Centre Microélectronique de Provence CMP-EMSE (Gardanne, France); (2) Armed Forces Biomedical Research Institute (France); (3) EMSE (Gardanne, France); (4) Racer Glove (Salon de Provence, France); (5) IRBA (Brétigny sur Orge, France)

2.3 EMERGING TECHNOLOGY TO ACHIEVE GOAL

#ABS154
POSTER PRESENTATION

FEBRUARY 12, 2020

DISTINGUISHING LIVE-FIRE MARKSMANSHIP STABILITY AND EFFICIENCY BETWEEN NOVICES AND EXPERTS THROUGH BODY-WORN SENSORS

PURPOSE

This investigation quantified live-fire marksmanship performance and evaluated differences between experience (expert/novice) and load (unloaded/load) conditions. Currently, rifle marksmanship tasks are evaluated with shot accuracy and experts are differentiated from novices based primarily on their shooting accuracy and duration served. While qualitative feedback is given to novice marksmen to improve performance, there is opportunity to provide quantitative feedback for live-fire training.

METHODS

Male novices (n=9, 22.6±3.64 years; 1.78±0.55 m; 81.0±14.3 kg) and experts (n=8, 28.2±5.19 years; 1.77±0.73 m; 80.7±8.07 kg) performed marksmanship tasks. Participants engaged targets in three trial phases: seven targets with the rifle supported on a barrier, four targets while maneuvering around barrels, and four targets while standing unsupported. These tasks were repeated with and without load (30.8 kg). Shots were detected using a rifle-mounted inertial measurement unit (IMU) and data were parsed into regions of target acquisition and recoil management. Accuracy was recorded by scoring hits within the a-c zones of an IPSC target. Rifle stability was defined as the root mean square (RMS) of angular velocity. Target-acquisition efficiency was defined as 1/(RMS×Time), where time is the target-acquisition period. Kruskal-Wallis tests were used to evaluate an effect of expertise and load. Friedman tests were used to evaluate an effect of trial phase and load. Post-hoc dependent signed-rank tests were used to compare load within expertise and independent rank-sum tests to compare between expertise within load.

RESULTS

In all trial phases, experts had a higher accuracy than novices ($p<0.05$). For rifle stability during supported target acquisition, significant differences ($p<0.05$) were found between experience for both load conditions for pitch (up/down), roll (cant), and yaw (left/right). For recoil management, significant differences ($p<0.001$) were observed between experience for pitch for both load conditions. Significant differences in stability were observed across trial phases for most metrics. Experts were observed to be more efficient during target acquisition in supported ($p=0.001$ loaded, $p=0.004$ unloaded) and barrel-run tasks ($p=0.006$ unloaded).

CONCLUSIONS

Quantitative metrics were identified that show statistically significant differences in performance between expert and novice marksmen. While expert marksmen are currently differentiated from novices using knowledge of results, these metrics could be used to more quantitatively inform knowledge of performance to differentiate and provide feedback to the two groups.

OPERATIONAL RELEVANCE

This study examined live-fire marksmanship performance, highlighting the utility of body-worn sensors to generate measures of stability and quantitatively differentiate between experts and novices in live-fire marksmanship exercises.

AUTHORS

Julia Milton (1)
Clifford Hancock (2)
Leia Stirling (3)
Leif Hasselquist (2)

(1) Massachusetts Institute of Technology (United States); (2) US Army Soldier Research, Development, and Engineering Center (Natick, United States); (3) University of Michigan (Ann Arbor, United States)

2.3 EMERGING TECHNOLOGY TO ACHIEVE GOAL

#ABS198

FEBRUARY 12, 2020

A 3-D VIRTUAL HUMAN THERMOREGULATORY MODEL TO PREDICT HEAT-STRESS RESPONSES

PURPOSE

Strenuous physical activity, exposure to high temperatures, or both, can lead to heat stress. To assess the risks associated with human exposure to a particular heat-stress condition, we need to determine the spatiotemporal temperature distribution in the human body. However, the lack of experimental techniques to obtain organ-specific heat loads and the inability to perform human exposure studies necessitate an alternative approach. Here, we developed a three-dimensional (3-D) virtual thermoregulatory human model to predict the distribution of temperatures throughout the body as a function of time under any environmental and exertional heat-stress condition.

METHODS

We developed a 3-D finite element model of heat transfer in the human body, using an anatomically realistic description of a 50th percentile U.S. male. We represented key heat-transfer mechanisms, including those of conduction and convection, and thermoregulatory mechanisms, such as sweating and vasomotion, using Pennes bioheat equation. In addition, we modeled daily temperature changes due to the circadian rhythm and used literature data to represent thermo-physical material properties for different organs. We then simulated two environmental conditions (hot and very humid, very hot and humid), each with two clothing conditions (t-shirt and battle dress uniform), for a range of activity levels over an 8-hr period for each condition. Finally, we validated the simulations with experimental data using a rectal probe.

RESULTS

The predicted core body temperature closely matched (R-squared 0.75) the measured data for the two environmental and two clothing conditions. Organs, such as the heart, brain, liver, and kidney, attained temperatures higher than the core body temperature. For example, the maximum temperature of the heart was higher than the core body temperature by as much as 0.4 degrees Celsius for the different conditions.

CONCLUSIONS

We developed a 3-D human thermoregulatory model and validated it with rectal temperature measurements in subjects exposed to environmental and exertional stressors. We also demonstrated the ability to estimate increases in organ-specific temperature, which often exceeded the core body temperature.

OPERATIONAL RELEVANCE

The validated 3-D thermoregulatory model will allow us to assess the temperature loads in a human during various environmental and exertional heat-stress scenarios, affording the ability to link increases in organ temperature with decreases in physical and cognitive performance. Finally, it provides a unique opportunity to readily compare and contrast dozens of existing and future cooling strategies for the human body, which cannot be evaluated experimentally.

AUTHORS

Rajeev Hatwar (1)
Jaques Reifman (2)
Ginu Unnikrishnan (3)
Samantha Hornby (3)
Srinivas Laxminarayan (3)
Luke Belval (4)
Gabrielle Giersch (4)
Douglas Casa (4)
Jaques Reifman (2)

(1) Department of Defense Biotechnology High Performance Computing Software Applications Institute and The Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc. (Fort Detrick, United States); (2) Department of Defense Biotechnology High Performance Computing Software Applications Institute, Telemedicine and Advanced Technology Research Center, United States Army Medical Research and Development Command (Fort Detrick, United States); (3) Department of Defense Biotechnology High Performance Computing Software Applications Institute, Telemedicine and Advanced Technology Research Center, United States Army Medical Research and Development Command; The Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc. (Fort Detrick, United States); (4) Korey Stringer Institute, University of Connecticut (Storrs, United States)

CAN APP-LED TACTICAL BREATHING TRAINING IMPROVE SOLDIER MARKSMANSHIP UNDER PRESSURE?

PURPOSE

Anxiety and increased arousal levels are known to significantly reduce shooting accuracy (Nibbelinga et al. 2014). This impacts the performance and operational effectiveness of military personnel. Considering the direct link between respiration and the activity of the autonomic nervous system (Grossman, 1983), this Canadian-New Zealand collaborative study explores the effectiveness of app-led tactical breathing training (i.e. a controlled breathing technique) for improving marksmanship in soldiers within high stress environments.

METHODS

An initial cohort of 28 New Zealand Army soldiers undertaking their Annual Weapons Qualification (AWQ) was divided into two equal groups: (i) a tactical-breathing group, receiving five days of app-based training; and (ii) a control group, receiving no training. Demographics and personality characteristics (HEXACO) were captured at baseline. Subject-perceived anxiety and emotion were measured via State and Trait Anxiety Inventory (STAI) and Positive and Negative Affect Schedule (PANAS) scores at baseline and on the AWQ-day. Heart rate variability (HRV, linked to autonomic nervous system activity) was measured at rest (baseline), during the tactical breathing sessions, and during a representative period of the AWQ. Marksmanship performance was assessed via AWQ score. Statistically significant differences between groups were determined via ANCOVA and t-tests.

RESULTS

Preliminary data analyses revealed no significant difference in AWQ scores between the control and tactical breathing groups. Baseline state and trait anxiety scores correlated significantly with AWQ-day state anxiety scores; when these relationships were factored out, there was no between-groups difference in AWQ-day state anxiety scores. AWQ scores correlated negatively with HRV Standard Deviation of Normal-to-Normal intervals (SDNN), a measure of changes to the sympathetic-parasympathetic systems relationship. Further, baseline SDNN was lower than AWQ-day SDNN. Present findings are limited by a small sample size; further data collection is underway.

CONCLUSIONS

Preliminary findings suggest no significant improvement in marksmanship performance with tactical breathing training, however, additional data is required. Further analysis on a larger sample size will establish how app-led tactical breathing training affects arousal control (HRV data) and the role of other factors such as age, aerobic fitness and tactical breathing experience.

OPERATIONAL RELEVANCE

This study provides insights into the ability of app-led tactical breathing training to control arousal levels and improve marksmanship in soldiers during high pressure activities.

AUTHORS

Samantha Rodrigues (1)
Helen Kilding (1)
Josh Granek (2)
Madeleine D'Agata (2)
Blake Martin (2)
Ramtin Lotfabadi (3)
Ryan Bae (2)
Hamid Boland (2)

(1) Defence Technology Agency (DTA) (Auckland, New Zealand); (2) Defence Research and Development Canada (DRDC) (Toronto, Canada); (3) University of Waterloo (Waterloo, Canada)

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2.3 EMERGING TECHNOLOGY TO ACHIEVE GOAL

#ABS131

FEBRUARY 12, 2020

THE DEVELOPMENT OF A TOOL TO ASSESS CERVICAL JOINT LOADS IN DIFFERENT HELMETED CONDITIONS FOR FAST JET PILOTS

PURPOSE

Advancements in helmet safety and technology has seen helmet design for fast jet pilots continually evolve, increasing both the mass and the distribution of this. While these technologies have endeavored to increase operational capacity and safety, it could be argued that they have placed greater stresses on the musculoskeletal structures of the neck. It has been reported that the prevalence of flight-related neck pain in fast jet aircrew is as high as 95% affecting longevity of active service. The aim of this research was to develop a tool that could measure dynamic cervical joint load in different helmeted conditions under gravity environments that reflect in-vivo flying.

METHODS

Three-dimensional trajectory data was collected using a VICON Motion Capture System from 20 RAAF fast jet pilots wearing 2 different helmet types (HGU-55/P and JHMCS) with differing inertial properties. Pilots were seated in an F/A-18A ejection seat and performed a series of common aerial combat head checks. Using Opensim software, a previously validated musculoskeletal neck model, altered to incorporate the mass of the helmet and the ability to create different gravity (Gz) environments was then used to derive cervical joint (C1, C4 and C7) kinematics and kinetics. The same dataset was then modelled on 10 separate occasions at different Gz, ranging between 1-9, reflecting typical flying conditions. Effect sizes (ES) were calculated to functionally differentiate between groups.

RESULTS

The heavier JHMCS helmet, with a more anteriorly located center of mass was associated with up to 20% (~5.4Nm) more load compared HGU-55/P helmet (ES 2.04 at 9Gz). Every unit increase of Gz added approximately 11% (~4.6Nm) (ES 0.49) to calculated loads for the JHMCS and 10% (4.0Nm~) (ES 0.46) for the HGU-55/P helmet at the three cervical joints. Joints loads increased inferiorly the highest seen at C7 (42.5Nm at 9Gz).

CONCLUSION

It is possible to estimate dynamic neck forces at different Gz associated with aerial combat head check movements using Opensim technology. Quantifying neck forces more representative of in-vivo conditions is an important step towards understanding the load placed on the musculoskeletal structures of the neck between helmet configurations.

OPERATIONAL RELEVANCE

Having the ability to quantify loads experienced by pilots, allows for informed decisions to be made when augmenting or changing helmet configurations. This automated model can be adapted to any airframe or helmet type if the appropriate trajectory data is collected and helmet inertial properties are known.

AUTHORS

Wayne Spratford (1)

Phillip Newman (2)

(1) University of Canberra (Coombs, Australia); (2) University of Canberra (Canberra, Australia)

DEFENSE TRAINING & COACHING SYSTEM; AN INTEGRATED SYSTEM TO MONITOR THE SOLDIERS PHYSICAL PERFORMANCE

PURPOSE

In the last few years the Dutch Army developed an online training platform, called Defense Training and Coaching System (DTCS). Purpose of this platform is to make the training program for the soldier 24/7 available and to monitor and coach the soldier by his Physical Trainer. The soldier can execute his recommended training program at any place at any time. This will increase the training frequency of the soldier.

METHOD

This online platform is built in cooperation with a civil company, Technogym. We built our own Defense Training Library with all the trainings that our PT & Sports organization provides to the Dutch Army.

Besides Technogym there is also a partnership with Garmin to develop a Defense Smartwatch that can collect the outdoor training data. The whole system is GDPR prove.

RESULTS

When the DTCS is fully implemented in the Dutch Army we will have a system that:

- Collects bio medical data by a Tanita body composition monitor
- Collects indoor and outdoor training data from soldiers
- Gives soldiers the possibility to train 24/7 based on our recommended training programs
- Gives the soldier insight on an individual level as well on unit or group level in his training programs that are focused on:
  - Lifestyle and Heath (Fit for Life)
  - General Military Fitness (Fit for Function)
  - Military Specific Fitness (Fit for Action)
- Gives commanders insight in the physical performance of their unit

The soldier can use the Defense Mobile Sport App to use the platform.

CONCLUSIONS

In March 2020 we will start a pilot with DTCS fully operational capable on four Army bases in the Netherlands. We will start with small amount of soldiers (25-30 per base) Those four bases will have all right pre-conditions like the additional hard- and software from Technogym, the Defense Smartwatch and a good WiFi signal in all the buildings on the base.

Former pilots with parts of the DTCS shows great commitment by soldiers and trainers.

OPERATIONAL RELEVANCE

With DTCS, the planning and monitoring of the physical training is based on a modern, innovative platform. It will improve the lifestyle employability and the soldiers physical performance. We expect less drop outs due to physical injuries.

AUTHORS

Bart Steenge (1)

(1) PT & Sports Organization Royal Netherlands Army (Amersfoort, Netherlands)

FAT MASS INDEX AND FOOD CONSUMPTION FREQUENCY OF POLISH SOLDIERS DELEGATED TO SERVE IN THE INTERNATIONAL SECURITY ASSISTANCE FORCE IN AFGHANISTAN

PURPOSE

The aim of the study was to assess the impact of dietary behaviors of Polish soldiers on the Fat Mass Index (FMI).

METHODS

The study was carried out with participation of 111 soldiers delegated to serve in the International Security Assistance Force in Afghanistan, aged 33±6; years of service: 10±6. Body composition was determined by bioelectrical impedance analysis using TANITA MC-780 analyzer and index for fat mass was calculated: fat mass index: FMI = fat mass/height2 (kg/m2). According to the calculated FMI each person was qualified to one of the following groups: fat deficit, normal fat or excess fat. The soldiers were asked to fill in the 61-item food frequency questionnaire. U Mann-Whitney test was used to compare food consumption frequency between two groups: normal fat and excess fat.

RESULTS

The correct FMI was found in 54% of the soldiers, while an excessive amount of fat tissue, as interpreted by the FMI above 6 kg/m2, was found among 41% of the soldiers. Out of the 61 products selected, significant differences ($p < 0.05$) in food consumption frequency between two groups of soldiers (normal fat vs excess fat) and eight products were found. Compare to normal fat soldiers, soldiers with excess fat consumed less often ready-to-eat breakfast cereal products ($p = 0.038$), fruits togetherall types ($p = 0.015$), bananas ($p = 0.037$), apples and pears ($p = 0.026$), sweet fruit preserves and candied fruits ($p = 0.023$) and consumed more often energy drinks ($p = 0.011$), sweetened sodas such as Fanta, Coca-Cola, Mirinda, Sprite ($p = 0.033$) and vodka and spirits ($p = 0.020$).

CONCLUSIONS

The smaller scale of rational dietary choices (especially fruit, sweetened and alcohol beverages consumption) was characteristic of soldiers with excess fat. There is a need for nutritional education and further monitoring of both the nutritional status and dietary behaviors of soldiers.

OPERATIONAL RELEVANCE

Overweight and obesity, as well as underweight, unprofitably influence fitness and physical endurance of the body. It is particularly significant in the case of soldiers, as it can considerably impair efficiency of military training as well as impede or preclude them from performing complicated military tasks, causing, in specific situations, a threat to soldiers life and health.

AUTHORS

Jerzy Bertrandt (1)
Roman Lakomy (2)
Tomasz Lepionka (2)
Ewa Szarska (3)
Andrzej Tomczak (4)
Adam Nowosad (5)
Anna Anyżewska (2)

(1) Military Institute of Hygiene and Epidemiology (Warsaw, Poland); (2) Laboratory of Food and Nutrition Hygiene, Military Institute of Hygiene and Epidemiology (Warsaw, Poland); (3) Laboratory of Physiology, Mili tary Institute of Hygiene and Epidemiology (Warsaw, Poland); (4) The War Studies University in Warsaw, Faculty of National Security, Department of Security Education (Warsaw, Poland); (5) Military Research and Deployment Center for Food Services (Warsaw, Poland)

ASSESSMENT OF ENERGY EXPENDITURE OF POLISH SOLDIERS SERVING IN SPECIAL FORCES UNITS

PURPOSE

The aim of the study was assessment of energy expenditure of Polish soldiers serving in Special Forces troops during a typical training day.

METHODS

Investigations of the energy expenditure included soldiers of 2 special units of the Polish Armed Forces: "GROM" and a special unit of Military Police. A method of measuring the heart rate using the Polar Sport Tester S810i and Polar RC3 GPS was used to measure the energy expenditure. 22 soldiers in the age of 30.1 ± 3.0 participated in the research, men serving in the Special Unit "GROM". The average height of the surveyed soldiers was 179.8 ± 6.6 cm, and the body weight was 86.8 ± 10.0 kg. Energy expenditure research was carried out during the actual training in the garrison conditions. Moreover total of 78 men, professional soldiers aged 32.5 ± 5.9 years with an average body weight of 86.9 ± 8.8 kg and an average increase of 181.5 ± 5.8 cm took part in the research, serving at special unit of Military Police.

RESULTS

It was shown that the average energy expenditure of soldiers of the "GROM" unit trained in garrison conditions during the 8-hour training day was 1716.0 kcal, while the soldiers of the MP special unit spent 2477 kcal.

CONCLUSIONS

According to the classification of work severity according to Christensen, the work done by the soldiers should be classified in the category of heavy and very heavy work.

OPERATIONAL RELEVANCE

The amount of energy expenditures related to the performance of various training activities by soldiers is an important determinant determining the amount of 24-hour energy expenditures. Knowing them allows to dispense the physical load during training and allows to determine the soldier's daily needs for energy, which is closely related to maintaining a good nutritional status and high physical condition.

AUTHORS

Jerzy Bertrandt (1)
Roman Lakomy (2)
Tomasz Lepionka (2)
Szarska Ewa (3)
Andrzej Tomczak (4)
Ewelina Maculewicz (5)
Anna Anyżewska (2)

(1) Military Institute of Hygiene and Epidemiology (Warsaw, Poland); (2) Laboratory of Food and Nutrition Hygiene, Military Institute of Hygiene and Epidemiology (Warsaw, Poland); (3) Laboratory of Physiology, Military Institute of Hygiene and Epidemiology, Warsaw (Warsaw, Poland); (4) The War Studies University in Warsaw, Faculty of National Security, Department of Security Education (Warsaw, Poland); (5) Laboratory of Physiology, Military Institute of Hygiene and Epidemiology (Warsaw, Poland)

PHYSICAL ABILITIES RELATED TO PEACE-KEEPING AND DOMESTIC SECURITY EFFORTS

PURPOSE

The physical tasks and abilities of emerging peace-keeping conflicts can closely resemble similar tasks and abilities required of US sworn peace officers (SPO) assigned to patrol duties. The purpose of this study was to describe physical abilities important for tasks associated with peace-keeping and domestic security.

METHODS

A survey of 5,527 SPOs from small, medium, and large agencies in California (USA) assigned to patrol duties in rural, suburban, and urban environments was conducted on 49 job-relevant physical tasks. Criticality/importance, frequency, and duration of physical tasks such as force required during arrest, lifting, pulling, running, etc. were also rated. Though content analysis, a panel of subject matter experts categorized the tasks into physiological ability demands using both Relative Percent Contribution (RPC) of each ability relative to other abilities and an Essentiality Rating (ER) computed as frequency rating multiplied by importance rating.

RESULTS

Over 75% (n=3890) of respondents had been assigned to patrol duties at least two years, with 87.8% (n=4,479) of respondents identifying as male and 12.2% (n=620) as female. RPC determinations were: anaerobic capacity (12.3%), aerobic capacity (4.6%), muscular strength (10.3%), muscular endurance (8.2%), power (13.3%), flexibility/range of motion (ROM) (14.4%), balance (5.6%), stability (17.9%), and agility (13.3%). ER determinations were: anaerobic capacity (12.5%), aerobic capacity (4.7%), muscular strength (9.5%), muscular endurance (8.6%), power (12.5%), flexibility/ROM (14.2%), balance (5.7%), stability (18.4%), and agility (13.9%).

CONCLUSIONS

Considering both RPC and ER, physical tasks grouped by physiological abilities involving stability, agility, flexibility/ROM, power, and anaerobic capacity scored higher than other abilities. Of note, muscular strength was also consistently rated higher than muscular endurance. These data indicate that the important physiological qualities for peace-keeping and domestic security may be different to those needed in other aspects of military work.

OPERATIONAL RELEVANCE

As soldiers are often called to peace-keeping and law enforcement-type missions, review of law enforcement physical demands research can inform needs analysis as well as physical training programming goals. A majority of reported domestic law enforcement physical tasks involve stability, agility, flexibility/ROM, power and anaerobic abilities. Physical training programming to prepare soldiers assigned these types of tasks should consider these abilities to increase likelihood of mission success.

AUTHORS

Joseph Dulla (1)
Ben Schram (2)
Robin Orr (3)
Robert Lockie (4)
Jay Dawes (5)

(1) Los Angeles County Sheriff's Department (Los Angeles, United States); (2) Faculty of Health Sciences and Medicine, Bond Institute of Health and Sport, Bond University,Tactical Research Unit (Gold Coast, Australia); (3) Faculty of Health Sciences and Medicine, Bond Institute of Health and Sport, Bond University,Tactical Research Unit,Gold Coast QLD 4229, Australia (Gold Coast, Australia); (4) Faculty, Department of Kinesiology, California State University, Fullerton, Fullerton, USA (Fullerton, United States); (5) Faculty, College of Health, Education, and Aviation, Oklahoma State University, Stillwater, Oklahoma, USA (Stillwater, United States)

DIETARY INTAKE, BELIEFS AND BARRIERS IN A MIXED COHORT OF LAW ENFORCEMENT PERSONNEL UNDERGOING TRAINING

PURPOSE

Law enforcement personnel may follow suboptimal dietary practices which can impair performance or enhance their risk for nutrition-related chronic diseases. Shift work, food availability, psychological stress associated with duty tasks and other practical factors can contribute to a range of negative health-related behaviors. The purpose of this study was to describe food habits, barriers and beliefs of a cohort of law enforcement personnel to advise appropriate nutrition support.

METHODS

Law enforcement personnel (n=159), aged 18years, were surveyed at a recruitment training unit. Including custody assistants, civilian jailers, sworn deputies, police officers and outside law enforcement reserve peace officers (26.5 (19-60) years; 74% males). Validated paper-based surveys were conducted including The Perceived Barriers to Healthy Eating Scale, Food Choice Questionnaire and Rapid Eating Assessment for Participants. Survey data were analyzed using SPSS Statistics. Categorical variables were reported as frequency (n) and total percentage (%). Percentages refer to valid data available for variables.

RESULTS

Overall, 91% (n=143) of participants placed high importance on consuming nutritious food that keeps them heathy with 80% (n=126) placed importance on consuming food high in vitamins and minerals. A further 80% (n=127) emphasized high protein content and 41% (n=62) followed a high protein diet and 50% did not follow a special diet (n=77). Additional variables of high importance were taste (84%, n=134), availability (82%, n=131), ability to keep them awake and alert (80%, n=127), value for money (77%, n=123), simple to cook (72%, n=114) and easy to prepare (67%, n=106).

Barriers to healthy eating were busy lifestyle (60%, n=94), irregular working hours (41%, n=64), lengthy food preparation (35%, n=55), price of healthy food (32%, n=51) and cooking skills (30%, n=48). Overall however, 80% (n=127) stated they were very willing to make changes in eating habits to be healthier. Perceived support to eat healthier included family support, meal preparation, increasing knowledge in healthy eating, cooking and food preparation and seeking a guidance from a nutritionist/professional.

CONCLUSIONS

This study highlights food habits, barriers and beliefs of law enforcement personnel. Understanding unique needs and barriers of law enforcement personnel is important to tailor appropriate nutrition support for motivated personnel.

OPERATIONAL RELEVANCE

Police officers are at a higher risk of cardiovascular disease than the general population. Dietary intake is strongly linked to health and performance and modifiable changes that support law enforcement personnel to improve dietary intake, recognize and challenges will have clear implications for their disease-risk and performance.

AUTHORS

Joseph Dulla (1)
Charlene Matthews (2)
Kristen MacKenzie-Shalders (3)
Robin Orr (4)

(1) Los Angeles County Sheriff's Department/Bond University (Los Angeles, United States); (2) Faculty of Health Sciences and Medicine, Nutrition and Dietetics, Bond University, Gold Coast QLD 4229, Australia (Gold Coast, Australia); (3) Faculty of Health Sciences and Medicine, Bond Institute of Health and Sport, Bond University,Gold Coast QLD 4229, Australia (Gold Coast, Australia); (4) Faculty of Health Sciences and Medicine, Bond Institute of Health and Sport, Bond University,Tactical Research Unit,Gold Coast QLD 4229, Australia (Gold Coast, Australia)

THE RELATIVE IMPACT OF MORALE WELFARE ON HEALTH AND MOTIVATION DURING DEPLOYMENT

PURPOSE

Several individual and organizational factors are relevant for soldiers combat readiness during deployment. While there is ample evidence for the meaning of job characteristics (job content, working climate, demands and infrastructure), research is scarce with regard to the additional benefit of morale welfare which is also considered as one of the important factors that may maintain and develop combat readiness during deployment. Therefore, this study aims at examining the relative influence different aspects of morale welfare (internet supply, sports, entertainment, assistance) on physical and mental health, commitment, current motivation and intention to enroll for another deployment. Taking a comprehensive approach, it is hypothesized that the perceived quality of morale welfare explains variance in outcomes even after controlling for job characteristics and demographics.

METHODS

To test our hypotheses we conducted a survey study during deployment. Participants were N=3095 soldiers of the German Federal Armed Forces serving in different international missions (MINUSMA, UNIFIL, RS, Counter Daesh / Capacity Building Iraq, etc.). 30,7% were service men (enlisted ranks), 41,6% NCO, 12,3% officers and 5,45% were staff officers. 52,2% were under 30 years old. 39,3% were married and 37,8% had children. 8% were female. Participation was voluntary and response rates varied between missions (40% – 90%). We conducted correlational and hierarchical regression analyses.

RESULTS

As expected analyses of correlations reveal that facets of morale welfare are positively related to commitment, job satisfaction, motivation and health, but negatively with physical and mental health complains. These relationships can also be found on the group level. Hierarchical regressions show that facets of morale welfare explain additional variance in outcomes after controlling for demographics, and entering job characteristics. There were significant changes in R^2 for sports and entertainment in predicting motivation, job satisfaction and commitment. Availability and quality of internet supply and sports explained additional variance in physical and mental health outcomes. Hypotheses are supported.

CONCLUSIONS

Although the major amount of variance in indicators of combat readiness can be explained by demographics and job characteristics, the study provides evidence for the meaning of moral welfare. Particularly sports, entertainment and internet independently contribute to combat readiness in terms of motivation, commitment, satisfaction and health.

OPERATIONAL RELEVANCE

Although not the first condition sine qua non in deployment, military organizations should not underestimate the value of morale welfare for performance. Instead, it can be recommended to systematically maintain and develop morale welfare programs.

AUTHORS

Joerg Felfe (1)
Annabell Reiner (1)
Ines Wunderlich (1)
Wenzel Matiaske (1)
Martina Maas (1)
Keven England (2)
Alexander Kleiszmantatis (2)

(1) Hemut-Schmidt University (Hamburg, Germany); (2) German Federal Armed Forces (Potsdam, Germany)

EXPOSING KINESIOLOGY STUDENTS TO PHYSICAL REQUIREMENTS OF MILITARY JOBS THROUGH PHYSICAL TEST AS A WAY TO IMPROVE THEIR PRACTICE WITH SOLDIERS AND RECRUITS

PURPOSE

Improper implementations of training programs may detrimentally affect work capacity, increase the likelihood of injuries, and jeopardize the selection process for recruitment and deployment. The objective of the current project was to evaluate the impact of a new curriculum aimed at improving kinesiology students knowledge and understanding of the physical requirements associated with soldiers job to improve their clinical practice with this clientele.

METHODS

During an undergrad semester, 25 kinesiology students were invited to participate in different physical evaluation protocols used for selection, employment, and deployment among the Canadian Armed Forces (CAF). Used as an experiential learning task (Kolb, 1984), these tests were used to demonstrate the physical requirements associated with different roles in the CAF (i.e., FORCE, SAR-Tech, and Firefighter). Once completed, participants were encouraged to write open-ended comments about these tests and on their overall experience and knowledge gain through this experiential learning task. These comments were then compiled and analyzed for the creation of themes and content analysis.

RESULTS

Once aggregated, students responses highlighted five greater themes: 1) increased awareness of what constitutes a proper and well-designed evaluation of army readiness; 2) better understanding of what are the physical requirements associated with these jobs; 3) how can Personal Protective Equipment or gears can impact ones performance (ex. Firefighter and SAR-Tech evaluations), 4) they have all express that tests looked easier on paper but that there was a clear difference between doing just enough to pass and performing during evaluations; and 5) students recognized the utmost importance of a good health condition and associated healthy habits that are necessary for such jobs.

CONCLUSIONS

Early expositions of health professionals to military requirements have the potential to enhance the quality of their approach to better prepare military and recruits in terms of physical preparedness. This new curriculum promoted better insights into the specific requirements of military employment and was effective at sensitizing kinesiology students for more tailored interventions.

OPERATIONAL RELEVANCE

The improvement of interventions aimed at military and recruits will improve their overall physical readiness for deployment, their performance on the job, or the initial level of fitness before entering the force.

AUTHORS

Martin Lavallière (1)
Frédérique Lehouillier (1)
Serge Couture (2)

(1) UQAC, Lab BioNR & CISD (Chicoutimi, Canada); (2) UQAC (Chicoutimi, Canada)

A FEASIBILITY STUDY COMPARING A PHOTOBIOLOGIC THERAPY KIOSK TO ORAL SUPPLEMENTATION TO PROMOTE VITAMIN D SUFFICIENCY

PURPOSE

To demonstrate the capability of a photobiologic therapy kiosk (PBK) to stimulate production of circulating 25-hydroxyvitamin (OH)D as safely and efficiently as an oral D3 supplement (OS). Vitamin D deficiency negatively affects health at all ages, contributes to accelerated bone loss during adulthood, and has been linked to a growing list of conditions including musculoskeletal injuries, depression, and cardiovascular disease with a high likelihood of degradation of Warfighter readiness. Narrow band UVB radiation penetrates exposed skin and efficiently produces D3 when delivered via PBK.

METHODS

Aims of this prospective randomized trial were: 1. Determine acceptability and feasibility of the PBK; 2. Demonstrate the PBK is equivalent to recommended daily D3 intake to raise/ maintain 25(OH)D levels; and 3. Examine the relationship of season, body fat, and skin type to 25(OH)D response. Intervention was PBK every other week or OS (D3 600 IU) daily for 10 weeks. Primary outcome was serum 25(OH)D level. Mann-Whitney test used to assess continuous data, Chi squared test for pairwise comparisons of categorical data. Significance set at $p < 0.05$.

RESULTS

98 adults volunteered; attrition rate 10% with final OS n=45, PBK n=43. Demographics: median age 35 yrs, mostly female (60%), with no differences observed between groups for age, race/ethnicity, or marital status. No difference seen in skin type, nor birth location, sun exposure, or use of sunscreen. OS group had higher BMI and%body fat. Baseline 25(OH)D levels were similar, $p = 0.25$. Month 3 median OS 25(OH)D 25.5 ng/mL and PBK 30 ng/mL; $p = .01$. Month 4 OS 25(OH) D level 21 ng/mL, and PBK 27 ng/mL; $p = .04$. Adherence: OS 92% vs PBK 100%. There were no adverse events.

CONCLUSIONS

Use of the PBK every other week achieved higher serum levels of 25(OH)D than standard of care vitamin D 600 IUs/ day for 10 weeks, although both groups returned to baseline levels a short 30 days later. At a time when self-care measures are highly valued for health promotion, programmed UVB delivered via PBK in the community, appears to be a safe, efficacious alternative to oral D3 supplementation but requires recurring use.

OPERATIONAL RELEVANCE

Vitamin D deficiency is widespread in Service Members of all ages with links to physical and mental health. Results from this study suggest a need for early intervention in preventable health conditions impacting Warfighter performance and readiness, particularly pre-deployment when optimizing long-term wellness for duty in an austere environment.

AUTHORS

Mary McCarthy (1)
Evelyn Elshaw (2)
Barbara Szekely (2)
Tom Beltran (2)

(1) U.S. Army (Tacoma, United States); (2) The Geneva Foundation (Tacoma, United States)

GENITOURINARY HEALTH IN FEMALE MILITARY PERSONNEL: AN EXPLORATION OF PREVALENCE AND IMPACTS ON OCCUPATIONAL PERFORMANCE

PURPOSE

Genitourinary health issues, such as incontinence, pelvic organ prolapse and urinary tract infections, more commonly affect women. Whilst anatomical differences, parity, and menopause represent non-modifiable risk factors, high impact physical activity, load carriage, and sanitary conditions have been implicated. This presentation will explore what is currently known about the genitourinary health of women working in military contexts, examine the specific risk factors, and consider the relationships with occupational health and performance.

METHOD

Published studies of relevance to the aim were identified through searches of journal databases and consultation with experts in the field. Findings of relevance were extracted and synthesised to provide an overview of current knowledge on the topic.

RESULTS

Genitourinary symptoms such as urinary tract infections are quite common, with 30.4% of women in the US Armed Forces experiencing them compared with 3.5% of men. Similarly, in a US military survey, 26% of female soldiers reported experiencing urinary incontinence during physical activity. One third reporting incontinence also needed to modify or stop the aggravating activity, demonstrating that occupational performance was affected. Of concern is that common strategies to manage urinary incontinence – restricting fluid intake or postponing voiding – may lead to more serious health issues such as heat illness.

Differences in genitourinary anatomy, poor sanitation conditions and more challenging toileting practices, particularly during field exercises or when deployed, are likely to increase the risk of urinary symptoms and infections in servicewomen. Female military personnel have also been reported to be less likely to seek medical attention for genitourinary symptoms because of limited women-specific health services and female medical staff, embarrassment and poor confidentiality.

These findings provided background for the development of a survey on female pelvic health in the Australian Defence Force. Preliminary findings from this survey will be discussed, if available, alongside the findings from published studies.

CONCLUSIONS

Further research is required to more broadly investigate female genitourinary health in military contexts, including the types, severity, prevalence and their coexistence in this population, the strategies used to manage these conditions in military contexts, and the impacts of female genitourinary conditions on occupational performance.

OPERATIONAL RELEVANCE

Women are increasingly assuming non-traditional, more physically-demanding roles within military forces. The unique operational demands of many military roles may place servicewomen at a higher risk of genitourinary health issues, which in turn may impact on their occupational health, safety and performance.

AUTHORS

Simone O'Shea (1)
Rob Orr (2)
Rod Pope (1)
Rob Orr (2)
Katharine Freire (1)

(1) School of Community Health, Charles Sturt University (Albury, Australia); (2) Tactical Research Unit, Bond University (Robina, Australia)

3.1
HOLISTIC HEALTH AND FITNESS/ THE PERFORMANCE TRIAD
#ABS271
POSTER PRESENTATION

FEBRUARY 12, 2020

ASSOCIATIONS BETWEEN AGE, PHYSICAL FITNESS, AND BODY COMPOSITION IN U.S. ARMY ACTIVE DUTY SOLDIERS

PURPOSE

To determine changes in physical fitness and body composition that accompany increased age in U.S. Army Soldiers, we examined associations/interactions between age, physical fitness, and body composition in Active Duty Soldiers across a wide variety of ages.

METHODS

Male (n=123,963; 28±7 y (mean±SD)) and female (n=21,462; 28±7 y) Soldiers with complete 3-event Army Physical Fitness Test (APFT) and anthropometrics (weight, height) records were examined by continuous age (17-70 y) or stratified by age groups. The APFT assessed muscular endurance through push-ups (PU) and sit-ups (SU) in two minutes and cardiovascular endurance through a timed two-mile run (2MR). Anthropometrics and body composition were assessed via body mass index (BMI; kg*m-2) and weight-for-height (Wt/Ht) standards. Determinations of passing/failing body composition standards were made using age/sex-adjusted measurements (Wt/Ht and subsequent/conditional circumference-based (tape test) body fat (%BF)) following Army Body Composition Program (ABCP) guidelines. Data were analyzed with independent t-tests, correlations, and Mantel-Haenszel chi square.

RESULTS

Women, on average, performed fewer PU (38.1±11.6 vs. 62.3±13.3) and SU (65.7±12.7 vs. 66.4±11.7) repetitions and ran slower on the 2MR (17.8±2.1 vs. 15.3±1.7 minutes) vs. men (all $p<0.01$). Correlations indicated that PU, SU, and 2MR performance decreased ($p<0.01$) with increasing age in women (r=-0.05,-0.05, and 0.17, respectively by event) and men (r=-0.04,-0.15, and 0.20, respectively). However, linear trends and higher odds ratios (ORs) indicated that successively older APFT age-grouped men and women were more likely to achieve maximal (100 points) scores on each APFT event or 300 points on the composite APFT, compared to the youngest group (17-21 y). BMI increased with increasing age (women: r=0.11 and men: r=0.19), as did the likelihood to be overweight (25-29.9 kg*m-2) or obese (30 kg*m-2) in successively older APFT age-grouped men and women. Older ABCP age-grouped men were 22.730.2% less likely to pass Wt/Ht standards (ORs: 0.70-0.77, $p<0.01$), but successively older ABCP age-grouped men were 1.57.0 times as likely to pass%BF standards (ORs: 1.45-6.99, $p<0.01$), compared to the youngest group (17-20 y). For women, there were no associations between passing/failing Wt/Ht standards and age group; however, successively older ABCP age-grouped women were 2.38.2 times as likely to pass%BF standards (ORs: 2.26-8.22, $p<0.01$), compared to the youngest group.

CONCLUSION

Fitness declined and BMI/%BF increased with increasing age; however, more lenient standards may disproportionately benefit aging Army Servicemembers.

OPERATIONAL RELEVANCE

Fitness and body composition standards for older age groups may need to be revisited.

AUTHORS

Joseph Pierce (1)
Keith Hauret (1)
Ryan Steelman (1)
Bruce Jones (1)

(1) U.S. Army Public Health Center (APHC) (Aberdeen Proving Ground, United States)

COMPARING THE INCIDENCE OF THE FIVE MOST IMPORTANT (THE BIG FIVE) NON-COMMUNICABLE DISEASES IN MILITARY PERSONNEL AND CIVILIANS IN GERMANY

PURPOSE

Military personnel is exposed to occupation-specific stressors and demands, e.g. exposure to heat/cold, heavy load-carrying or disadvantageous working hours. Simultaneously, recent studies reveal declining physical performance and resilience in soldiers. Soldiers are not immune to the negative impacts of unhealthy leisure time behavior and as a result are prone to the development of the corresponding lifestyle diseases.

Aim of the present study is the comparison of German military personnel with their civilian counterpart concerning incidence of the Big Five of non-communicable diseases as defined by the WHO (cancer, type-II diabetes, cardiovascular disease, chronic diseases of the lower respiratory tract, and mental illness).

METHODS

Big Five (B5) incidence based on sick days (unfit for service) were extracted from the registry databases at the Bundeswehr Institute for Preventive Medicine for the years 2012 – 2016 and stratified for age and gender. Corresponding data for civilians were obtained from official reports of the statutory health insurance (GKV). Data were transformed into incidence rates (sick days per 10.000 persons) and standard mortality rates for both groups for better comparability.

RESULTS

Civilians showed markedly higher B5 incidence than soldiers. Except for chronic diseases of the lower respiratory tract, marked gender-specific differences were observed in civilians. In comparison, gender-related differences were virtually #ABSent in soldiers. Notable exception were mental illnesses: female soldiers showed an elevated rate of #ABSence for the years 2012 2015.

CONCLUSION

These preliminary results must be taken with careful caveats due to unadjusted differences in age and gender distributions and the potential influence of socioeconomic status. The phenomenon of considerably lower B5-related sick-days in soldiers might be an indicator of positive effects of health and fitness promotion in the military, specific protective factors such as regular physical training/activity on duty and close-meshed control by the medical corps.

Further root cause analyses with tighter control for socioeconomic factors and age and gender distribution are needed to confirm this hypothesis.

OPERATIONAL RELEVANCE

Despite occupation-specific stressors and demands, higher levels of mandatory physical activity as well as health and fitness promotion in the armed forces may be a protective factor against the Big Five in soldiers.

AUTHORS

Peter Richter (1)
Melanie Schmeil (1)
Alexander Sievert (1)
Dieter Leyk (2)

(1) Bundeswehr Institute for Preventive Medicine (Andernach, Germany); (2) 1. Bundeswehr Institute for Preventive Medicine, 2. German Sport University Cologne – Department of Physiology and Anatomy (Andernach, Germany)

CORRELATION BETWEEN VISCERAL ADIPOSAL TISSUE AND METABOLIC SYNDROME RISK FACTORS IN BRAZILIAN ARMY MILITARY

INTRODUCTION

The metabolic syndrome (MS) is defined as a condition where risk factors for cardiovascular diseases and diabetes mellitus occurs in the same individual. Its main components are central obesity, hypertension, dyslipidemia and insulin resistance. It is more common in the male population. Adipose tissue, depending on where it is stored, differentially affects metabolic health, with visceral adipose tissue (VAT) being more damaging. The objective of this study was to verify the correlation between VAT and MS risk factors in military of the Brazilian Army.

METHODS

A total of 246 Brazilian men Army soldiers (38.2 ± 7.28 years, 177.4 ± 6.06 cm, 87.5 ± 11.94 kg) participated in the study. We collected data on height, body weight, and metabolic syndrome (fasting glycemia, triglycerides, HDL cholesterol, waist circumference, systolic (SBP) and diastolic (DBP) blood pressure). MS was defined based on the IDF/IAS/IASO harmonizing criteria as the presence of any three out of the five risk factors.

The VAT was obtained from dual energy X-ray #ABSorptiometry (DXA) scans analyzes. The sample was divided into two groups: military syndromic and non-syndromic. Student t and Mann Whitney tests were performed to find differences between groups, as well as Pearson and Spearman correlation test for correlation between variables. Data were analyzed in the BioEstat® program, version 5.0, with a 5% percentile ($p < 0.05$) as the significance level adopted.

RESULTS

It was found that 72 military (29,3%) had MS. We find significant differences in waist circumference, triglycerides, blood glucose, SBP, DBP and VAT, being the highest values in the syndromic group. For HDL cholesterol, a statistically significant difference was also found, but with a lower value for the syndromic group. A very strong positive association was found between VAT and waist circumference, fasting blood glucose, triglycerides, systolic blood pressure diastolic blood pressure. A negative association was found between VAT and HDL cholesterol.

DISCUSSION AND CONCLUSION

The prevalence of MS in Brazilian military was similar to that found in the general Brazilian population. The amount of VAT tissue found in the syndromic group was much higher than that found in the non-syndromic group. It is known that this is more metabolically harmful than the subcutaneous adipose tissue, which may be one of the justifications of the VAT to be strongly associated with the risk factors of the MS. Visceral adipose tissue can be used as an anthropometric indicator for the diagnosis of MS in Military of the Brazilian Army.

AUTHORS

Laércio Rodrigues (1)
Samir Rosa (2)
Ricardo Falcão (1)
Marcos Fortes (2)
Miriam Mainenti (1)
José Fernandes Filho (3)

(1) Brazilian Army School of Physical Education (Rio de Janeiro, Brazil); (2) Brazilian Army Research Institute of Physical Fitness (Rio de Janeiro, Brazil); (3) Rio de Janeiro Federal University (Rio de Janeiro, Brazil)

AGE AND SEX RELATED ABILITY AND READINESS FOR SPORTING EFFORTS OF 20 TO 64 YEARS OLD RUNNERS

PURPOSE

Physical and sporting performance are subject to characteristic age-related change processes caused by biological ageing and, no less important, changes in training and lifestyle. Changes restricting physical resp. sporting performance often begin as early as young adulthood. Training parameters like volume and intensity play a decisive role for the adaptive outcome. The present large-scale survey of regularly trained runners examines the ability and willingness to train intensively, and to push themselves to the limits of their capabilities.

METHODS

The nationwide survey (www.dshs-koeln.de/med-pace) gathers data of actively exercising subjects. The questionnaire includes items concerning sporting activity (e.g. training habits, sport experience), health and medical risk factors (modified PAR-Q questionnaire). Subjective data about how often subjects train close to the limits of their physical capacity ("exercise intensity") and their motivation for physical activity are estimated by using 10-point-Likert-scales. A subsample of 13,627 runners was extracted from participants with complete datasets (>160.000). Selection criteria were: (1) regular training for at least 2 years with (2) 2-5 sessions/week and (3) 11-60 km/week. Statistical analyses include ANOVA, correlation, regression-analyses, and pair-comparisons by Duncan-test.

RESULTS

8,592 men and 5,035 women (43.7±10.5 vs. 40.3±10.9 years; $p<0.001$) began running 10.4±9.1 resp. 8.6±7.5 years in the past ($p<0.001$) with volumes of 32.2±12.3 resp. 28.5±11.5 km/week ($p<0.001$). Age-related exercise-intensity decrease was approximately continuous and independent of training volume. This also applied for the intensity related to motivation, whereas motivation remained almost constant (each $p<0.001$). Females rarely train to their performance limits, reported greater motivation and lower intensity/motivation relation (5.66±1.88 vs. 5.80±1.89, 8.45±1.44 vs. 8.31±1.37, 0.70±0.39 vs. 0.72±0.36, each $p<0.001$). Intensity correlates with age, motivation, and running experience ($r=-0.21$, $r=0.14$, $r=-0.12$, all $p<0.001$). Regression analysis indicated age, motivation, and sex as strongest predictors for intensity (standard-beta-0.18, 0.14,-0.06, all $p<0.001$). Training volume and health status had no explanatory value.

CONCLUSION

From young adulthood, the frequency of training close to physical limits is declining in men and women. Intensity, besides volume and frequency of training, is one criteria for adaptation. Despite almost consistent high motivation for exercise, subjective assessment of exercise intensity decreased with age.

OPERATIONAL RELEVANCE

Endurance training is one highly relevant aspect to maintain and improve physical fitness. In view of the application of more varied and intensive forms of training even in advanced age groups, training elements like CrossFit or high-intensity training could be considered.

AUTHORS

Thomas Rüther (1)
Nadine Hartmann (2)
Alexander Witzki (2)
Alexander Sievert (2)
Ralph Schomaker (3)
Herbert Löllgen (4)
Dieter Leyk (5)

(1) German Sport University – Research Group Epidemiology of Performance (Cologne, Germany); (2) Bundeswehr Institute for Preventive Medicine – Division A: Health and Performance Promotion (Andernach, Germany); (3) Centre of Sports Medicine (Münster, Germany); (4) European Federation of Sports Medicine Associations (Lausanne, Switzerland); (5) 1. Bundeswehr Institute for Preventive Medicine – Division A: Health and Performance Promotion, 2. German Sport University – Research Group Epidemiology of Performance (Andernach, Germany)

THE EFFECTS OF SEATED LOAD CARRIAGE ON MOBILITY

PURPOSE

Increased sitting time has been associated with higher rates of obesity, greater risk of chronic disease, increased pain, and poor mobility. Sedentary tasks requiring sitting for extended periods, often with external load (e.g. body armor) are common tactical occupational requirements, which may have detrimental effects on health, mobility and functional task performance. Thus, the purpose of this study was to determine the effect of an acute seated load carriage (LC) session on dynamic mobility.

METHODS

Eighteen recreationally active Merrimack College students (age: 23.33 +/-1.45 yrs.) participated in the randomized, within groups, crossover study. All subjects completed three total study visits: a familiarization session, a seated LC session and an unloaded seated session. For both experimental sessions, subjects were seated for 1 hour on a 55 cm (21.65 in.) high bench without back support. During the loaded session, subjects wore a 15.88 kg (35 lb.) tactical vest. Directly prior to and immediately after the 1-hour period, subjects mobility was assessed using the deep squat (DS), shoulder mobility (SM), and straight leg raise (SLR) components of the Functional Movement Screen (FMS). Differences in pre-and post-FMS scores were assessed using paired T-tests. Statistical significance was set at $p<0.05$.

RESULTS

In the loaded condition, we observed significant differences between pre-and post-FMS scores for the DS ($p<0.05$), but no significant differences in the SLR and SM tests. There were no significant differences between pre-and post-FMS scores for any of the tests in the unloaded condition.

CONCLUSION

Our study demonstrated a significant change in dynamic mobility as a result of extended sitting time while wearing a 15.88 kg load. As the DS test specifically assesses hip, trunk and pelvis range of motion (ROM) as well as postural control, the changes in DS score may reflect reductions in hip, trunk, and pelvis ROM and increased core musculature fatigue as a result of sitting with the addition of external load.

OPERATIONAL RELEVANCE

Our results suggest that use of a weighted tactical vest when in a seated posture may contribute to reductions in ROM and increased postural fatigue, with potential negative impact on tactical occupational task performance, health, and resilience. More research is needed to confirm these findings in tactical populations, utilizing longer sitting duration and varying types of tactical LC equipment.

AUTHORS

Tunde Szivak (1)
Jamilia Almonte (1)
Joshua Grover (1)
(1) Merrimack College (North Andover, United States)

3.1
HOLISTIC HEALTH AND FITNESS/ THE PERFORMANCE TRIAD
#ABS034
POSTER PRESENTATION

FEBRUARY 12, 2020

SOLDIERS' PHYSICAL FITNESS DECREASES AND BMI INCREASES DURING THEIR EARLY CAREER

PURPOSE

In Finland, aerobic fitness of Finnish conscripts has decreased from 1980s (Santtila et al. 2018), but there are no studies about physical fitness in professional soldiers during their working career. The purpose was to evaluate physical fitness and body composition in soldiers during their early career in the Finnish Defence Forces (FDF).

METHODS

A longitudinal study including 180 Lieutenants, who had started their officer career in 2013 or 2014. In the FDF, soldiers perform physical fitness tests and body composition measurements annually. The physical fitness tests consist of 12-min running test, standing long jump, and 1-min sit-up and 1-min push-up tests. Before the physical fitness tests body mass, height and waist circumference are measured. The physical fitness and body composition data were collected from the official data base of the FDF for the baseline results in 2013 or 2014 (PRE) and for the 4-year follow-up results in 2017 and 2018 (POST). Differences between PRE and POST results were detected by using dependent t-tests.

RESULTS

Aerobic fitness performance decreased by 2% (-57 m) (PRE: 2790±322 vs. POST: 2736±259 m, $p<0.05$) and standing long jump by 1% (-2.3 cm) (PRE: 241±18 vs. POST: 239±19 cm, $p<0.05$). Sit-ups decreased by 3% (-2 reps./min) (PRE: 49±8 vs. POST: 47±8 reps./min, $p<0.05$) and push-ups by 4% (-2 reps./min) (PRE: 46±11 vs. POST: 44±11 reps./min, $p<0.05$). Inversely, body mass increased by 4% (+3.4 kg) (PRE: 81.5±9.8 vs. POST: 84.8±10.6 kg, $p<0.05$) and BMI by 4% (+1.1) (PRE: 25.0±2.6 vs. POST: 26.1±3.0 kg, $p<0.05$). Waist circumference increased by 4% (+3.7 cm) (PRE: 87.0±8.3 vs. POST: 90.7±8.8 cm, $p<0.05$).

CONCLUSIONS

Negative changes in physical fitness and body composition exist during the early career of soldiers. Therefore, support, such as individually optimized physical training programs, may be needed in order to maintain or improve their fitness levels. It may be that the new demands from military occupation in general, including numerous military field training days and, on the other hand, challenges in combining family and working life induce combination of stress factors, As a consequence, they may be reflected as decreased physical training and non-optimal diet leading to negative changes in physical fitness and body composition in early career of the soldiers.

OPERATIONAL RELEVANCE

Negative trends in fitness and body composition observed may compromise optimal performance in some occupational tasks, which require high level of physical fitness.

AUTHORS

Jani P Vaara (1)
Kai Pihlainen (2)
Jussi Rusila (1)
Tommi Ojanen (3)
Heikki Kyröläinen (4)

(1) National Defence University (Helsinki, Finland); (2) Training Division, Defence Command (Helsinki, Finland); (3) Finnish Research Agency (Tuusula, Finland); (4) University of Jyväskylä (Jyväskylä, Finland)

REFERENCES

Santtila et al. 2018.

MODELING THE RELATIONSHIP BETWEEN HELMET PAD PHYSICAL PROPERTIES AND PERCEIVED COMFORT

PURPOSE

Comfort is critical for helmet pad suspension system acceptability and wear compliance. User comfort is typically not assessed early in development, potentially resulting in a pad that performs well during impact testing but causes discomfort to users during long-term wear times. This projects goal was to identify critical physical properties that best predicts user wear comfort for early indications of system acceptability.

METHODS

Fifteen Soldier volunteers provided comfort ratings on a 1 to 100 visual analog scale and feedback at the end of a 2-4 hour wear period for five separate Army Combat Helmet (ACH) pad systems, utilizing a repeated measures design. Measures of pad foam stiffness over a range of temperatures and drop test mechanics at an impact velocity of 3.05 m/s were also collected. These physical pad properties included: start and flexpoint temperatures; start, flexpoint, 30C, and body temperature stiffness; peak force, peak time and estimated impact time. A linear mixed model (LMM) was used to investigate which combination of physical pad properties were significant predictors of perceived comfort.

RESULTS

Although many combinations of properties provided excellent predictive models of comfort, the simplest and best fitting model included only pad start temperature. The model that included pad start temperature as a significant predictor explained significantly more variance of perceived comfort than did the unconditional model that included only the within-subjects residual variance (change in-2 restricted log likelihood of 23.275, df = 2, $p < .001$).

CONCLUSIONS & OPERATIONAL RELEVANCE

The presented results provide initial information from two test methods (properties and human subject based) on the relationship between the physical pad properties and perceived helmet comfort. This model indicated that many of the standard physical properties test methods for helmet development are significantly correlated with comfort, with start temperature being the most significant predictor. Although physical properties can provide initial indications of predicted pad comfort, subject variability was large and other factors need to be explored further to account for some of these individual differences to fully understand perceived helmet pad comfort (e.g., contact pressure, fit, activity). A fully developed comprehensive model will be helpful to manufacturers and research/development organizations when trying to predict pad comfort for end users, thus improved fiscal responsibility, decreasing system development false starts, and improving the ability to provide Soldiers with the best equipment for maximum performance and protection.

AUTHORS

Stephanie Brown (1)
Melissa Roth (1)
Edward Hennessy (1)
Jose Villa (1)
K. Blake Mitchell (1)

(1) U.S. Army Combat Capabilities Development Command Soldier Center (Natick, United States)

4.4
BASIC TRAINING AS A PLATFORM FOR RESEARCH

#ABS015
POSTER PRESENTATION

FEBRUARY 12, 2020

REVITALIZATION OF THE FORCE SIMULATOR COMPATIBLE WITH TOUCAN T-27 AND SUPER TOUCAN AT-29 AIRCRAFT

The innovative design of a "Force Simulator for the EMB 312 T-27-Toucan" aircraft was developed through the regular research support from FAPESP, N° 2005/51519-0. The result of this research project can be observed through the acquired patent (Privilege of Innovation/Registration number: 0000220708555664), 7 (seven) published articles (3 with impact factor), and presentations at National and International congresses as a result of research using this equipment. In the period from 2008 to 2017, this Simulator was widely used in the post-doctoral research of the beneficiary of the project, entitled "Analysis of Intracranial Pressure (ICP) using a non-invasive method in Brazilian Air Force Aviators submitted to increases in Gz in flight and simulator force tests", FAPESP n° 2014/21803-7. Research partnerships were carried out with researchers from the Medical School of Ribeirão Preto/USP, Institute of Physics of São Carlos/USP, Technological Institute of Aeronautics, and Center of Aerospace Research in Microgravity of the Pontifical Catholic University of RS, providing great study possibilities in the area. Aiming at the continuity of the experiments, we are requesting through FAPESP Regular Aid support for "Revitalization of the Force Simulator and suitability of compatible loads on the T-27 Toucan and AT-29 Super toucan aircraft". The objective of this current project is to carry out more advanced research in a sector still little explored in Brazil (aerospace), but with increasing worldwide expansion, providing continuity to studies revitalizing the Force Simulator. For this we count on our experience of more than thirteen years of research in the field, highlighting the results already acquired up to the present moment, and will receive scientific support from researchers and highly specialized institutions. Thus, we won an Regular assistance and financial support for this project to the São Paulo Research Foundation (FAPESP).

AUTHORS

Thiago Augusto Rochetti Bezerra (1)
Paulo Roberto Pereira Santiago (2)
Antonio Carlos Shimano (3)
Juliana Cristina Viola (4)

(1) Graduate Program in Operational Human Performance/PPGDHO, Brazilian Air Force, University of the Air Force, Brazil. (Pirassununga, Brazil); (2) School of Physical Education and Sport of Ribeirão Preto, University of São Paulo, Brazil (Ribeirão Preto, Brazil); (3) School of Medicine of Ribeirão Preto, University of São Paulo, Brazil (Ribeirão Preto, Brazil); (4) Methodist University of Piracicaba, Brazil (Piracicaba, Brazil)

4.4
BASIC TRAINING AS A PLATFORM FOR RESEARCH

#ABS331

FEBRUARY 12, 2020

EFFECT OF A CORE STRENGTH-TRAINING ON INJURY INCIDENCE RATE IN SWISS INFANTRY RECRUITS

PURPOSE

A disequilibrium between low physical fitness and high demands during daily military routine leads to increased injury incidence rates (IIR; Rosendal et al., 2003). Thus, the aim of the study was to investigate the effect of a core strength-training program on injuries in infantry recruits.

METHODS

During week one of basic military training, recruits performed the trunk muscular strength test (TMS; Wyss et al., 2007). Based on TMS results, individuals were assigned to three groups: intervention group (IG) low TMS (<120s), control group (CG) low TMS (<120s), CG high TMS (>120s). The IG performed a circuit core strength-training, focusing on coordination and core strength under physiotherapist supervision, twice a week during 5 weeks in addition to the standard Swiss Armed Forces physical training. Whereas, both CG only participated in the standard training. In week 7, TMS was repeated. Additionally, trained medical staff, blinded to the individuals group assignment, recorded musculoskeletal injuries, days with dispensation from physical training and medical attrition. To analyze the changes within and between groups, non-parametric group mean tests were applied.

RESULTS

Both groups with low TMS, intervention (n=65) and control (n=96), significantly ($p<0.001$) improved core strength, with the IG significantly outperforming the CG (+74% starting at 93±27s vs. +62% starting at 87±21s, all $p<0.01$). CG high TMS (n=120) showed no change (-1%, starting at 192±67s, $p=0.525$). IIR were 30%, 60%, and 31% for IG, CG low TMS and CG high TMS, respectively. Compared to CG low TMS, dispensation days and medical attrition were reduced by-57% and-27% in IG and-32% and-39% in CG high TMS, respectively.

CONCLUSIONS

Both groups with low initial TMS results improved core strength significantly during the study period. However, only IG was able to reduce IIR by 50% to the level of the CG with high initial TMS.

OPERATIONAL RELEVANCE

With only a 5-week training program (+60-75 min/week), beneficial effects on physical fitness, IIR, dispensation days and attrition rate were observed. If the Swiss Armed Forces were to implement such a program, at least for trainees with low core strength, it would save costs and increase squads military performance.

AUTHORS

Lilian Roos (1)
Andrea Chavez (2)
Andrea Chavez (2)
Thomas Wyss (1)

(1) Swiss Federal Institute of Sport Magglingen SFISM (Magglingen, Switzerland); (2) Swiss Armed Forces Staff Medical Services (Ittigen, Switzerland)

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4.4
BASIC TRAINING AS A PLATFORM FOR RESEARCH

#ABS258
POSTER PRESENTATION

FEBRUARY 12, 2020

MODELING FACTORS AFFECTING GRADUATION FROM SECONDARY OFFICER TRAINING

PURPOSE

The purpose of this study was to identify factors contributing to military officers graduating from secondary officer training (SOT) on their first attempt.

METHODS

Data on 1,040 officers (932 males and 108 females) from five different training companies were collected at the start of SOT. Independent variables included sex, marital status, race, age, education level, commissioning source, smoking history, presence of current musculoskeletal injury or pain (MSKI/MSKP), Connor-Davidson Resilience Scale (CD-RISC) and Short Grit Scale scores. The response variable graduation on first attempt was obtained from official records. Officers who graduated on their first attempt were categorized as yes and the others as no. Associations between independent variables and the likelihood of graduating from SOT on the first attempt were assessed using a logistic regression model.

RESULTS

Among the 1,040 officers surveyed, the majority were single (79.8%; n=830), had a bachelors degree (94.5%; n=983), and were white (72.3%; n=752). A total of 11.8% (n=122) of officers were from a military academy, 9.5% (n=99) from an enlisted commissioning source, 18.8% (n=196) from a leadership course, 43.6% (n=453) from officer basic training, and 16.3% (n=170) from an ROTC program. A small percentage of officers, 11.2% (n=116), were smokers. Among officers, 13.8% (n=143) reported entering SOT with MSKI/MSKP. In total, 86.0% (n=894) of officers graduated on their first attempt. Factors that lowered the odds of graduating on the first attempt were: age older than 25.6 years (OR=0.47, 95%CI=0.23-0.93, p<0.01), commissioning from officer basic training (OR=0.51, 95%CI=0.23-1.05, p=0.08), presence of current MSKI/MSKP (OR=0.47, 95%CI=0.30-0.75, p<0.01), low Grit score (OR=0.58, 95%CI=0.39-0.89, p=0.01). Having a graduate or professional degree (OR=3.82, 95%CI=1.45-13.2, p=0.01) increased the odds of graduating on the first attempt.

CONCLUSIONS

Older officers, officers commissioning after officer basic training, and those with current MSKI/MSKP, and/or low Grit scores are less likely to complete SOT on their first attempt. Having a graduate or professional degree increases the chance of graduating on the first attempt. Implementing programs that treat common MSKI/MSKP complaints upon entering SOT, as well as programs that improve resiliency, may increase first-time SOT graduation rates.

OPERATIONAL RELEVANCE

Various factors influence an individuals likelihood of successfully completing military training on the first attempt. Identifying modifiable factors that increase the likelihood of graduating from training may inform intervention efforts to improve first time graduation rates. This study underscores the importance of MSKI/MSKP and low resiliency as hindrances to successful completion of military training

AUTHORS

John Tra (1)
Daniel Clifton (2)
Daniel Clifton (1)
Amelia Barrett (1)
Emily Southmayd (1)
Sarah de la Motte (1)

(1) 1 Consortium for Health and Military Performance, Department of Military and Emergency Medicine, F. Edward Hébert School of Medicine, Uniformed Services University. 2 Henry M. Jackson Foundation for the Advancement of Military Medicine (Bethesda, United States); (2) Consortium for Health and Military Performance, Uniformed Services University (Bethesda, United States)

A MINIMALISTIC 4 WEEK EXERCISE PROGRAM WITHOUT ADDITIONAL EQUIPMENT IMPROVES GLOBAL STRENGTH, ENDURANCE AND FLEXIBILITY IN UNTRAINED PERSONS

INTRODUCTION

Physical fitness is a major requirement for soldiers to conduct demanding training programs but also to perform tasks on the battlefield. As soldiers for the German Army (Bundeswehr, BW) are recruited from a population which may have developed physical deficits already in school age, there is a high probability that a yet undefined range of soldiers is not in adequate physical condition at the time of deployment. The time between application and deployment offers therefore a possibility to develop strength, endurance and flexibility via a defined training program.

PURPOSE

We aimed to validate the effectiveness of a standardized 4-week training program designed to improve general strength, endurance and flexibility capacities in untrained and sedentary active persons.

METHODS

The exercise plan was developed by sport scientists of the Department for Development from the German Armed Forces Sports School, Warendorf. It was designed for a time time frame of 4 weeks and 4 training sessions per week with volume and intensity progression. Each session lasted 45 min containing a variable mixture of extensive running and bodyweight exercises without any equipment. These consisted basic flexibility routines for warmup, static and dynamic bodyweight strength exercises including, abdominal exercises, pushups, planks, lunges and unilateral variations of these exercises. 9 sedentary active persons (8 females, 1 male) (Age: 34±15, Bodyheight: 171±7 cm, Bodyweight: 69±7 kg) were recruited to participate in the training intervention. Basic strength, endurance and flexibility diagnostics were conducted PRE and POST the study. Statistic evaluation was carried out using two-sided, dependent T-Tests with an alpha level of $p<=0.05$.

RESULTS

Subjects performed in mean 74% of all exercises. 1RM significantly increased in benchpress ($p<0.01$) from 32,2 +-7,5 kg to 36 +-9,5 kg. Time to exhaustion increased ($p =0.021$) from in mean 14,7 to 16,0 min. Peak power output on the ergometer tendencially increased ($p=0.051$) from 155+-33 to 166+-30 Watts. Knee to-wall tests indicated increased flexibility ($p<0.05$) development in both knees from 11,8 +-3,6 cm to 13,4 +-2,9cm (left knee) and from 11,7 +-3,3 to 13,7 +-2,9 cm (right knee). Conclusion: The developed training procedure is sufficient to induce significant improvements of physical performance in untrained persons even with moderate reductions in training time and without equipment.

OPERATIONAL RELEVANCE

We assume this exercise setup to be suitable for enhancing physical fitness in untrained recruits.

AUTHORS

Sebastian Gehlert (1)
Birgit Conrad (2)
Lisa Bardenhorst (3)
Kassube Florian (3)
Roling Birgit (2)
Marcus Wesseler (2)

(1) University of Hildesheim / German Armed Forces Sports School (Hildesheim, Germany); (2) German Armed Forces Sports School, Department for Development, Warendorf, Germany (Warendorf, Germany); (3) University of Hildesheim / Department of Sports Science (Hildesheim, Germany)

RELATIONSHIP BETWEEN CARDIORESPIRATORY FITNESS AND MEASURES OF STRESS AND SLEEP IN ARMY RECRUITS DURING BASIC MILITARY TRAINING

PURPOSE

Military training typically involves a combination of physically and psychologically challenging activities. Excessive stress and/or insufficient recovery may lead to excessive allostatic strain, which may in turn result in various undesirable outcomes including injury, illness and performance decrements. Physical characteristics, specifically cardiorespiratory fitness has previously been shown to attenuate hormonal and subjective stress reactivity in response to military training. Furthermore, cardiorespiratory fitness helps to moderate reactivity to psychological stressors, even in the #ABSence of physical stress. The current study sought to investigate relationships between physical characteristics, stress responses and sleep in Army recruits undertaking basic military training (BMT). It was hypothesised that recruits with higher cardiorespiratory fitness would demonstrate lower stress and better sleep, when compared to less fit recruits over BMT.

METHODS

Thirty eight recruits (34M/4F; age: 24.0 ± 6.8 y, height: 1.78 ± 0.10, body mass: 77.7 ± 14.7, multi-stage shuttle run test predicted VO2max: 43.0 ± 4.6 mL·kg-1·min-1, mean ± SD) participated in the 12-week study. Perceived daily load was assessed each evening with the NASA task load index and daily rate of perceived exertion, and were averaged across each week. Sleep quality and sleep latency were self-reported each day and averaged for each week. Every Sunday morning, wakening saliva samples were collected for cortisol analysis, together with the Short Recovery Stress Scale (SRSS) to assess changes in perceived stress. Relationships were assessed using linear mixed models ($p<0.05$).

RESULTS

Baseline cardiorespiratory fitness was a predictor ($p=0.032$, $r2=0.11$) of the stress composite on the SRSS. There were no other relationships between baseline cardiorespiratory fitness and measures of stress or sleep during BMT.

CONCLUSIONS

Notwithstanding the small sample size, the current results indicate that cardiorespiratory fitness has a weak moderating effect on stress, but it is not associated with improved indices of sleep, or perceived mental or physical exertion in Army recruits undertaking BMT. BMT imposes a variety of physical, physiological, cognitive and psychological stressors upon recruits. Their subsequent response to these stressors is likely influenced by a variety of intra-individual characteristics.

OPERATIONAL RELEVANCE

It is often assumed by military personnel that more fit recruits will cope better with the demands of BMT. However, the current results showed that baseline cardiorespiratory fitness cannot be used to confidently predict the stress response in recruits undertaking BMT.

AUTHORS

Jace Drain (1)
Jamie Tait (2)
Sean Bulmer (3)
Paul Gastin (4)
Luana Main (2)

(1) Defence Science and Technology Group (Fishermans Bend, Australia); (2) Deakin University, Geelong, Institute for Physical Activity and Nutrition, School of Exercise and Nutrition Sciences, Australia (Burwood, Australia); (3) Deakin University, Centre for Sport Research, School of Exercise and Nutrition Sciences, Australia (Burwood, Australia); (4) La Trobe University, School of Allied Health, Human Services and Sport, Melbourne, Australia (Bundoora, Australia)

ASSOCIATION OF PERFORMANCE ON THE OCCUPATIONAL PHYSICAL ASSESSMENT TEST WITH RISK OF INJURY DURING U.S. ARMY INITIAL ENTRY TRAINING

PURPOSE

The U.S. Armys Occupational Physical Assessment Test (OPAT) was developed to screen recruits into jobs they should be physically capable of performing by the end of Initial Entry Training (IET). The four OPAT events are seated power throw, standing long jump, deadlift, and interval aerobic run (IAR). Army jobs are grouped by physical demand categories (PDCs): Heavy (HV: highest), Significant (SI), and Moderate (MO; lowest). Sex-neutral OPAT performance standards were set for each PDC. Recruits must meet the jobs PDC standard on all events. Recruits not meeting the lowest passable standard (MO) on 1 event are considered Unprepared (UN) and cannot begin IET. This study was conducted before OPAT became a requirement and evaluated the association of OPAT performance with injury risks during 10 weeks of IET.

METHODS

1,181 trainees (men: n=948; women: n=233) took the OPAT at the start of IET. Trainees attended similar 10-week IET courses. Injuries were identified from electronic medical records. Trainees with 1 injury were considered injury cases. Analysis for the association of OPAT performance with injury risk were stratified by sex. Risk ratios (RR) and 95% confidence intervals (CI) were used to compare injury risk by OPAT PDC, using the HV PDC standard as the referent group.

RESULTS

Overall, 48% of women and 32% of men were injured during 10 weeks (RR women/men: 1.51; 95% CI: 1.28-1.78). OPAT performance distribution by PDCs differed by sex ($p<0.05$); 77% of men achieved HV or SI standards compared to 15% of women. Compared to men achieving OPATs HV standard on all events, injury risk was higher for men meeting the SI standard (RR: 1.37; 95% CI: 1.06-1.78) and UN men (RR: 1.55; 95% CI: 1.22-1.98). Among women, there was no difference in injury risk between OPAT PDCs. Of OPAT individual events, IAR event performance was associated with injury risk among men (RR UN/HV: 1.52; 95% CI: 1.19-1.95) and women (RR: UN/HV: 1.52; 1.03-2.26).

CONCLUSION

Lower performance on the 4-event OPAT was associated with higher injury risk among men, but injury risk among women was not related to overall OPAT performance. Of the individual events, the IAR (assessment of aerobic capacity) was associated with injury risk in both sexes.

OPERATIONAL RELEVANCE

The OPAT established minimum sex-neutral physical standards to enter the Army and for Army jobs by physical demand category. It is anticipated that implementing these standards for job qualification will result in lower IET injury rates.

AUTHORS

Keith Hauret (1)
Joseph Pierce (1)
Marilyn Sharp (2)
Maria Canino (2)
Jan Redmond (2)
Bruce Cohen (2)
Bruce Jones (1)

(1) U.S. Army Public Health Center (Monrovia, United States); (2) U.S. Army Research Institute of Environmental Medicine (Natick, MA, United States)

ASSOCIATION BETWEEN MUSCULOSKELETAL INJURIES AND THE CANADIAN ARMED FORCES PHYSICAL EMPLOYMENT STANDARD IN CANADIAN MILITARY RECRUITS

The purpose of this study was to investigate for relationships among age, sex, body composition, aerobic fitness, performance on the Fitness for Operational Requirements of the Canadian Armed Forces Employment (FORCE) evaluation and risk of sustaining a musculoskeletal injury requiring intervention in the Training Rehabilitation Program (MSKI-TRP) during Canadian Basic Military Qualification. This was a retrospective analysis of injuries in recruits introduced in the Training Rehabilitation Program (TRP). The Defence Research and Development Canada Human Research Ethics Committee (DRDC-HREC # 2018-046) approved this study. A total of 7192 recruits were enrolled in BMQ between the years 2016 and 2017. From those 7192 recruits, 320 (183 males, 124 females) were introduced in the TRP because of an MSKI. Traumatic MSKIs are the result of a specific single incident as opposed to overuse MSKIs that are caused by repetitive micro traumas. Details about MSKI-TRPs (occurrence, location and type of MSKI) were collected through a short survey completed by the injured recruits in collaboration with a member of the TRP interdisciplinary team. A medical diagnosis by the bases medical staff was, however, required prior to be inserted in the TRP. A two-tailed t-test and a multivariate stepwise logistic regression were completed to investigate the interrelationships of sex, age, FORCE performance (20 m rushes, sandbag lift, intermittent loaded shuttles, and sandbag drag) and health-related characteristics (waist circumference, predicted peak oxygen consumption [V O2peak]) on the odds ratio (OR) for sustaining an MSKI-TRP. The MSKI-TRP intervention rate observed was 4.3% (172 [56.0%] overuse and 135 [44.0%] traumatic). A total of 124 (10.9%) female and 183 (3.0%) male recruits sustained and MSKI-TRP. Rehabilitation duration was an average (SD) of 87 (76) days; nearly 80% of MSKI-TRP were lower-body injuries of which approximately 19.0% (n=46) were clinically treated as a stress fracture. MSKI-TRP recruits were older, performed worse on FORCE, had a larger waist circumference and lower V O2peak than non-TRP recruits ($p<0.01$). Recruits with low performance on the 20 m rushes, intermittent loaded shuttle or sandbag drag were 2.69 (1.89-3.83), 2.74 (1.91-3.95), 2.26 (1.52-3.37), all $p<0.01$ times more likely to sustain a MSKI-TRP respectively. Recruits with low V O2peak were also 2.19 (1.30-3.70) times more likely to sustain an MSKI-TRP. Neither sex nor waist circumference impacted risk of MSKI-TRP when controlling for FORCE performance. V O2peak and FORCE performance are useful measures when assessing odds of sustaining MSKI-TRP in Canadian military recruits.

AUTHORS

Francois Lalonde (1)
Etienne Chassée (1)
Guillaume Leclerc (2)
Marie-Andrée Laroche (2)
Renaud Guimond (3)
Carole-Anne Dufour (4)

(1) Human Performance Research and development, Canadian Forces Morale and Welfare Services, Ottawa, Canada. (Laprairie, Canada); (2) Personnel Support Program, Canadian Forces Leadership and Recruit School, Saint-Jean Garrison, Saint-Jean-sur-Richelieu, Canada (Saint-Jean-sur-le-Richelieu, Canada); (3) 41 Canadian Forces Health Services Centre, Saint-Jean Garrison, Saint-Jean-sur-Richelieu, Canada (Saint-Jean-sur-le-Richelieu, Canada); (4) Saint-Jean-sur-le-Richelieu (Saint-Jean-sur-le-Richelieu, Canada)

EVALUATION OF PHYSICAL FITNESS AND BODY COMPOSITION IN MILITARY ACADEMY STUDENTS

PURPOSE

The aim of the study was to estimate physical fitness of Military Academy students in the context of their body composition.

METHODS

The study group consisted of 88 men with an average age of 21,8 ± 1,65 who were students of Military Academy in Poland. All subjects were examined with the Tanita MC-780MA body analyzer followed by the Yo-Yo intermittent, progressive running test (Yo-Yo Level 1) using Fusion Sport Smart Speed Pro System. All examined soldiers gave their written consent to participate in this study and the procedures were approved by the local Commission of Ethics. Statistical analysis was carried out using Student-t test.

RESULTS

The average distance covered by the students was 756 ± 199 m. Subsequently body composition parameters of the first year students (n-40) were compared with the group of older students (n-48). The differences between the groups were not statistically significant, but 17,5% of younger group of participants (20.4±0.84) covered over 1000 m distance in the Yo-Yo test and only 4,2% of older group participants (23±1.17) was able to achieve this result. These observations are consistent with our earlier findings in Polish Army that most of people with very high initial fitness level lose it at later stage. The best runners represented 11,4% of all investigated men. In the next step we compared the top performing 10 individuals who covered over 1000 m (1139±79,47) to the same number of the lowest performing individuals (480,8±39,89). It was shown that water percent (60.9±2.28 vs 57±3.06) was significantly higher and visceral fat index (2.7±1.42 vs 5.6±2.95) was significantly lower in the top performing group. Fat percent (16.5±2.99 vs 20±4.91) and BMI (24.5±2.36 vs 26.1±3.52) were lower in the top performing group but these values were not statistically significant.

CONCLUSIONS

These findings demonstrate that in general students fitness level is not high. Summing up obtained results, it can be concluded that the body composition analyzer is useful for a quick assessment of exercise capacity. It was shown that water percent was significantly higher and visceral fat index was significantly lower in the top performing group.

OPERATIONAL RELEVANCE

The results should be presented and discussed with trainers at the Military Academy to modify training methods, noting that basic education about training methods and nourishment are necessary

AUTHORS

Ewelina Maculewicz (1)
Ewa Szarska (1)
Ryszard Puchała (1)
Paweł Cięszczyk (1)
Bożena Antkowiak (2)
Oktawiusz Antkowiak (2)
Marek Brytan (2)
Jerzy Bertrandt (3)

(1) Department of Applied Physiology, Military Institute of Hygiene and Epidemiology (Warsaw, Poland); (2) Department of Pharmacology and Toxicology, Military Institute of Hygiene and Epidemiology (Warsaw, Poland); (3) Laboratory of Food and Nutrition Hygiene, Military Institute of Hygiene and Epidemiology (Warsaw, Poland)

CHANGES IN SALIVARY TESTOSTERONE AND CORTISOL ACROSS 12 WEEKS OF BASIC MILITARY TRAINING

PURPOSE

Both testosterone and cortisol have been identified as potentially useful markers to indicate whether military training is too strenuous, and if so may precipitate a maladaptive response. Given recent changes to the Australian Basic Military Training (BMT) program, including the periodisation of physical training, the aim of the current project was to assess changes in markers of stress across the 12-week program. It was hypothesised that 1) changes in testosterone and cortisol would be consistent with exposure to an external stressor; 2) changes in testosterone and cortisol would be consistent with variations in training load across the program; and 3) given modifications to the BMT program, adequate recovery opportunities would be provided.

METHODS

48 Australian Army recruits consented to participate in the project. From this 32 males and 3 females provided weekly saliva samples for the duration of BMT; collected Sundays upon wakening, 30 min post wakening and immediately before bed. To assess subjective recovery and perceived stress, the Short Recovery Stress Scale was completed Sundays upon wakening. The Pittsburgh Sleep Quality Index was completed at baseline and once/month thereafter. Perceived daily load was assessed with the NASA task load index (NASA-TLX). Statistical analysis using Generalised Linear Mixed models were conducted.

RESULTS

There was a significant change in cortisol over time ($p<0.001$) with variations concurrent with variations in training load. The NASA-TLX also changed significantly over time ($p<0.001$), providing further contextual explanations for the observed biomarker findings. Specifically, there were significant changes ($p<0.01$) in mental demand, temporal demand, effort and frustration. Testosterone also changed significantly overtime ($p<0.001$), but contrary to expectations, increased, suggesting an adaptive response to training. Sleep status significantly improved over time ($p<0.05$).

CONCLUSIONS

BMT is stressful, noting that cortisol increased both with, and in the #ABSence of physical stress. The observed testosterone increases across BMT may indicate positive adaptation to the physical training completed, and similarly, be reflective of improved sleep, allowing an inference of adequate recovery provided across the BMT program.

OPERATIONAL RELEVANCE

The observed increases in cortisol were in agreement with previous research, and build upon the preliminary evidence of cortisol as a bio-behavioural indicator of stress in military contexts. The measurement of system-level markers of stress in military recruits is important when assessing stress exposure, and risk of overtraining. Similarly, the monitoring of sleep, and management of recruits perceptions of recovery may be key in managing adaptation to training stress into the future.

AUTHORS

Luana Main (1)
Sean Bulmer (2)
Jamie Tait (2)
Brad Aisbett (1)
Paul Gastin (3)
Jace Drain (4)

(1) Deakin University, Institute for Physical Activity and Nutrition, School of Exercise and Nutrition Sciences (Burwood, Australia); (2) Deakin University, Centre for Sport Research, School of Exercise and Nutrition Sciences (Melbourne, Australia); (3) La Trobe University, School of Allied Health, Human Services and Sport (Melbourne, Australia); (4) Defence Science and Technology Group (Melbourne, Australia)

4.4
BASIC TRAINING AS A PLATFORM FOR RESEARCH

#ABS333
POSTER PRESENTATION

FEBRUARY 12, 2020

HOW DO SWISS ARMED FORCES CONSCRIPTS PREPARE FOR MILITARY SERVICE: TODAY AND TOMORROW

PURPOSE

Daily military routine is physically and mentally more demanding than civilian life (Wyss et al., 2012). Therefore, physical training for military service would be reasonable. Thus, the aim was to evaluate the measures of individual preparation for basic military training (BMT).

METHODS

Volunteers of Swiss Armed Forces BMT schools answered a questionnaire in week 1 of BMT. This questionnaire assessed previous physical activity behavior and measures and/or tools used in preparation for BMT.

RESULTS

Data of 200 (80.3%) male participants was analyzed, thereof, 64.0% classified as trained, 4.0% as regularly active, 16.5% as unregularly active, 9.5% as untrained and 6.0% as inactive previous to BMT. However, 93% participants did not perceive themselves as physically prepared for military service. A third (32.5%) reported that they adapted their physical training before BMT. On the contrary, 16.5% of participants performed no physical activities at all before BMT. Finally, 35%, prepared by wearing in their combat boots. Only 9% reported the use of a smartphone training application to increase physical fitness.

CONCLUSIONS

In Switzerland, young men of full age have to serve mandatory. Despite this fact, only few change or optimize their individual physical training in preparation for BMT.

OPERATIONAL RELEVANCE

A smartphone training application could be a feasible tool during the individual preparation of young men and women for military service. In recent years, many Armed Forces worldwide discovered smartphone training applications to achieve or maintain a certain level of physical fitness within their trainees. The Swiss Armed Forces developed the training app ready #teamarmee with the aim to provide their personnel and the interested civilian population with a digital coach and individual training program based on the current physical fitness level and a specific training focus, adaptable to the occupational military functions. The use of smartphone training applications is not wide spread yet in the Swiss Armed Forces. However, when the (Swiss) Armed Forces know, how their future conscripts prepare for BMT, new or existing products can be adapted for the individual preparation. This would result in physically fitter personnel at the beginning of BMT and later service missions. In 2020, this study will be repeated one year after the introduction of the training app ready #teamarmee to assess if the app does have a (positive) effect.

AUTHORS

Regina Oeschger (1)
Thomas Wyss (1)
Gabrielle Vuille-dit-Bille (1)
Lilian Roos (1)

(1) Swiss Federal Institute of Sport Magglingen SFISM (Magglingen, Switzerland)

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THE INFLUENCE OF PHYSICAL TRAINING ON PHYSICAL CAPABILITY TESTS AND BODY COMPOSITION DURING BRAZILIAN MILITARY CADET TRAINING

PURPOSE

Methods to individualize training programs can provide better outcomes in military performance. The aim of this analysis was to study the effect of basic military training on physical capability tests and body composition among male Brazilian Army cadets with differing baseline capabilities.

METHODS

Freshmen male cadets (N = 356, stature: height: 175.4±0.3 cm, body mass: 69.6±0.5 kg, age: 18.8±0.1 years) undergoing neuromuscular and cardiopulmonary training 90 min/day, 5 days/week, performed running, swimming, pull-up, push-up, and sit-up physical tests, and their body composition was evaluated by densitometry (DXA) at baseline and after 31.9±0.2 weeks. Two-way mixed ANOVAs were conducted to analyze the effect of basic training over time between three groups (lower <1st, middle: 1st-3rd, upper >3rd quartiles defined at baseline). Percent change from baseline (((post-pre)*100)/pre) were calculated for all dependent variables.

RESULTS

Significant interaction effects (p0.001) between time and group were observed for all dependent variables. Percent changes/improvement (mean±SD) from baseline in running time were largest for the slowest group (-13.60±4.64), followed by the middle (-8.96±3.99) and fastest groups (-6.40±2.72). Swimming time also had the greatest improvement in the slowest group (-26.76±9.81), followed by the middle (-10.97±8.57) and fastest groups (-4.24±6.64). The pull-up test had greater improvement in the worst performing group (142.37±153.10), as compared to the middle (41.96±24.83) or best performing group (12.09±14.54). The push-up test showed similar results with improvements of 54.67±27.83, 26.73±12.29, and 2.45±9.92 in the worst, middle and best performing groups, respectively. Similarly, the sit-up test showed improvements of 104.73±48.14, 57.11±29.82, and 6.19±5.15 in the worst, middle and best performing groups, respectively. Fat mass increased in the leanest group by 12.51±15.23 and in the middle group by 5.31±14.40, while it decreased in the highest group (-7.26±14.31). Lean soft tissue increased in the lower group by 4.07±2.87, in the middle group by 2.92±2.77, and in the highest group 1.81±2.50.

CONCLUSIONS

Basic training improved more the groups that performed poorest at baseline. Positive changes in fat mass and lean soft tissue occurred together with the improvement in multiple physical tests among different capacities.

OPERATIONAL RELEVANCE

This study allows precision and control of the training effects, and follow-up a better prediction of performance outcomes. Thus, it is possible to modulate the training intensity without underestimating the best performance results and avoid risk factors due to potential overtraining effect.

AUTHORS

MAURO PASCOA (1)
Mita Lovalekar (2)
Qi Mi (2)
Juliano Borges (3)
Raquel Langer (3)
Vagner Cirolini (3)
Gil Guerra-Junior (3)
Ezequiel Goncalves (3)
Bradley Nindl (2)

(1) STATE UNIVERSITY OF CAMPINAS – UNICAMP BRAZIL (CAMPINAS, Brazil); (2) University of Pittsburgh (Pittsburgh PA, United States); (3) UNICAMP (Campinas SP, Brazil)

4.4
BASIC TRAINING AS A PLATFORM FOR RESEARCH

#ABS129
POSTER PRESENTATION

FEBRUARY 12, 2020

CHANGES IN PHYSICAL PERFORMANCE OF MILITARY CONSCRIPTS DURING THEIR BASIC TRAINING

PURPOSE

Employment of various training methods, as tactical or complex training, along with physical education helps increase physical performance during basic training.

METHODS

Following three disciplines were assessed Sit-Ups in 1 minute, Push-Ups in 30 seconds, and the Cooper Test. Results of individual disciplines were assessed according to limits set in four categories: Outstanding, Good, Satisfactory, and Unsatisfactory. The basic training lasted for three months, physical performance was tested before and after the training and assessed in following categories Improved, Deteriorated, or Unchanged.

Statistical analysis was prepared based on results of seven independent groups seven randomly chosen platoons that went through their basic training in 2018.

RESULTS

The average number of men in one platoon during their entrance tests was 47.29 ± 2.55, and during their final tests 38.71 ± 3.28.

Results of entrance tests: 19.53 ± 8.30% Outstanding, 40.02 ± 8.03% Good, 23.75 ± 10.23% Satisfactory, 12.11 ± 6,15% Unsatisfactory. Results of final tests: 36.97 ± 14.94% Outstanding, 46.37 ± 10.87% Good, 11.59 ± 9.03% Satisfactory, 5.07 ± 5,58% Unsatisfactory.

Results in individual disciplines after the basic training: Sit-Ups: 80.55 ± 14,11% Improved, 13.38 ± 10,50% Deteriorated, 6.07 ± 5.72% Unchanged, Push-Ups: 55.42 ± 9,79% Improved, 32.45 ± 10,94% Deteriorated, 12.13 ± 4.64% Unchanged, Cooper Test: 79.18 ± 7,41% Improved, 11.79 ± 7,02% Deteriorated, 9.02 ± 4.91% Unchanged.

CONCLUSION

During the training, 8.58 ± 2.92 men left, probably for psychical and physical burden.

A very positive aspect of the physical training reflected in the percentage of men who improved in the Outstanding (by 17%) and the Good (by 6%) categories.

Significant effects of the basic training on physical fitness and individual skills of the conscripts could be seen also in particular disciplines. The biggest improvement was reached in the Sit-Up category with 81% and the Cooper Test with 79.18% of the men enhancing their results. On the other hand, results of a relatively high percentage of the conscripts (32%) deteriorated in the Push-Up category.

OPERATIONAL RELEVANCE

Training programs of the Army of the Czech Republic, which implement also sport training exercises, prove to be very effective.

AUTHORS

Lubomir Privetivy (1)
Vilem Müller (2)

(1) Military Department of Faculty of Physical Education and Sport, Charles University, Prague, Czech Rep. (Czech Republic); (2) Center of Physical Education, Training Command – Military Academy (Vyskov, Czech Republic)

RESERVE OFFICER TRAINING CORPS CADETS PHYSICAL TRAINING ACTIVITY AND ITS INFLUENCE ON PHYSICAL ASSESSMENT TEST PERFORMANCE

PURPOSE

This study examined the relationship between Reserve Officer Training Corp (ROTC) physical training (PT) attendance and Army Physical Fitness Test (APFT) and Occupational Physical Assessment Test (OPAT) performance. It also aimed to characterize physical activity habits of cadets outside of PT during a single college semester.

METHODS

Twenty-six volunteer cadets (21 male; age=20.81±2.48 years; height=171.16±8.62 cm; body mass=75.49±13.17 kg; BMI=25.68±3.37 kg/m2) data were used for analysis. PT attendance, and diagnostic (start of semester) and record (end of semester) OPAT and APFT scores, were acquired from a single collegiate ROTC unit. Paired samples t-tests were utilized to evaluate differences in APFT and OPAT scores between the diagnostic and record tests. Effect size was calculated using Cohens d. Pearson Correlations were utilized to determine if a relationship existed between PT attendance and changes in APFT and OPAT component performance. Participating cadets also completed a monthly self-reported physical activity questionnaire throughout the semester; findings were reported using descriptive statistics.

RESULTS

Cadets significantly improved performance on the following OPAT components: standing long jump (p=0.034, d=0.16), seated power throw (p=0.029, d=0.17), and shuttle run (p=0.005, d=0.35). Cadets significantly improved performance on the following APFT components: sit-ups (p=0.003, d=0.36) and 2-mile run (p=0.045, d=0.27). Cadets attended an average of 87% of PT sessions between OPAT administrations and 85% of PT between APFT administrations. A significant, positive correlation was found between PT attendance and APFT sit-up improvements (r=0.473, p=0.015). No significant correlations were found between PT attendance and any other APFT or OPAT components. Cadets reported physical activity ranged from 2.8-3.1 days of aerobic activity, 3.2-3.8 days of strength/power activity, and 2.9-3.2 days of core strength/endurance activity per week.

CONCLUSIONS

Regular participation in a single semester of ROTC PT was found to significantly increase cadets scores in some, but not all, components of the APFT and OPAT. Cadets performance in the OPAT deadlift and APFT push-ups was unchanged. Self-reported physical activity questionnaire results indicates that cadets are regularly training outside of organized ROTC PT, which occurred four days a week.

OPERATIONAL RELEVANCE

This research indicates that ROTC PT effectively increases performance in measures of physical readiness. However, more targeted program design may be necessary to better prepare cadets for the new Army Combat Fitness Test. Additionally, the high exercise volume cadets report participating in, when both PT and outside activity are taken into consideration, may place cadets at increased risk of overuse injury.

AUTHORS

Kara Radzak (1)
Jessica Tom (1)
(1) University of Nevada, Las Vegas (Las Vegas, United States)

4.4
BASIC TRAINING AS A PLATFORM FOR RESEARCH

#ABS315
POSTER PRESENTATION

FEBRUARY 12, 2020

KNOWLEDGE TRANSFER: BASIC TRAINING AS A PLATFORM FOR RESEARCH

PURPOSE

Basic training is a crucial stage of training in which injuries occur at a higher rate than at other stages of a trainees career. Basic training is constantly changing based on reviews of ongoing injuries, equipment changes and performance requirements. The purpose of this investigation was to compare a basic recruit training course across two time periods (2018 and 2010) with a specific focus on distances walked and run, loads carried and lifted.

METHODS

Course PT programs were obtained from a 12-week basic training course in spreadsheet format which underwent a content and desktop analysis performed by an experienced army Physical Training Instructor. A full 24-hour allocation for each training day was conducted with respect to body positions, activities being performed, and loads carried and lifted. This was assisted by prior knowledge of basic training, maps of the training location and feedback from staff. An on-site observation period of two full days of training was used to validate the desktop analysis data.

RESULTS

Along with an increase in PT sessions from 37 in 2010 to 40 in 2019, A decrease in running distance of 12.8km (-42.52%) was found from 30.1km in 2008 to 17.3km in 2018 with a concurrent increase in walking distance of 17.58km (+4.4%) from 396.3km in 2010 to 413.9km in 2019. The amount of load lifted increased by 303 257.3kg/reps (+194%) from 156261.3kg/reps in 2010 to 459518.5kg/reps in 2018. Loads carried also increased by 51874 kg/hrs (+13.9%) from 372 381.5kg/hrs in 2010 to 424 256 kg/hrs in 2018.

CONCLUSIONS

Despite changes to training being important to ensure the updating of material, the downstream effect and its relationship to injury should be acknowledged. Changes to one domain in response to injury prevalence, may inadvertently affect another domain and be associated with a different injury, i.e. decreased running load with a concurrent increase in walking load.

OPERATIONAL RELEVANCE

Efforts to decrease one aspect of training may increase overall training load inadvertently. Efforts to decrease training volume may lead to increased training intensity without any subsequent changes in overall injury risk.

AUTHORS

Ben Schram (1)
Robin Orr (1)
Rodney Pope (1)

(1) Tactical Research Unit, Bond University (Robina, Australia)

INTERACTIONS OF SLEEP, WELL-BEING AND INFLAMMATORY MARKERS DURING 12 WEEKS OF BASIC MILITARY TRAINING

PURPOSE

Stress, anxiety and sleep quality are all closely linked to well-being, and can also elicit changes in immune function. In defence contexts, compromised immune function will directly impact solider resiliency. While decrements in well-being have been observed during military training 1, there is mixed evidence regarding whether inflammatory markers increase in this context 1-3.Therefore, the aim of the current project was to 1) assess changes in inflammation, subjective wellbeing and sleep across a 12-week basic military training (BMT) program, and 2) evaluate relationships between circulating inflammatory markers, well-being and sleep.

METHODS

Forty-eight Australian Army recruits consented to participate. To assess well-being and sleep, the Depression Anxiety and Stress Scale (DASS)-21 and Pittsburgh Sleep Quality Index (PSQI) were administered at weeks 1, 4, 8 and 12. 37 recruits provided plasma samples at the same time points, from which inflammatory cytokines [IL-4, IL-6, IL-1, IL-8, IL-10, and TNF-] were analysed. Changes and relationships were assessed using general linear mixed models.

RESULTS

Across BMT there were significant improvements in the PSQI global sleep index, depression, anxiety and stress (all p0.001), and decreases in TNF-(p=0.031). Compared to baseline levels, significant decreases in associations between stress and IL-10, IL-4, IL-6 and TNF-(all $p<0.05$), depression and anxiety and IL-10 ($p<0.05$), and sleep duration and IL-1, IL-8, and TNF-(all $p<0.05$), were detected across BMT.

CONCLUSIONS

Increases in anti-inflammatory cytokines (IL-4 and IL-10) were associated with greater well-being across BMT. Observed changes in the strength of association between pro-inflammatory cytokines (IL-6 and TNF-) and well-being may indicate a positive adaptation to BMT. Compensatory increases in anti-inflammatory cytokines in response to training demands were associated with greater well-being. Higher levels of pro-inflammatory cytokines were associated with decreased sleep durations across BMT.

OPERATIONAL RELEVANCE

The BMT program appears to support improved sleep and well-being over the 12 weeks, with minimal perturbation to immune function. With consistent associations between biomarkers, well-being and sleep in recruits, inflammatory markers may have utility as psychophysiological indicators of health status in military research. However subjective measures may represent more cost-effective proxies that can be administered quickly and easily for practical, ongoing monitoring of recruits in live training contexts.

AUTHORS

Jamie Tait (1)
Sean Bulmer (2)
Jace Drain (3)
Luana Main (2)

(1) Deakin University (Geelong, Australia); (2) Deakin University (Geelong, Australia); (3) Defence Science and Technology Group (Fisherman's Bend, Australia)

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IMPACT OF INITIAL TRAINING STATUS ON ADAPTATION TO BASIC MILITARY TRAINING

PURPOSE:

This study investigated the hypotheses that functional and physiological adaptations of both strength and endurance are dependent on individual initial physical capacity.

METHODS

Functional capacity and physiological parameters were determined in 290 conscripts before and after 9 weeks of basic military training including two hours of specific physical training weekly. Evaluation included a 12 min run test, standing long jump, pull-ups, shotput, lunges and push-ups. Additionally, a sub group (n=87) underwent physiological evaluation including peak oxygen uptake and maximal voluntary contraction (MVC) of knee extensors, elbow flexors and handgrip. Participants were divided into three equal sized groups based on initial performance (lowest: “LO”, medium: “ME” and highest: “HI”) for each obtained variable. Between group differences were investigated by a linear mixed model.

RESULTS

The change in measures of functional capacity were different between LO and HI for all variables (P<0.01): Standing long jump performance increased in LO (0.14±0.22 m, P<0.001), remained unaltered in ME and decreased in HI (-0.19±0.23 m, P<0.001). Pull up performance increased in LO (2±2 repetitions, P<0.001), tended to increase in ME (1±2 repetitions, P=0.58) and remained unaltered in HI. Shot put performance decreased (P<0.01) in LO (-0.10±0.32 m), ME (-0.26±0.28 m) and HI (-0.48±0.31 m). Run performance increased (P<0.001) in 12 min run test for LO (346±206 m), ME (156±166 m), and HI (81±152 m). Lunges performance increased (P<0.001) in LO (11±9 repetitions), ME (7±7 repetitions) and HI (3±6 repetitions). Push-ups performance increased (P<0.001) in LO (6±5 repetitions) and ME (3±6 repetitions). Maximal oxygen uptake increased in LO (335±239 mL O2 * min-1 P0.001) and remained unchanged in ME and HI. There were no significant between group differences in change in physiological measures of strength.

CONCLUSIONS

Changes in functional performance depended on initial physical capacity for strength and endurance variables. Likewise, peak oxygen uptake adaptation depended on initial capacity. Changes in maximal voluntary contraction was not dependent on initial training status.

OPERATIONAL RELEVANCE

Military physical training most often use a one-size fits all training regime. With limited time available, enhanced training outcomes could be expected by allocating the majority of the specific physical training to the modality of the individual weakest physical capacity were the potential for adaptation is highest.

AUTHORS

Anders Kilen (1)
Nikolai Baastrup Nordsborg (2)
Jacob Bejder (2)
Andreas Breenfeldt (2)
Thomas Bonne (2)
Niels Vidiendal Olsen (3)
Jesper Løvind Andersen (4)

(1) Center for Military Physical Training, Danish Armed Forces Medical Command, Denmark; Department of Nutrition, Exercise and Sports, University of Copenhagen, Denmark (Copenhagen East, Denmark); (2) Department of Nutrition, Exercise and Sports, University of Copenhagen, Denmark (Copenhagen, Denmark); (3) Department of Biomedicine, The Health Faculty, University of Copenhagen, Denmark (Copenhagen, Denmark); (4) Institute of Sports Medicine Copenhagen, Department of Orthopedic Surgery M, Bispebjerg Hospital and Center for Healthy Aging, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark (Copenhagen, Denmark)

CHANGES IN PHYSICAL PERFORMANCE FOLLOWING ROYAL AIR FORCE PHASE 1 TRAINING

PURPOSE

All recruits (less officers) entering the Royal Air Force (RAF) complete a common Phase 1 training course before progressing to trade-specific training. This study aimed to quantify the changes in physical performance during RAF Phase 1 training.

METHODS

One-hundred and eight recruits (98 male / 10 female, age 21 ± 3 y; stature 1.75 ± 0.07 m; body mass 72.5 ± 9.9 kg) volunteered. Participants completed a 2 km run, a seated 4 kg Medicine Ball Throw (MBT) and an Isometric Mid-Thigh Pull (IMTP) pre-and post-the 10-week Phase 1 training course (February May 2018). Paired samples t-tests were conducted to examine differences in performance pre-and post-training for participants as a group. Participants were categorised into quartile groups based upon their pre-training performance score for each of the fitness tests. Mean change in performance in each quartile were then examined using independent samples t-tests.

RESULTS

On average, after 10 weeks of training 2 km run time was faster (08:31 ± 00:49 vs. 08:07 ± 00:43 min:s, $p<0.001$), MBT distance decreased (4.6 ± 0.7 m vs. 4.5 ± 0.6 m, $p=0.002$), and there was no change in IMTP (138 ± 35 kg vs. 137 ± 34 kg; $p=0.656$). The slowest quartile at the start of training improved their run time by 42 ± 35 s, and the highest improved by 8 ± 14 s ($p<0.001$). The highest IMTP quartile decreased by 13 ± 25 kg whereas the lowest demonstrated an increase of 9 ± 17 kg ($p<0.001$). The highest performing MBT quartile demonstrated a decrease of 0.2 ± 0.3 m whereas the lowest performing demonstrated an increase of 0.1 ± 0.2 m ($p<0.001$).

CONCLUSION

When all participants were examined as a group 2 km run time improved, there were small decrements in MBT and no change in IMTP. However, when changes in physical performance were examined based on physical performance at the start of training those participants with the lowest physical performance at the start of training demonstrated greater improvements than those with the highest physical performance.

OPERATIONAL RELEVANCE

The 10-week training programme is sufficient to improve fitness for recruits in the lowest fitness quartiles on entry. However, due to the decrease in IMTP and MBT performance for recruits in the highest fitness quartiles, recruits may benefit from individualised physical training programmes to optimise improvements in physical performance during military training.

AUTHORS

Julianne Doherty (1)
S M Myers (1)
S L Coakley (1)
Carla Rue (1)
C A J Vine (1)
J P Greeves (2)
E A Fieldhouse (2)
E F Walker (1)
S D Blacker (1)

(1) Occupational Performance Research Group, Institute of Sport, University of Chichester, Chichester, UK (Chichester, United Kingdom); (2) Department of Army Health and Physical Performance Research, Army HQ, UK (Andover, United Kingdom)

CHANGES IN PHYSICAL PERFORMANCE DURING STANDARD ENTRY BASIC BRITISH ARMY TRAINING

PURPOSE

British Army Standard Entry (SE) recruits complete a 14-week Basic Training (BT) prior to Trade Training. Recruits follow a structured physical training programme during BT that aims to develop their role-related fitness. The aim of this study was to quantify the changes in physical performance during BT.

METHODS

One hundred and thirty-two recruits (mean ± SD; age 21 ± 4 years; stature: 1.75 ± 0.09 m; body mass 72.9 ± 11.1 kg) volunteered to complete all testing sessions. Recruits completed a best effort 2 km run, a seated 4 kg Medicine Ball Throw (MBT), and an Isometric Mid-Thigh Pull (IMTP) at the start and end of BT. Paired sample t-tests were conducted to examine pre-to post-BT performance differences. Recruits were categorised into quartiles based upon their pre-BT performance scores for each of the fitness tests and the mean changes in performance for each quartile were examined.

RESULTS

Following BT recruits improved 2 km run time by 5% (pre vs. post: 9:03 ± 0:59 vs 8:32 ± 0:56 min:s; $p<0.001$). There were no changes in MBT (4.3 ± 0.8 vs 4.4 ± 0.8 m, $p=0.118$) or IMTP (143 ± 48 vs 140 ± 41 kg, $p=0.168$) performance at the end of BT. When examining the changes in performance across the different quartiles; the high-performance quartile increased (performance declined) their run time (0:25 ± 10 min:s) whereas the low-performance quartile improved their run time by 1:11 ± 0:52 min:s. The high-performance quartile decreased their IMTP (-30 ± 33 kg) and MBT (-0.1 ± 0.5 m) performance. The low-performance quartile increased IMTP (9 ± 23 kg) and MBT (0.3 ± 0.3 m) performance following BT.

CONCLUSIONS

When examined as a group, 2 km run time improved with no change in MBT or IMTP performance. However, secondary analysis demonstrated greater improvements in performance occur for those in the low-performing quartiles after BT compared to those in the highest.

OPERATIONAL RELEVANCE

Whole group data should be interpreted with caution when quantifying the effectiveness of physical training programmes and instead sub-groups clustered on initial physical performance or individual performance should be considered.

AUTHORS

Kimberly M Ashdown (1)
S D Blacker (1)
S L Coakley (1)
C A Rue (1)
T R Flood (1)
E A Fieldhouse (2)
J P Greeves (2)
S D Myers (1)

(1) Occupational Performance Research Group, Institute of Sport, University of Chichester (United Kingdom); (2) Army Personnel Research Capability, Army HQ, Andover (Andover, United Kingdom)

TRAINING LOAD AND PERCEIVED WELLBEING DURING BASIC MILITARY TRAINING

PURPOSE

Increased training loads, insufficient recovery and psychological stress during Basic Military Training (BMT) have been linked to injury, illness, performance decrements and psychophysiological disturbance(1). To reduce adverse outcomes, the Australian Army has recently made changes to BMT, including a periodised physical training program to include progressive overload and periods of recovery. In elite sport, measures of subjective well-being are widely accepted and have proved effective in monitoring adaptation to training, however their utility in BMT is yet to be investigated. Therefore, the aims of this study were to 1) quantify changes in training load across BMT; 2) explore associations between training load and subjective well-being; and 3) establish whether the intended recovery opportunities were provided in BMT.

METHODS

Forty-eight recruits consented to participate. Training load was quantified using a daily Rating of Perceived Exertion (RPE), and Actigraph GT9Xs using Montoyes 2016 algorithm(2) for wrist worn energy expenditure (EE). The Multi-component Training Distress Scale (MTDS) was administered weekly to assess well-being. One-way repeated ANOVA using the Greenhouse Gaiser significance method and Bonferonni post hoc tests for between week comparisons were applied ($p<0.05$). Associations between variables were assessed using linear mixed models.

RESULTS

Main effects of time were observed for well-being (n=29) and EE (n=19), and RPE (n=32) (all $p<0.02$). Weeks six and twelve were designated recovery periods; during these weeks, EE and RPE reduced, and well-being increased, with significant changes from previous weeks (all $p< 0.05$). Linear mixed models revealed that over the course of BMT, well-being scores reduced when RPE and EE increase (all $p<0.05$).

CONCLUSIONS

Training load varied significantly over 12-weeks of BMT, and load variations were consistent with intended periodisation. Concurrent load reduction and improvements in subjective well-being are shown during intended recovery periods of weeks six and twelve during BMT. The MTDS was effective in detecting training load changes during BMT.

OPERATIONAL RELEVANCE

Australian BMT appears to provide recovery opportunities at intended stages, accompanied by improvements in subjective well-being. Had these recovery opportunities not been provided, visual extrapolation of MTDS data suggests the potential for compromised well-being. By providing insight into multiple domains of well-being, the MTDS provides a foundation for future load-monitoring during BMT, facilitating individualised management of fatigue and adaption with targeted intervention as necessary.

AUTHORS

Sean Bulmer (1)
Paul B. Gastin (2)
Jace Drain (3)
Brad Aisbett (4)
Luana C. Main (4)

(1) Deakin University, Centre for Sport Research, School of Exercise and Nutrition Sciences (Burwood, Australia); (2) La Trobe University, School of Allied Health, Human Services and Sport, Melbourne, Australia (Melbourne, Australia); (3) Defence Science and Technology Group (Fishermans Bend, Australia); (4) Deakin University, Institute for Physical Activity and Nutrition, School of Exercise and Nutrition Science (Geelong, Australia)

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4.4
BASIC TRAINING AS A PLATFORM FOR RESEARCH

#ABS094

FEBRUARY 12, 2020

DIFFERENCE IN ENTRY BODY COMPOSITION OF U.S. ARMY TRAINEES OVER 30 YEARS

PURPOSE

Obesity rates have doubled in the United States over the past 30 years. While entry standards may prevent individuals with extreme body composition from entering the military, the body composition of the average recruit may have changed during this time period. Greater body fat percentage (%BF) and lower lean mass (LM) have been associated with lower physical fitness. The purpose of this study is to compare entry body composition of recent trainees to trainees from 30 years ago.

METHODS

Body composition was measured in trainees from 1984-1986 (n=1306 males, 302 females) and 2017-2018 (n=573 male, 223 females) at the beginning of Basic Combat Training (BCT). Data were collected using underwater weighing on the earlier cohort and DXA on the more recent cohort. Two-way (cohort x sex) ANOVAs were used to assess differences in body composition.

RESULTS

Recent trainees were heavier than the earlier trainees (male: 77.5 vs 76.9 kg; female: 62.3 vs 60.5 kg; p=0.03 for both). There was no significant BMI difference in males by cohort (p=0.63); however, the recent cohort of females had a higher BMI (23.9 vs 22.9 kgm-2; p<0.01). In the recent cohort,%BF was higher (male: 22.7% vs 20.1%, female: 32.1% vs 28.0%; p<0.01) and LM was lower (male: 57.8 vs 61.0 kg, female: 41.0 vs 43.3 kg; p<0.01) than the earlier trainees.

CONCLUSIONS

While caution should be taken when comparing data collected using differing techniques, these data suggest that, consistent with the national population, recent trainees have a greater%BF and lower LM than trainees from 30 years ago.

OPERATIONAL RELEVANCE

Body composition has been linked to military relevant outcomes, including musculoskeletal injury, physical performance, and discharge from BCT. Current trainees are entering BCT with greater%BF and less LM than they were 30 years ago. While the effects of these changes on military task performance remain to be determined, a greater emphasis may need to be placed on fat loss and lean mass gain during BCT than was previously necessary.

AUTHORS

Stephen Foulis (1)
Julie Hughes (1)
Marilyn Sharp (1)
Leila Walker (1)
Katelyn Guerriere (1)
Kathryn Taylor (1)
Karl Friedl (1)

(1) U.S. Army Research Institute of Environmental Medicine (Natick, United States)

SEX DIFFERENCES IN DIETARY INTAKE IN BRITISH ARMY RECRUITS

PURPOSE

Quantify energy, macro and micronutrient intake of British Army recruits during Basic Training (BT), comparing against military dietary reference values (MDRV), recommended daily allowances (RDA) and sports nutrition guidelines.

METHODS

Twenty-eight female (mean ± SD: age 21.4 ± 3.0 yrs, height: 163.7 ± 5.0 cm, mass 65.0 ± 6.7, body mass index: 24.2 ± 2.6 kg/m2) and 17 male (age 20.4 ± 2.3 yrs, height: 178.0 ± 7.9 cm, mass 74.6 ± 8.1, body mass index: 22.5 ± 1.7 kg/m2) recruits from the Army training centre Pirbright volunteered for this study, approved by the Ministry of Defence research ethics committee. Researcher-led food weighing and participant-completed food diaries were used to capture dietary intake over 8-days during week-10 of BT and analysed descriptively. Independent t-tests quantified differences in dietary intake values between sex (= p<.05).

RESULTS

Men had significantly greater mean daily EI (2846 vs 2223kcal, p<.01) compared to women, however both sexes consumed 69% and 72% less than the recommended MDRVs, respectively. Women consumed significantly less carbohydrate than men when expressed relative to body mass (3.8 vs 4.7g/kg/d, p=.025) and as a percentage of total energy intake (EI) (43% vs 49%, p<.01). Carbohydrate intake in both sexes did not meet the MDRVs (mean: 46% vs MDRVs: 50-60%) or sports nutrition guidelines (mean: 4.3 vs 6-10g/kg/d), however protein recommendations were met. Women consumed significantly less calcium (689 vs 1078mg/d, p<.01), iron (7.2 vs 10.3mg/d, p<.01), vitamin D (1.8 vs 2.5/d, p<.01) and magnesium (175 vs 239mg/d, p<.01) compared to men and did not meet the RDA for these micronutrients. Men exceeded the RDA for calcium (1078 vs 700mg/d), iron (10 vs 8.7mg/d) and vitamin C (67 vs 40mg/s) but not for magnesium (239 vs 300mg/d) or vitamin D (2.5 vs 10/d). Both men and women consumed adequate vitamin C (67 and 49mg/d respectively) compared to the RDA (40mg/d).

CONCLUSIONS

Male and female recruits had inadequate dietary intake compared to military and sports nutrition guidelines. Women consumed significantly less macro and micronutrients compared to their male counterparts.

OPERATIONAL RELEVANCE

Lack of adequate dietary intake relative to the demands of BT may have significant sex-specific implications on the health and operational readiness of the recruit during BT and throughout their career. Further research investigating the effects of an additional meal or supplement to meet the energy expenditure demands of BT and the nutritional deficiencies identified in British Army recruits is warranted.

AUTHORS

Shaun Chapman (1)
Alex Rawcliffe (1)
Justin Roberts (2)
Rachel Izard (1)

(1) HQ Army Recruiting and Initial Training Command (Upavon, United Kingdom); (2) Anglia Ruskin University (Cambridge, United Kingdom)

DEVELOPMENT OF A NEW BASIC TRAINING IN THE GERMAN ARMY: FIRST STUDY RESULTS

PURPOSE

Establishing and maintaining adequate physical fitness is a prerequisite for operational readiness of soldiers.

Globally declining fitness levels have resulted in the increasing inability of applicants to meet the physical demands of twelve-week standard Basic Training (BT).

Hence, a new concept for BT, with physical training tailored to individual fitness levels was developed. Methodological key features are: (i) Classification of applicants into three performance groups (high-medium-low) at the beginning of BT based on Basis-Fitness-Test (BFT) results, (ii) customized training in performance groups by full-time physical training instructors, (iii) increased training volume (+40h) and emphasis on sports training for the first six weeks of BT.

Purpose of the accompanying pilot study was to assess performance improvements by the new BT concept (intervention group IG) compared to standard BT (control group CG).

METHODS

Male recruits from two different BT units (IG: thirty-six, CG: fourteen) performed the BFT at the beginning and at the end of BT. BFT consists of three events (in track suit): (i) 11x10m-shuttle-run, (ii) flexed-arm-hang in chin-up position, and (iii) 1000m-run.

Military fitness was also assessed with the Basic-Military-Fitness-Tool (BMFT) after six weeks and at the end of BT. BMFT reflects essential military demands and consists of four tasks that are carried out in one single timed run in field uniform with body armor and helmet: (A) maneuver under fire, (B) casualty rescue, (C) load carrying, and (D) load lifting.

RESULTS

IG improved their BFT results from 338.6±62.2 (M±SD points) to 390.5±54.4 and CG from 349.7±37.2 to 369.4±36.6 (p0.001). Performance increase in the different IG performance groups was 44.1±26.1 (IG-high), 49.9±26.5 (IG-medium), and 82.8±38.1 (IG-low) respectively.

IG improved their BMFT results from 158.7±23.5 (M±SD seconds) to 149.5±18.7 and CG from 147.5±15.1 to 147.3±13.9 (p0.001). Performance improvement in the different IG performance groups was 5.0±7.0 (IG-high), 10.2±5.7 (IG-medium), and 22.4±16.4 (IG-low) respectively.

CONCLUSION

The most important finding were markedly more pronounced performance improvements of recruits undergoing the new restructured BT compared to CG, with the lowest ranking performance group in the IG benefiting most from the customized training.

OPERATIONAL RELEVANCE

Despite comparatively few participants in this pilot study, the results underline the advantages of the new concept, that was launched Army-wide in May 2019. An ongoing standardized data collection process will be implemented. Future results will serve as data-base for generating situation reports, conceptual development, and establishment of a Fitness-Register-BT-Army.

AUTHORS

Ulrich Rohde (1)
Alexander Sievert (1)
Dieter Leyk (2)

(1) Bundeswehr Institute for Preventive Medicine (Andernach, Germany); (2) 1. Bundeswehr Institute for Preventive Medicine, 2. German Sport University Cologne – Department of Physiology and Anatomy (Andernach, Germany)

CHANGES IN PHYSICAL PERFORMANCE OF BRITISH ARMY JUNIOR ENTRY RECRUITS FOLLOWING BASIC TRAINING

PURPOSE

British Army Junior Entry (JE) recruits complete a 49-week Basic Training (BT) course, prior to Trade Training. During BT recruits follow a structured physical training programme to develop their fitness. The aim of this study was to quantify the changes in physical performance following BT.

METHODS

One hundred and forty-one recruits (131 male / 10 female, mean ± SD; age 16 ± 1 years; stature 1.74 ± 0.07 m; body mass 68.6 ± 9.2 kg) volunteered to complete all testing sessions between March and November 2018. Recruits completed a 2 km best-effort run, a seated 4 kg Medicine Ball Throw (MBT), and an Isometric Mid-Thigh Pull (IMTP). Paired sample t-tests were performed to examine pre-to post-BT performance differences. Recruits were categorised into quartile groups based on their pre-BT performance scores for each fitness test, and the mean changes in performance for each quartile were examined using independent samples t-tests.

RESULTS

Following BT recruits 2 km run time improved by 2% (pre vs post; 8:50 ± 0:59 vs 8:37 ± 0:47 min:s, $p<0.001$), MBT by 7% (4.05 ± 0.55 vs 4.30 ± 0.60 m, $p<0.001$), and IMTP by 11% (124 ± 41 vs 133 ± 37 kg, $p<0.001$). When examining the changes in performance across the different quartiles, the low-performance quartile increased their IMTP performance (19 ± 27 kg) post-BT, whilst the high-performance quartile demonstrated a mean decrease (-7 ±-32 kg) ($p<0.001$). All quartiles increased their MBT performance following training, with the lowest-performance quartile showing an increase of 0.3 ± 0.3 m compared to the high-performance quartile 0.2 ± 0.4 m ($p=0.267$). The low-performance quartile decreased their run time by 54 ± 52 s following BT, compared with the high-performance quartile recruits who increased their run time by 18 ± 28 s ($p<0.001$).

CONCLUSIONS

Junior Entry recruits improved performance in the 2 km run, MBT and IMTP following their 49-week BT. However, secondary analysis demonstrated that greater performance improvements occur for those in the lowest performing quartiles at the start of BT compared with those in the highest.

OPERATIONAL RELEVANCE

The all-round improvements in Junior Entry physical fitness reflects both the trainability of the younger recruits and the length of their BT. However, whole group data should be interpreted with caution when quantifying the effectiveness of physical training programmes.

AUTHORS

Ella F Walker (1)
Sam D Blacker (2)
Sarah L Coakley (1)
Carla A Rue (2)
Julianne Doherty (1)
Hale B (1)
Anne E Fieldhouse (3)
Julie P Greeves (3)
Steve D Myers (1)

(1) Occupational Performance Research Group, Institute of Sport, University of Chichester (United Kingdom); (2) University of Chichester (Chichester, United Kingdom); (3) Department of Army Health and Physical Performance Research, Army HQ (Andover, United Kingdom)

TS3.
FACTORS AFFECTING SOLDIER SHOOTING PERFORMANCE

#ABS288

FEBRUARY 12, 2020

HUMAN FACTORS ASSESSMENT OF SMALL ARMS RECOIL

Criticism of the effectiveness of the NATO standard 5.56 mm ammunition have led certain NATO armies to consider the larger 7.62 NATO or intermediate calibre ammunition for standard issue service rifles. Recoil energies produced by larger and more powerful ammunition may have an adverse effect on the shooters tolerance and marksmanship, particularly during multi shot engagements. Recoil as experienced by a shooter is known as felt recoil and is a complex psycho-physiological event that can result in flinching, barrel rise or physical injury. In order to better understand the effects of felt recoil on shooters health and performance and evaluate the efficacy of recoil management devices, better research tools and methodologies are needed. To address this knowledge gap, research under DRDCs Future Small Arms Research project was conducted to a) develop a comprehensive understanding of the various factors that contribute to felt recoil and muzzle movement, and b) develop a standardized methodology to evaluate felt recoil and assess small arms systems.

A comprehensive human factors project plan and literature review identified a suite of test fixtures and methods that would be used to conduct felt recoil research. Based on this review, a range of field-based sensors, motion capture were used to measure firearm recoil physics, muzzle movement and shooters physical response to shooting in-service small arms or a custom instrumented firearm. These tools enabled the quantification of marksmanship performance and response to recoil across shooters of various physical characteristics and firearms of various recoil properties. Based on this research, shooter response to recoil was characterized. Biomechanical modeling permitted the identification of mass, spring and damper characteristics of the shooter to inform the development of an reconfigurable bench test fixture which mimics shooter dynamics. Finally, exploratory factor analysis and regression modeling of psychophysical and psychometric questionnaire data resulted in the development of the Felt Recoil Scale questionnaire.

Development of standardized test fixtures and methods is essential to the understanding of human response to firearm recoil in order to improve shooter performance and tolerance. Additionally, these tools can be utilized to investigate the relative effectiveness of recoil mitigation technologies as well as firearm types and configuration. An overview of the tools and methods developed, key research findings and lessons learned will provide the military decision maker with insights and considerations for assessing future small arms development and informing system acquisition.

AUTHORS

Allan Keefe (1)
Rogerio Pimentel (1)
Andrew Morton (2)
Harry Angel (2)

(1) Defence Research and Development Canada (Toronto, Canada); (2) HumanSystems Incorporated (Guelph, Canada)

PROFILING NOVICE MARKSMEN: THE FIRST STEP IN PROVIDING PERSONALIZED TRAINING INTERVENTIONS

INTRODUCTION

Marksman performance are depending on a complex interplay of, e.g., motivation, experience, physiological capacities like endurance and strength, and cognitive skills like visual perception (in action/under pressure) and decision making, fine and gross motor skills and visual-motor components. This combination of talents determine performance of marksman and-women. Studies that recently examined marksmanship performance revealed that the marksmanship of infantry units decreases despite of the availability of new technologies and different training programs. Next to marksmanship studies from e.g. Canadian and Swedish Defence Research and Development Departments, we measured in 2017 marksmanship skills of one hundred and twenty-two recruits prior and after the three existing rifle training interventions (Binsch et al., 2017). Results showed that the current training improved recruits hit probability by only 11%, and that it does not matter which shooting training intervention was applied. We now conducted additional analyses in which we focus on within-subject differences. The aim of this analytical approach is to classify and cluster recruits that are more talented than others. Based on individual talents and skill development, personalized training interventions could be developed and individual marksmanship skills could be predicted.

METHODS

The measures consisted of the mean hit probability and the mean radius estimations of a group of 10 shots per participant and three distances (100m, 200m, 300m). The recruits shot in kneeling position on standardized shooting targets with the C7 rifle (Colt, Canada) on a live firing range. Coordinates of each individual shot were recorded using the LOHMA system (Theissen, Germany). Data from two shooting days were collected, i.e., one day at the beginning of their military education (before marksmanship training) and on one day after the training was accomplished. We used data mining algorithms to develop clusters of participants and conducted correlations in order test adequate predictions.

RESULTS

The results showed that we were able to classify recruits on their personal marksmanship skills.

CONCLUSIONS

Earlier results indicated that current methods for training and maintaining marksmanship skills are inadequate. Strategies are discussed for using personalized training interventions to maximize skill acquisition and retention.

OPERATIONAL RELEVANCE

This research shows how to classify soldiers on their marksmanship performance. Performance that are dependent on Soldiers cognitive, mental and physical capabilities.

AUTHORS

Olaf Binsch (1)

Jeroen Hogema (1)

Esther Oprins (1)

(1) Netherlands Organisation for Applied Scientific Research, Department of Human Factors, Soesterberg, The Netherlands (Soesterberg, Netherlands)

Binsch, O., Zuur, P., & Hogema, J. (2017). Controlled Every Soldier A Rifleman (CESAR). In Proceedings of the 4th International Congress on Soldiers Physical Performance; ICSPP 2017. 28 November-1 December 2017. Melbourne, Australia.

TS3.
FACTORS AFFECTING SOLDIER SHOOTING PERFORMANCE

#ABS400

FEBRUARY 12, 2020

THE EFFECTS OF WEAPON RECOIL ON SOLDIER SHOOTING PERFORMANCE

As part of the Small Arms Ammunition Configuration (SAAC) study, a focused examination of the effects of recoil on shooting performance was conducted. Data collected in this study was used to feed a model of overall weapon system error for a variety of weapon-ammunition configurations.

One hundred fifty-seven Soldiers participated in this study. Soldiers fired a total of 50 rounds from the prone unsupported firing position and 50 rounds from the standing unsupported firing position. They provided an estimate of pain after every 10 rounds. When Soldiers had fired all 100 shots, they completed a perceived recoil questionnaire to characterize the recoil they experienced when firing in their assigned condition.

For this study, the independent variables were the impulse level of the round in lb-sec (0, 1.29, 2.60, and 2.96), weapon weight (9.5 and 11.5 pounds), body armor (with and without), buttstock pad (with or without) and Soldier experience level.

The dependent measures in this study were the aiming error of each shot, pain scale responses, and perceived recoil subjective responses.

The results for the radial aiming error data showed there was an interaction effect between weapon weight and impulse level. For the lighter weapon, the no recoil condition had significantly less aiming error than the other three recoil conditions. For the heavier weapon condition, both the no recoil and the 1.29 lb-sec impulse level (5.56mm ammunition) had smaller aiming error than highest two impulse levels. The heavier weapon seemed to help with recoil management of the 1.29 lb-sec impulse level (5.56mm) as aiming error was lower than the two higher impulse levels with the heavier weapon but not for the lighter weapon. For the highest two impulse levels, the heavier weapon did not reduce the effect of the impulse on aiming error.

Neither the body armor nor the butt pad significantly affected the aiming performance of the high recoil conditions. However, both the body armor and the butt pad significantly reduced the subjective magnitude of recoil.

The subjective recoil magnitude data was sensitive to differences in weapon weight as well as to differences in impulse level. For both weapon weights, the subjective recoil magnitude was higher for the higher impulse except for the 9.5 pound weapon where the highest two impulse levels were not statistically different in recoil magnitude.

AUTHORS

William Harper (1)
Frank Morelli (1)
Patrick Wiley (1)

(1) US Army Data and Analysis Center (APG, United States)

A COMBINATION OF A MARCH AND A SHORT EXHAUSTING-EXERCISE WITH LOAD-CARRIAGE DECREASE PHYSICAL PERFORMANCE AND MARKSMANSHIP ACCURACY

PURPOSE

The ability to chain a load-carried approach march with an assault is mandatory for dismounted soldiers. Our aim was to study the influence of a combination of a march followed by a short high-intensity-exercise on physical performances and marksmanship accuracy in three groups differently experienced to load-carriage.

METHODS

Soldiers volunteers to participate to our study, constituted three groups according to their experience of load-carriage: highly (HI, n = 17), moderately (MO, n = 14) and little experienced (LO, n = 17). They performed an 8-km flat march (imposed pace: 5-km/h, load-carriage: 20-kg). Then, volunteers performed an exhausting-exercise with 10-kg load-carriage consisting of 3 cycles of 4 exercises (A: 10-reps, crossing a plyobox, 40-cm height; B: 4-reps, rope pulling with, weight of 40-kg; C: 7-reps, lifting a weight of 10-kg from the ground to a 140-cm height; D: 10-reps, wall ball exercise with a 4-kg ball to throw above a 280-cm height). Before (T0), after the march (T1) and after the exhausting-exercise (T2), grip strength and jumping performances (10-reps counter-movement jumps) were evaluated. Marksmanship accuracy was evaluated at T0 and T2 with a kneeled 20-shots test using SCATT system. Data were analyzed with a two-way ANOVA with repeated-measures.

RESULTS

The total time to complete the exhausting-exercise was not different among groups (average time: 4-min 45-s ± 29-s). Grip strength was superior in HI (56.35 ± 7.61-kg) compared to MO (47.66 ± 4.63-kg; $p<0.05$) and LO (50.77 ± 6.57-kg; $p<0.001$), with no effect of fatigue. A diminution of mean jump height was observed at T2 compared to T1 (28.39 ± 3.88 vs 29.86 ± 3.85-cm; $p<0.005$), with no difference between groups. The marksmanship accuracy decreased similarly in all groups as shown by the reduction of the total score (on total of 218 points) between T0 and T2 (172.06 ± 14.76 vs 150.79 ± 24.63, respectively; $p<0.001$), and the reduction of shooting stability (shown by an increase of the average length of tracing; 302.19 ± 94.29 vs 400.99 ± 102.1-mm, respectively; $p<0.001$).

CONCLUSION

We described that the combination of a march and an exhausting-exercise performed with a moderately heavy load induced a diminution of both physical performances (small size) and marksmanship accuracy (large size), independently of experience level.

OPERATIONAL RELEVANCE

Load carriage in a realistic scenario impaired accuracy of shooting and probably agility. Experience is not sufficient to limit impairment. Nevertheless cognitive performance, decision making and reaction time could be differently altered.

AUTHORS

Julien Siracusa (1)
Anne-Fleur Gaston (1)
Sebastian Garcia-Vicencio (1)
Keyne Charlot (1)
Cyprien Bourrilhon (1)
Alexandra Malgoyre (1)

(1) Institut de Recherche Biomédicale des Armées, Armed Forces Biomedical Research Institute (Bretigny-sur-Orge, France)

TS3.
FACTORS AFFECTING SOLDIER SHOOTING PERFORMANCE

#ABS399

FEBRUARY 12, 2020

SMALL ARMS FIRE CONTROL COTS (TP, KPATS) EVALUATION SUMMARY

The purpose of this study was to conduct an evaluation of small arms fire control technologies using COTS systems and determine the benefits of each system for both hit percentage and engagement time relative to a baseline weapon system across several ranges.

Two COTS systems, TrackingPoint (TP) Precision Guided Firearm and Kopin Corps Precision Acquisition and Targeting System (KPATS) were compared to M4A1 baseline system w/ Trijicon M150 (M4A1+ACOG). TP and KPATS incorporate laser rangefinders and ballistic algorithms to provide an adjusted reticle for aiming. Two variants of the TP weapon were used to yield four weapon conditions. TP variants included the TP in precision mode (TP-P) and the TP weapon in suppression mode (TP-S).

Shooting performance data was collected for 16 Soldiers, for four operationally relevant range scenarios; reflexive fire, short range, mid range, and long range. Two way ANOVAs were used to analyze the effect of weapon configuration and range on hit percentage and engagement time. Tukey ad hoc analysis were used when the ANOVA returned a significant f-statistic.

For reflexive fire engagements (10m, 25m) and short range engagements (50m, 100m), the fire control features of KPATS and TP provided no hit performance benefit and significantly increased engagement time in comparison to the M4A1+ACOG system. Soldier ratings and feedback indicated that weight, size, and shape of these systems had negative implications in terms of fatigue and controllability.

For mid range engagements (100m to 300m), adding the KPATS to the M4A1+ACOG system offered no performance benefit and significantly increased engagement time. Use of the TP system in suppression mode, in a supported posture, added significant benefits in regard to hit rate if enough time was available. However, using TP weapon system in precision mode, which added the trigger interrupt feature into the fire control process, offered no additional performance benefit but significantly increased engagement time.

For long range engagements (400m to 600m) there was no advantage for the KPATS system over the M4A1+ACOG with regard to hit rate. There is a trend towards improvement for hit rate using the TP systems vs. the M4A1+ACOG. Limitations of the TP lasing capabilities (>500m) made this difficult to truly assess. Although there appears to be potential to improve hit rate using the TP systems, this benefit may be overshadowed by a significant limitation with regard to engagement time.

AUTHORS

Patrick Wiley (1)

William Harper (2)

(1) US Army, CCDEVCOM (Aberdeen, United States); (2) US Army CCDEVCOM (aberdeen, United States)

TS5.
GLOBAL WARMING AND URBANIZATION- IMPLICATIONS ON THE MODERN WARFIGHTERS' PREPARATION AND OPERATION

#ABS412
POSTER PRESENTATION

FEBRUARY 12, 2020

ENVIRONMENTAL DETERMINANTS OF HEAT INJURY RISK IN THE SINGAPORE ARMED FORCES

PURPOSE

We sought to elicit environmental determinants of heat injury risk in military training in the Singapore Armed Forces.

METHODS

By combining daily national weather data with the militarys heat injury registry data for incident heat exhaustion and heat stroke we were able to create a robust panel dataset comprising ecological exposure and outcome parameters of interest. We employed multivariable Poisson regression model to estimate adjusted incidence rate ratios (IRR) and better understand how climatic parameters influenced heat injury risk.

RESULTS

Over the period from 2012 to 2018 we captured n=187 incident cases of heat injury and heat stroke. During the same period we saw a narrow range of average daily temperatures from 23.0 to 30.7 deg C and daily average levels of relative humidity ranging from 57.0 to 99.7% and dew-point temperatures ranging from 18.8 to 26.3 deg C. Heat injury incidence was greatest on days with higher average daily temperatures while the risk of heat injury on any given day was lower at the extremes of relative humidity. Our multivariable analyses showed that dew-point temperatures above 25 deg C were associated with an IRR of 2.18 (95% Confidence Interval 1.48 to 3.28) times higher risk of heat injury than the days with lower dew-point temperatures. This association was preserved with IRR 2.17 (95% Confidence Interval 1.44 to 3.12) when we considered the average dew-point reading on the day immediately prior to the incident case of heat injury.

CONCLUSION

Variations in climatic parameters explain a significant portion of excess heat injury risk experienced in the Singapore Armed Forces.

OPERATIONAL RELEVANCE

While conducting training under hot and humid climatic conditions we propose dew-point temperatures equal or greater than 25.0 deg C as a high risk threshold for heat injury.

AUTHORS

Edwin Chong (1)
Alexander Gorny (1)
Beng Hoong Poon (2)
Andrew Sayampanathan (3)

(1) Centre of Excellence for Soldier Performance, Singapore Armed Forces (Singapore, Singapore); (2) Changi General Hospital (Singapore, Singapore); (3) Singapore General Hospital (Singapore, Singapore)

THE EFFECTS OF MASS AND MASS LOCATION ON SHOT TIME

PURPOSE

Biomechanical first principles suggest that adding mass to a rifle will make raising the rifle slower, however this has not been quantified. The aim of this research was to understand the effects of added mass and mass location on shot time. It was hypothesised that the weapon configuration with the greatest moment of inertia would be slower to raise and aim than the other configurations.

METHODS

Fourteen male rifle users (age: 34.1 ± 6.9 years, 181.4 ± 8.4 cm tall and 91.6 ± 12.9 kg in mass) fired four weapon configurations, including a baseline (unweighted; Pos0) M4 carbine and the M4 affixed with a 1-kg mass at three locations along the top of the rifle (Pos1-Pos3). Participants fired 60 shots at their own pace at an instrumented target located 50 m away. The weapon was fitted with a Myomotion Inertial Measurement Unit (Noraxon USA) with accelerometer data used to mark the events of weapon raise, aim start and the shot. The time interval between the raise and shot events was denoted as total time, raise and aim events as raise time, and aim and shot events as aim time. Data were analysed using one-way repeated measures ANOVAs to ascertain a difference in total, raise and aim time between weapon configurations, and where significant main effects were found, post hoc comparisons were made using Tukeys corrections. Effect statistics for main effects (partial Eta squared; p2) and post hoc comparisons (Cohens d) are also reported.

RESULTS

There was a significant main effect of total time $F(3,45)=2.96$, $p=0.042$, $p2 =0.16$. Post hoc tests revealed Pos3 was slower than Pos0 ($p=0.020$, $d=-0.43$). There was a significant main effect of raise time $F(3,45)=3.14$, $p=0.034$, $p2 =0.17$, where Pos3 was slower to raise than Pos0 ($p=0.017$, $d=-0.52$) and Pos2 ($p=0.018$, $d=-0.40$). There was not a significant main effect of aim time $F(3,45)=1.62$, $p=0.197$, $p2 =0.10$.

CONCLUSIONS

Total shot time increases with the addition of a 1-kg mass to the front of a rifle, which arises from the longer time taken to raise the weapon. Weapon configuration does not seem to affect the length of time participants aimed the weapon at the target.

OPERATIONAL RELEVANCE

The results of this study indicate that the addition of mass to the weapon system can degrade the performance of the soldier, which needs to be taken into consideration when making capability trade-off decisions in the acquisition of weapon accessories.

AUTHORS

Jemma Coleman (1)
Kane Middleton (2)

(1) DST Group (Fishermans Bend, Australia); (2) School of Allied Health, Human Services and Sport, La Trobe University (Bundoora, Australia)

QUANTIFYING THE PHYSICAL ATTRIBUTES AND PERFORMANCE METRICS OF EXPERT MARKSMEN RELATIVE TO NOVICE MARKSMEN

PURPOSE

A fundamental capability of the Soldier is the ability to optimize marksmanship through experience and training and under a variety of conditions, weapons, and postures. The purpose of this research was to identify the salient baseline characteristics and postural control strategies that distinguish expert marksman versus novice marksmen.

METHODS

Eighteen military personnel volunteered for this study (mean age: 25±5yrs, height: 1.8±0.6m, weight: 81±11kg). Expert marksmen (N=9) were active duty competitive shooters or instructors. Novice marksmen (N=9) were active duty with less than a year of service. All participants were asked to complete a dynamic live fire marksmanship course twice at a tactical pace under two clothing and individual equipment (CIE) conditions: CIE I (6 kg) and CIE II (25 kg). The dynamic shooting course was spilt into two sections: #1. A series of barrels that must be navigated in a serpentine pattern while shooting followed by #2. A 10 m sprint to a static, standing firing position. Rifle motion and participant mechanics were measured during shooting via IMUs attached to the head, sternum, sacrum, hands, thighs, shanks, feet and rifle. A mixed design ANOVA (= 0.05) was used to analyse the dependent IMU-derived measures.

RESULTS AND DISCUSSION

Significant ($p<0.05$) differences were found between expert vs novice performance for both portions of the dynamic course.1.Barrel Zig-zag: Experts hit 25% more targets with corresponding differences in postural strategy including 23.3 degree greater torso lean while loaded and 11.83 degree greater torso lean while unloaded, 15.51% greater ankle range of motion, 16.27% faster average course speed, 18.46% greater average foot acceleration while transitioning between targets, and stabilized the motion of the weapon 34.2% more while transitioning between targets. 2. Standing Un-supported: Experts hit 17.78% more targets with differences in postural strategy including 50.4% more weapon stability during target transitions, 48.1% more torso stability during target transitions, 50.8% more foot stability during target transitions, and 35.5% slower rotational rate of their feet during target transitions.

CONCLUSIONS

It is likely that experts are using multiple strategies to stabilize their rifle and optimize performance while shooting. Greater understanding of the control strategies used by expert marksmen can allow for more optimized training strategies for novice marksmen.

AUTHORS

Leif Hasselquist (1)
Clifford Hancock (1)
Meghan O'Donovan (1)
Jonathan Kaplan (1)
Joseph Patterson (1)

(1) Combat Capabilities Development Command Soldier Center (Natick, United States)

BIOMECHANICS AND MARKSMANSHIP PERFORMANCE OF LOADED AND UNLOADED WALKING WHILE MAINTAINING WEAPON AIM

PURPOSE

To characterize movement patterns and marksmanship of walking while holding weapon aim with and without body-borne load.

METHODS:

Twenty-three male military personnel and civilian operators completed static and dynamic shooting tasks (23.9±5.7 years, 180.3±8.3 cm, 81.2±8.0 kg). Tasks were completed without load and with load. Participants were randomized to complete the loaded condition with either a 11.2 kg half-kit ballistic vest (n=12) or a 22.7 kg full kit ballistic vest (n=13). Two participants completed both load conditions. A single trial consisted of three self-paced controlled pairs with a 5.56 x 45 mm chambered rifle. Three trials were completed for all conditions (18 rounds per load). For static shooting, participants shot off-hand at a target positioned 10 meters away. For dynamic shooting, participants walked at a self-selected normal pace along a 15-meters path while holding weapon aim at a target (i.e. shoot on the move (SM)). Lower extremity joint angles were collected via wireless inertial measurement units and spatiotemporal parameters were collected via optical detection system for SM trials. Hit locations were collected via automated scoring system and mean radial error (MRE) (cm) was calculated. Repeated measures 2 (task) x 2 (load) ANOVAs were performed for marksmanship performance. One-way ANOVAs were performed to determine the effect of load on SM biomechanics. Alpha level was set a priori at p0.05.

RESULTS

A shooting task main effect was observed on marksmanship performance ($p<0.01$), where MRE was greater during SM than static shooting (3.89 to 5.41 cm difference). No main effect of load was observed on marksmanship performance ($p>0.05$). No SM kinematic or spatiotemporal differences were observed due to load ($p>0.05$).

CONCLUSIONS

Static and dynamic shooting tasks elicit different marksmanship performance of operators. These findings suggest that, at short range distances, target engagement while walking may elicit greater accessory body movement or higher attentional demand than static shooting which could affect target accuracy. Load may not influence marksmanship performance, but shooting task should be considered when assessing marksmanship performance of an operator.

OPERATIONAL RELEVANCE

Target accuracy during dynamic shooting tasks are crucial to mission objectives with target engagement. Results from this study emphasize that static shooting tasks may not be appropriate to evaluate an operators marksmanship performance under dynamic environments. These findings warrant further investigation to better understand the influence of load and movement patterns on dynamic shooting to guide training paradigms and optimize operational effectiveness.

AUTHORS

Maria Talarico (1)
Jennifer Neugebauer (2)
Frank Morelli (2)
James Onate (1)

(1) The Ohio State University (United States); (2) U.S. Army Futures Command (AFC), Combat Capabilities Development Command (CCDC) – Data and Analysis Center (DAC), Aberdeen Proving Ground, MD, USA (Aberdeen Proving Ground, United States)

THE BENEFITS OF USING A MARKSMANSHIP SIMULATOR FOR TRAINING AND RAPID ASSESSMENTS OF PERFORMANCE ACROSS THE ENTIRE MARKSMANSHIP PROCESS

PURPOSE

Weapon simulators provide flexibility in marksmanship assessments compared to live fire, allowing for both controlled laboratory and holistic field testing. This study serves as an example of how lab-based marksmanship simulations resulted in the ability to model relationships between body mechanics and proficiency. Specifically, this study focused on the mechanics and proficiency of Expert versus Novice shooters.

METHODS

Utilizing a repeated measures design, sixteen Soldier volunteers (8 Expert; 8 Novice) completed static and dynamic shooting tasks in two shooting postures (kneeling and standing), and two encumbrance-levels (loaded and unloaded). The static task prioritized accuracy over speed while shooting a single target from a stationary position and was accomplished three times/condition. The dynamic task included running, positioning, and engaging two targets (speed prioritized while still achieving target hit) and was run twice/condition.

The static task was assessed using measures of lethality, timing, and aiming characteristics from the simulator data. The dynamic task was assessed similarly, but also included mobility timing, and shooting efficiency (hits/second). Additionally, biomechanical movements during the approach, stance, and transitions were assessed using motion capture, inertial measurement units, and force plates.

RESULTS

Experts performed significantly better in the static task ($p<.05$ all measures but precision). In the dynamic task, Experts acquired/engaged targets more rapidly and efficiently than Novices ($p<.05$ in acquisition time, engagement time, and shooting efficiency), but with similar accuracy and precision. Additionally, aiming and stability data indicated that Experts anticipated transitions to next engagement, resulting in more distance covered across shorter aim times on the initial and final shots per target ($p<.05$). To further understand these results, multivariate correlations and a stepwise regression were utilized to select biomechanical factors that best predicted marksmanship performance during the first target engagement in the dynamic task. The initial model indicated that greater head-to-rifle angle in the frontal-plane, more extended dominant leg knee angle, and greater non-dominant leg instantaneous peak loading rate accounted for 70% variance in shooting accuracy ($p<.001$, adjusted $R2=.64$).

CONCLUSIONS/OPERATIONAL RELEVANCE

Simulator systems provide valuable information on shooting performance differences while maintaining the ability to be used in an instrumented laboratory setting. These benefits allowed for modeling the Soldier behind the weapon in an integrated manner, isolating the key characteristics that differentiate individual skill between the Experts and Novices.

AUTHORS

Stephanie Brown (1)
Clifford Hancock (1)
Meghan O'Donovan (1)
Leif Hasselquist (1)

(1) U.S. Army Combat Capabilities Development Command Soldier Center (Natick, United States)

TS14.
INTERACTION BETWEEN PHYSICAL AND COGNITIVE WORKLOAD AND PERFORMANCE

#ABS245

FEBRUARY 12, 2020

COGNITIVE LOAD UNDER PHYSICAL DEMANDING CIRCUMSTANCES

PURPOSE

Various studies highlight the interaction between physical and cognitive performance. These studies can be organized in a framework with two dimensions; order and dependency. Order differentiates between cognitive tasks that are performed while being physically active (simultaneously) or before/after a physical activity (sequentially). Dependency indicates whether the physical activity is dependent or independent on the outcome of the cognitive task. Many studies mainly investigated the physical-cognitive interaction sequentially using tasks that are independent. However, our cognitive task analysis revealed that in many occasions the physical activity and cognitive tasks occur simultaneously, and the cognitive outcome directly impacts the physical activity. Therefore, more insight is required into the combined effects of physical and cognitive performance for both dependent and independent tasks.

METHODS

A series of studies was conducted where physical activity and cognitive task performance were studied simultaneously. In the first study (N = 4), a detection response task was applied to soldiers walking on different undergrounds. In a second study (N=9), a zigzag run was combined with a militarized cognitive flexibility task, where the outcome of the task was used as cue for the running direction. In a third study (N=22), the effects on cognitive performance were measured for three activity levels (static, medium, high) using a spinning bike. Cognitive performance was measured using four cognitive tasks (tower of London, 2-Back task, psychomotor vigilance task and Wisconsin card sorting task) and a secondary detection response task.

RESULTS

The results of study 1 showed that response times on a detection response task were slower when participants walked on grass surfaces compared to asphalt surfaces. This suggests that walking on uneven undergrounds required attention which resulted in a decrease in cognitive performance. The second study revealed that while simultaneously performing the cognitive flexibility task and the zigzag run, participants ran slower than in a traditional zigzag run to perform the cognitive task. Results of the third study showed that performance on the cognitive tasks increased with increasing activity levels. Participants responded faster and made fewer errors.

CONCLUSIONS

Results showed that performing cognitive tasks during physical activity impacts physical performance (reduced running speed), as well as available cognitive resources (caused by environmental context such as underground) and cognitive performance (depending on the physical load).

OPERATIONAL RELEVANCE

This study demonstrates the importance to consider the dependency between physical and cognitive performance when implementing and designing technology for dismounted soldiers.

AUTHORS

Maurice van Beurden (1)
Linsey Roijendijk (1)

(1) The Netherlands Organisation for Applied Scientific Research (Soesterberg, Netherlands)

REDUCING PHYSICAL WORKLOAD BY ADDING MORE WEIGHT: THE IMPACT OF DISMOUNTED SOLDIER INFORMATION TECHNOLOGY ON SOLDIER WORKLOAD AND PERFORMANCE

BACKGROUND

Soldier physical performance research has focussed on physical intervention strategies such as lightening the load, load carriage design, and physical conditioning. Might benefits in physical performance be gained by introducing technologies that assist soldiers in their perceptual and cognitive functions, despite the added energy cost to carry their weight?

PURPOSE

To evaluate the performance and workload impact of introducing a network-enabled integrated soldier communications and situation awareness support system to Canadian soldiers for select tasks and missions at the infantry section and below.

METHOD

After three days of training, three sections of ten soldiers each (n30) completed operational tasks in each of two counter-balanced equipment conditions: baseline soldier system (radio, map & compass, DAGR (Defence Advanced GPS Receiver) providing own GPS (global positioning system) location for Section Commander), versus the new Integrated Soldier System – Suite (ISS-S) comprising digital radio, GPS, personal computer with digital map, blue force tracking, plus planning and plotting capabilities. Testing took place over a week and included: route planning; navigation; messaging/reporting; mini-team and section level missions. Measures included: task completion time, localization accuracy, distance travelled, and NASA Task Load Index (TLX). Energy cost was estimated from speeds and distance travelled.

RESULTS

Significant performance improvements were achieved using ISS-S over baseline in terms of speed of terrain traverse, task completion time, improved accuracy in entity localization or target designation, or reduced overall distance travelled, across numerous tasks at the individual and small team levels.

While not statistically significant (due to small sample size), section mission performance was noticeably better with ISS-S: missions were completed 28% faster; and half as many mission failed. Whereas non-leaders rated both systems similarly in terms of overall workload, leaders tended to rate the baseline condition as requiring higher workloads. Subsequent analysis reveals that the energy cost of using ISS-S is significantly lower because soldiers are more efficient in completing tasks, despite the higher load weight.

CONCLUSION

The introduction of ISS-S significantly improves soldier and team performance and effectiveness across a variety of tactical activities. Despite the added weight of the system, the physical effort required to complete a mission may actually be reduced due to performance efficiencies gained.

OPERATIONAL RELEVANCE

Opportunities to mitigate soldier physical burden may be gained through the introduction of technologies that support perceptual and cognitive functions, despite their added weight.

AUTHORS

Linda Bossi (1)
David Tack (2)
Ed Nakaza (3)
Chris Apostoli (4)
Justin G. Hollands (1)

(1) Defence R&D Canada (Toronto, Canada); (2) HumanSystems Incorporated, Vice President of Operations (Guelph, Canada); (3) HumanSystems Incorporated, Senior Consultant (Guelph, Canada); (4) Defence R&D Canada, Engineer (Toronto, Canada)

TS14.
INTERACTION BETWEEN PHYSICAL AND COGNITIVE WORKLOAD AND PERFORMANCE

#ABS339

FEBRUARY 12, 2020

INTERACTIONS BETWEEN PHYSICAL WORKLOAD AND COGNITIVE PERFORMANCE DURING PROLONGED LOAD CARRIAGE

PURPOSE

Dismounted Soldiers must maintain situational awareness and react to threats while moving through complex terrain under heavy loads. Decrements in cognitive performance have been observed during prolonged physical activity, however, the interactions between physical and cognitive performance during dismounted Soldier tasks are not well understood. The purpose of this study was to evaluate changes in cognitive task performance over the course of a prolonged load carriage task and changes in gait characteristics associated with performance of the cognitive task.

METHODS

Sixteen Soldiers, across two different studies, completed a load carriage task over a course consisting of paved road and wooded terrain for distances of up to 20 km. Following each 5-km lap of the over ground course subjects walked on a force-sensing treadmill for 5 minutes, completing a Sustained Attention to Response Test (SART) during the third minute. SART error rates (omission and commission) and response times were determined from subject input recorded using an instrumented weapon. Immediately following each treadmill period subjects also performed a verbal memory recall of the words presented during the SART. Spatiotemporal gait variables were calculated for each treadmill period during the minute preceding the SART (WALK) and during performance of the SART (COG). Main and interactive effects of load carriage duration and cognitive task activity were assessed using repeated measures ANOVA.

RESULTS

Neither the spatiotemporal variables nor the number of recalled words changed significantly with increasing distance walked. For a given distance, spatiotemporal variables did not differ significantly between WALK and COG periods. Preliminary analyses of the SART data (N=4) indicate a trend for reduced response time following 5-km of load carriage but no difference in errors of omission or commission.

CONCLUSIONS

Results from this evaluation indicate that prolonged load carriage has no effect on treadmill walking or verbal recall performance for distances up to 20km. Additionally, treadmill walking performance does not appear to be negatively affected by simultaneous performance of a cognitive task. Conclusions regarding SART performance are pending further data analysis. Future studies should seek to verify study outcomes using more operationally-relevant cognitive tasks performed over complex real-world terrain.

OPERATIONAL RELEVANCE

A fundamental understanding of interactions between physical and cognitive workload and performance can support mission planning and design of information displays for dismounted Soldiers. Findings from this study indicate that physical and cognitive performance can be maintained during prolonged load carriage.

AUTHORS

Angela Boynton (1)

James Head (1)

(1) Army Research Laboratory (Aberdeen Proving Ground, United States)

THE INTERACTION BETWEEN PHYSICAL AND COGNITIVE PERFORMANCE DURING MILITARY SURVIVAL TRAINING (SERE)

PURPOSE

Soldiers often need to operate in physically and cognitively demanding conditions. However, even though there is a lot of research on physical stress, the understanding of the cognitive load and the interaction between physical and cognitive stress is less well understood. The purpose of the present study was to examine the interaction between physical stress and cognitive performance among Finnish Soldier during a SERE (survival, evasion, resistance, and escape) training exercise.

METHODS

Two groups of soldiers (RECO, n=18 and EXP, n=18) participated in the 10 day exercise. RECO group had a 2-days rest in the middle of the field training (MIDREST) whereas EXP group continued their training without the recovery period. We examined the interaction between physical and cognitive performance by comparing RECO and EXP groups before and after the MIDREST period. On the basis of previous research we measured cortisol (COR) and insulin-like growth factor-1 (IGF-1) concentrations and assessed cognitive performance with omission of responses in sustained attention to response (SART) test (see millisecond.com). Data was analyzed in SPSS statistical package GLM Repeated Measures Analysis.

RESULTS

Significant COR x Omission Errors x Group ($p<.001$) and IGF-1 x Omission Errors x Group ($p=.008$) interactions were found between the pre-and post-rest measurements. COR levels decreased, ING-1 increased and cognitive performance increased in RECO group from pre-to post rest measurement, whereas the opposite was true for the EXP group.

CONCLUSIONS

From the cognitive functioning point of view, the two day rest period in the middle of 10 day survival training promoted soldiers beneficial cortisol and insulin-like growth factor-1 levels as well as cognitive performance. As expected and suggested in previous research, lower levels of cortisol and higher levels of IGF-1 were related to better cognitive performance (in terms of less omission errors).

OPERATIONAL RELEVANCE

Understanding the interactions between physical stress and cognitive performance (for example to make a decision to shoot or not to shoot) is highly important in planning and executing successful operations, training, rest and nutrition.

AUTHORS

Kari Kallinen (1)

Tommi Ojanen (1)

(1) Finnish Defense Research Agency (Jarvenpaa, Finland)

COGNITIVE AND PHYSICAL PERFORMANCE OF DISMOUNTED SOLDIERS DURING A SIMULATED PATROL

PURPOSE

Performing a dismounted patrol is a Soldier task requiring sustained physical exertion and continuous navigation and surveillance of the surrounding environment. This study aimed to quantify the cognitive and physical performance of Soldiers for tasks relevant to performing a patrol while carrying two different loads. The objective of this study was to determine if the load carried or the amount of time Soldiers had been walking affected their cognitive or physical performance during a simulated patrol.

METHODS

Ten male Soldiers each conducted two patrols through a simulated urban environment. For one patrol, they carried 26.4 kg, and for the other, they carried 35.5 kg. Patrol tasks included using hand held maps to navigate through the environment, reporting arrival at check points marked on the map, and reporting sightings of specific objects. Measures included time to complete the patrols, percentage of check points reported, percentage of objects reported, subjective workload assessment, and rating of the difficulty of conducting these tasks. An analysis of variance was conducted to identify significant differences. The level of significance was set at 0.05.

RESULTS

The subjective rating of workload was significantly greater when Soldiers carried the heavier load. Similarly, they rated navigating, reporting check points and objects, and walking as being significantly more difficult with the heavier load. Interestingly, the Soldiers time to complete the patrols and percentage of check points and objects reported were very consistent. There were no significant differences as a function of load carried or the amount of time they had been walking.

CONCLUSIONS

During this simulated patrol, the Soldiers cognitive and physical performance was not affected by the load carried or the amount of time they had been walking. However, Soldiers rated their workload and difficulty performing the patrol tasks as being greater when they carried the heavier load. This may affect performance on patrols greater than 2 hours long or done on consecutive days for weeks at a time.

OPERATIONAL RELEVANCE

When planning and conducting patrols, consistent levels of performance can be expected if the time spent walking during the patrol is up to 2 hours. In addition, the load carried should be 26.4 kg (or less) because of the increased workload required when carrying a heavy load (35.5 kg).

AUTHORS

Harrison Crowell (1)
Michael LaFiandra (2)
Courtney Haynes (1)
Jeffrey Nickel (1)

(1) U.S. Army Research Laboratory (United States); (2) United States Military Academy (United States)

Cognitive and Physical Performance of Dismounted Soldiers during a Simulated Patrol

Harrison Philip Crowell, Courtney A. Haynes, and Jeffrey D. Nickel

U.S. Army Research Laboratory

HIGH GRIT SCORES ASSOCIATED WITH ELEVATED BDNF DURING MILITARY OPERATIONAL STRESS

PURPOSE

Insulin-like growth factor 1 (IGF-I), brain-derived neurotrophic factor (BDNF), and the anti-aging protein klotho (-Klotho) are susceptible to various stressors, such as sleep deprivation and psychological stress. The Connor-Davidson Resilience Scale (CD-RISC) and the Grit Scale (GRIT) have been used to measure resilience. This study determined relationships between self-report measures of resilience and IGF-1, BDNF, and-Klotho concentrations during simulated military operational stress (SMOS).

METHODS

Nineteen male Soldiers (255 years, 1776cm, 8113 kg, 187 BF%) completed a 5-day/night protocol designed to SMOS. Upon arrival, subjects completed CD-RISC and GRIT. Subjects consumed 50% of baseline caloric demands on Days 3 (D3) and 4 (D4). Subjects completed physical and cognitive evaluations from 0900 to 2230. Nights 3 and 4 included restricted sleep from 0100-0300 and 0500-0700, completing psychomotor evaluations between 0300 and 0500. Fasted blood was drawn each morning at 0800 to analyze IGF-1 (APLCO, Salem, USA) and-Klotho (Immuno-Biological Laboratories, Takasaki, Japan) using ELISAs. BDNF was analyzed using MILLIPLEX Magnetic Bead Panel 3 (EMD Millipore, Burlington, Massachusetts). One-way repeated measures ANOVA or Friedman test with a Bonferroni correction for multiple comparisons were used ($p<.05$, $p<.005$, respectively). CD-RISC and GRIT scores were dichotomized to high (H-) and low (L-) groups based on median split and two-way mixed ANOVA determined differences in basal concentrations between high and low scores ($p<.05$).

RESULTS

IGF-I changed across the SMOS ($p=.012$), with a peak on D2 (337.8 85.6 ng/mL) that declined by D5 (307.0 101.0 ng/mL). BDNF decreased from D1 (3.2 2.6 ng/mL) to D3 (1.6 1.2 ng/mL, $p=.003$), recovering by D5 (2.8 1.9 ng/mL).-Klotho declined across the 5-day protocol ($p<.001$, D1: 0.9 0.3 ng/mL vs. D5: 0.8 0.3 ng/mL). H-GRIT (GRIT score > 3.9) BDNF concentration was 2.2 ng/mL higher on D2 ($p=.011$), 1.5 ng/mL higher on D3 ($p=.002$), and 2.7 ng/mL higher on D5 ($p<.001$) than L-GRIT. No significant differences were observed between H-CD-RISC and L-CD-RISC across SMOS for IGF-1, BDNF, or-Klotho.

CONCLUSIONS

IGF-I and-klotho declined ~9.1% and ~11.1%, respectively, during SMOS. BDNF decreased ~48.9% after one night of sleep restriction but recovered with adequate sleep. H-GRIT individuals had significantly higher BDNF concentrations at various timepoints throughout SMOS.

OPERATIONAL RELEVANCE

Acute SMOS can negatively impact key biomarkers associated with neural processing and cellular stress tolerance. Preliminary evidence suggests that H-GRIT may be associated with elevated BDNF.

AUTHORS

Meaghan Beckner (1)
Brian Martin (1)
David Rivetti (1)
William Conkright (1)
Shawn Eagle (1)
Shawn Flanagan (1)
Anne Germain (2)
Christopher Connaboy (1)
Bradley Nindl (1)

(1) Neuromuscular Research Laboratory/Warrior Human Performance Research Center, Department of Sports Medicine and Nutrition, School of Health and Rehabilitation Sciences, University of Pittsburgh (Pittsburgh, United States); (2) Military Sleep Tactics and Resilience Research Team, Department of Psychiatry, School of Medicine, University of Pittsburgh (Pittsburgh, United States)

EMERGING NEUROMODULATORY INTERVENTIONS TO ENHANCE MILITARY COGNITIVE AND PHYSIOLOGICAL RESILIENCY

Non-invasive brain stimulation is increasingly used to improve cognition, physical performance, and resilience against physiological stress. Techniques and applications vary, but typically emphasize the importance of cerebral cortex for decision-making, vigilance, memory, emotional regulation, creativity, and motor performance. In this thematic session, we present ongoing work aimed at improving physiological resilience in the warfighter. Our experiments leverage the recent discovery of cortical projections to the adrenal medulla and raise the possibility that corticoadrenomedullary modulation (or CAM) could be used to enhance performance and treat myriad conditions involving aberrant neuroimmune or endocrine function. Basic questions and early applications designed to maximize efficacy, tolerability, and translation to tactical performance will be discussed. In addition to repetitive transcranial magnetic stimulation (rTMS), other common non-invasive brain stimulation techniques have produced a number of realizations of potential value to the Warfighter. Therefore, we will also highlight recent developments in the general field of brain stimulation that will be of interest to the military human performance scientist. This session will provide the viewer with a basic understanding of non-invasive neuromodulation techniques and measurements and overview of cutting-edge applications based on recent and ongoing research.

AUTHORS

Shawn Flanagan (1)

(1) University of Pittsburgh (Pittsburgh, United States)

TS22.
OPTIMIZING MENTAL AND PHYSICAL RESILIENCE TO IMPROVE SOLDIER READINESS
#ABS425

FEBRUARY 12, 2020

THE IMPACT OF PRE-CONDITIONING ON SOLDIER RESILIENCE DURING MILITARY TRAINING AND OPERATIONS

PURPOSE

The Australian Army developed a 7-week pre-conditioning program for female applicants who failed to meet the pre-enlistment fitness standards but were otherwise deemed suitable for enlistment. The study investigated the impact of the 7-week supplementary period of physical training prior to the commencement of basic military training (BMT) upon resilience and subsequent completion of the Australian Army BMT regimen. Increased physical fitness, reduced risk of injury and attrition are benefits observed from periods of pre-conditioning prior to the commencement of basic military training.

METHODS

The 7-week pre-conditioning training regimen consisted of 50 physical conditioning sessions (12 endurance, 12 trunk and remedial, 11 strength, 10 recovery and 5 familiarisation and assessment) occurring often twice per day. Pre-conditioning participants were assessed for cardiorespiratory endurance, upper-body muscular endurance, functional basic military training outcomes, and incidence of musculoskeletal injury during the 7-week pre-conditioning and 12-week BMT periods.

RESULTS

Five hundred and thirty two (n=532) recruits participated in the pre-conditioning training regimen. The majority of these participants successfully entered BMT (69%), but 25% failed to meet the pre-enlistment fitness standard upon completion of the pre-conditioning regimen and 6% were discharged prior to completion of the pre-conditioning period. Predicted cardiorespiratory endurance at commencement (n=532) was 30.9 ± 6.3 mL·kg-1·min-1 with those participants that entered BMT (PASS, n=368) having a significantly higher score (31.9 ± 3.7 mL·kg-1·min-1) than those (n=132) that did not enter BMT (FAIL, 28.7 ± 3.0 mL·kg-1·min-1). Irrespective of outcome both PASS and FAIL groups significantly increased fitness following pre-conditioning with a mean increase of 7.8 ± 3.5 mL.kg-1.min-1 and 6.2 ± 3.1 mL·kg-1·min-1 respectively. However, for local muscle endurance FAIL showed reduced improvement following pre-conditioning (n=131; 4.1 ± 4.5 repetitions), than PASS (n=368; 7.1 ± 4.8 repetitions).

CONCLUSIONS

A 7-week pre-conditioning program significantly increased the physical fitness of all participants, however despite these improvements, physical performance was still below the average fitness of female recruits who met the pre-enlistment fitness standard at recruiting and entered into BMT directly.

OPERATIONAL RELEVANCE

Physical demands associated with military service and duration of preparatory military training have remained relatively unchanged. Yet, physical fitness is declining in the broader community increasing the difficulty of recruiting participants appropriate to withstand the rigours military training and service. Extension of the preparatory military training period via pre-conditioning may ensure military personnel are appropriately conditioned to complete training and meet the physical demands of military service.

AUTHORS

Herbert Groeller (1)
Herbert Groeller (2)
Jace Drain (3)

(1) Centre for Human and Applied Physiology, School of Medicine, University of Wollongong (Wollongong, Australia); (2) Centre for Human and Applied Physiology, School of Medicine, University of Wollongong (Wollongong, Australia); (3) Defence Science and Technology Group (Melbourne, Australia)

TS22.
OPTIMIZING MENTAL AND PHYSICAL RESILIENCE TO IMPROVE SOLDIER READINESS
#ABS379

ADAPTABILITY, EMOTION PERCEPTION AND ATTENTION: TACTICAL COGNITIVE RESILIENCE IN RESPONSE TO OPERATIONAL STRESS

PURPOSE

To assess tactical cognitive readiness and resiliency in a military operational stress paradigm, we examined performance on the Soldier Performance and Effective, Adaptable Response (SPEAR) task, Psychomotor Vigilance Test (PVT), and the Reading the Mind in the Eyes Test (RMET) in response to a sleep and caloric restriction protocol.

METHODS

Fifteen Service Members completed a 5-day/night protocol designed to simulate military operational stress. Subjects were given 50% of baseline caloric demands on Days 3 and 4. Nights 3 and 4 included restricted sleep from 0100-0300 and 0500-0700. On the evenings of Day 2 (D2) and Day 4 (D4), subjects completed neuropsychological assessments of emotion recognition (RMET), followed by a military relevant scenario-based adaptive decision-making task (SPEAR) consisting of two blocks: security force assistance (SFA) and combat operation (CO) scenarios. Subjects completed assessment of vigilance (PVT) at approximately 2230. 2x2 ANOVA determined differences in SPEAR block scores between days. Correlations and regressions were computed to examine the relationships of SPEAR, RMET, and PVT. ($p<0.05$).

RESULTS

There was no significant interaction between block and day on performance scores ($F_{1,14}=3.871$, $p=0.070$). The main effect of block was significant ($F_{1,14}=7.814$, $p=0.014$). CO block was associated with a mean score 7.433 points higher than SFA block ($p=0.014$). D4 Total SPEAR score and RMET accuracy were significantly correlated ($r=0.626$, $p=0.012$). D4 RMET accuracy predicted D4 SFA scores ($F_{1,13} = 8.4$, $p=0.37$), accounting for 29.3% of the explained variability in D4 SFA. Change in PVT from D2 to D4 significantly predicted SFA changes ($p=0.025$), and accounted for 35.4% of the explained variability in SFA changes from D2 to D4.

CONCLUSIONS

SPEAR performance for the SFA challenge was lower relative to the CO challenge. The stress of the sleep and caloric restrictions revealed important relationships with emotion perception and attention measures at D4. Of note are the findings associated with these measures and the SFA scenarios, which require expanded social, cultural and military situational awareness to determine adaptive solutions to the tactical decision making challenge.

AUTHORS

Amy Haufler (1)
Meaghan Beckner (2)
William Conkright (2)
Alice LaGoy (2)
Shawn Flanagan (2)
Anne Germain (3)
Christopher Connoboy (3)
Bradley Nindl (2)

(1) National Security Analysis Department, Johns Hopkins University Applied Physics Laboratory (Laurel, United States); (2) Neuromuscular Research Laboratory, Department of Sports Medicine and Nutrition, School of Health and Rehabilitation Sciences, University of Pittsburgh (Pittsburgh, United States); (3) Military Sleep Tactics and Resilience Research Team, Department of Psychiatry, School of Medicine, University of Pittsburgh (Pittsburgh, United States)

TS22.
OPTIMIZING MENTAL AND PHYSICAL RESILIENCE TO IMPROVE SOLDIER READINESS
#ABS409

FEBRUARY 12, 2020

BIOMARKER RESPONSES UNDERLYING MILITARY OPERATIONAL AND EXTREME STRESS

Resilience can be defined in numerous ways depending on who is providing the definition. For example, the ability to withstand a particular stress. However, just as one individual is able to withstand or overcome a particular event or stressor, another may be resilient by their ability to quickly recover and still perform at an optimal level. There are a multitude of stressors an individual is placed under during military operational and extreme stress. For example, these may be in the form of psychological strain (active combat, confinement) physical exertion (ruck marching, lifting equipment), reduced sleep, caloric restriction, and emotional factors (separation of family). The environment has been previously described as volatile, uncertain, complex, and ambiguous (VUCA). While each of these may have varying effects depending on the individual, they all will have a particular influence biologically, depending on the stressor. These individual differences are particularly important when it comes to the ability to not only perform optimally in a military environment but thrive, avoid injury and carry out the mission.

The purpose of the current session is to discuss the various biomarkers previously indicated in resilience type research, as well as those identified with regard to injury. Such as, Brain-derived neurotrophic factor (BDNF), Neuropeptide-Y (NPY), the hypothalamic-pituitary-adrenal (HPA) axis, cortisol, inflammatory cytokines, dehydroepiandrosterone (DHEA), Insulin-like growth factor-I (IGF-I) and growth hormone (GH). These biomarkers will be discussed in relation to simulated military operational stress (SMOS), as well other military relevant investigations to help identify the effects of SMOS on sex, environment, and physical fitness.

OPERATIONAL RELEVANCE

A multifaceted approach of SMOS between sexes, environments allows for the identification of biomarkers present in individuals who will thrive in the face of particular stress. These as well as other data discussed will help to identify individual biomarkers present in those able to withstand and overcome imposed military relevant stressors.

AUTHORS

Brian Martin (1)

Bradley Nindl (2)

(1) 1978 (PITTSBURGH, United States); (2) University of Pittsburgh (Pittsburgh, United States)

TS22.
OPTIMIZING MENTAL AND PHYSICAL RESILIENCE TO IMPROVE SOLDIER READINESS
#ABS068

FEBRUARY 12, 2020

SEX DIFFERENCES IN THE RECOVERY OF PHYSICAL PERFORMANCE AND PHYSIOLOGICAL MARKERS AFTER STRENUOUS MILITARY FIELD TRAINING

PURPOSE

The acute physiological effects of strenuous military field exercises (MFEs) have been studied extensively in men, but studies in women are sparse. Therefore, the purpose of this study was to investigate sex differences in the effects of a demanding MFE on physical performance, body composition and blood biomarkers.

METHODS

Body composition, blood samples and physical performance were tested in 23 male and 12 female conscripts serving in the Special Forces division before, and 0, 1, 3, 7 and 14 days after a 6-day MFE consisting of rigorous physical activity (>6000 kcalday-1) with food (~700 kcalday-1) and sleep (1-6 hoursday-1) restriction. Men and women performed mostly the same activities throughout the MFE. A mixed design ANOVA was conducted to investigate changes over time and interaction between time and sex. A significant interaction was followed up using pairwise comparisons with Bonferroni adjustment.

RESULTS

During the MFE, body mass was more ($p < 0.001$) reduced in men (6.5 ± 1.1 kg, $p < 0.001$) than in women (2.7 ± 0.7 kg, $p < 0.001$), and lean body mass was only reduced in men (2.7 ± 1.0 kg, $p < 0.001$). Changes in body composition were recovered within one week. Performance was reduced similar in both sexes for counter movement jump (CMJ) (19 ± 8 vs. 18 ± 11%, $p < 0.001$), medicine ball throw (MBT) (11 ± 7 vs. 11 ± 7%, $p < 0.001$) and an anaerobic performance test (EVAC) (55 ± 22 vs. 47 ± 31%, $p < 0.001$, men and women respectively). MBT and EVAC performance recovered within two weeks, whereas CMJ performance was still reduced in men (17 ± 6%, $p < 0.001$) and women (9 ± 8%, $p < 0.05$) after two weeks recovery, with a larger reduction in men. Both sexes had reduced Insulin-like growth factor 1 (28 ± 9 vs. 41 ± 8%, $p < 0.01$) and increased cortisol (26 ± 26 vs. 66 ± 93%, $p < 0.001$, men and women respectively). Most biomarkers returned to baseline values within one week.

CONCLUSIONS

Men lost more body mass and lean mass than women during a demanding MFE. Both sexes had large reductions in performance, with no sex differences. Women recovered explosive strength in the legs faster than men.

OPERATIONAL RELEVANCE

The long recovery time after MFEs and the sex differences in the response to MFEs are important knowledge when planning military operations and long-term training.

AUTHORS

Hilde Teien (1)
Olav Vikmoen (2)
Marius Raustoel (3)
Anders Aandstad (4)
Truls Raastad (3)

(1) Norwegian Defence Research Establichment, FFI (Kjeller, Norway); (2) Norwegian Defence Research Establishment, FFI (Kjeller, Norway); (3) Norwegian School of Sport Sciences (NIH) (Oslo, Norway); (4) Norwegian Defence University College (Oslo, Norway)

STRENGTH AND CONDITIONING FOR FIREFIGHTER TRAINEES: IMPROVING HEALTH, FITNESS AND OCCUPATIONAL PERFORMANCE WITH LIMITED RESOURCES

In order to perform the arduous demands of their job, firefighters must possess a enough level of strength, muscular endurance, and aerobic fitness. As a part of their normal occupational duties firefighters may be required to perform highly demanding physical tasks, such as carrying heavy tools, rescuing victims, stair climbing, hose pull and hydrant hook-up, charged hose advances, forcible entries, and ladder raises. These tasks are often performed in dangerous and uncontrolled environments, while wearing personal protective equipment that can weigh as much as 22 kg. On this basis, it is vital that new trainees undergoing training at their fire academy develop the requisite fitness to be successful when performing occupational activities. However, there are often challenges with training large groups of trainees due to resource constraints. The purpose of this presentation is to provide attendees with an evidence-based approach for developing and maintaining health, fitness and occupational performance among firefighter trainees over a 16-week training academy when time, space and resources are limited.

AUTHORS

Jay Dawes (1)

(1) Oklahoma State University (Stilwater, United States)

RECOMMENDATIONS FOR DEVELOPING AND IMPLEMENTING A COMPREHENSIVE FIRE SERVICE SCREENING ASSESSMENT

The fire service is a critical component to public safety and one of the most accessed public services in the United States. According to the United States Bureau of Labor Statistics, the total incidence rate of work-related injury in the fire service is 397.5/10,000 full time employees, approximately four times higher than other public safety occupations. Additionally, despite a drop in the overall number of injuries over the last three decades, musculoskeletal injury rates have remained consistent at near 50% of all injuries in the United States' fire service. Efforts have been made to screen firefighters for work readiness and risk of illness and death, particularly for cardiovascular complications related to the increased strain associated with firefighting, however minimal work has been completed on the physical performance tests to determine physical readiness for work and to identify areas of improvement related to musculoskeletal health and wellness. Through this presentation we will describe existing physical performance tests which will could add value to a comprehensive firefighter health and wellness screening; outline the challenges and opportunities in the fire service for musculoskeletal screening assessments; and propose appropriate screening tools including patient-reported and clinician-rated outcome measures to create a comprehensive screening battery. The goal of this presentation is to provide attendees with models of screening that include the firefighter and the practitioner in the decision-making process. Additionally, the long-range goal of this presentation is to serve as a call to action to reduce healthcare-related spending in the fire service by translating risk factor identification through firefighter screening and providing early intervention to reduce the number, severity, and burden of firefighter injury.

AUTHORS

Kenneth Games (1)

(1) Indiana State University (Terre Haute, United States)

DEVELOPMENT OF A WORK REST PROTOCOL FOR FIREFIGHTER RECOVERY OPERATIONS

A total of 58,835 firefighter injuries occurred in 2017, the fewest number of injuries ever recorded. At the same time, there has been a 28% increase in non-fire related emergencies. The highest number of injuries (24,495) occurred at fire ground related activities (structural fire, brush fire, vehicle fires, etc.), followed by non-fire related injuries (rescue calls, hazard calls, national disasters, etc). A large portion of these injuries result in missed workdays, forcing fire departments to compensate for manpower losses. Musculoskeletal injury accounts for 48% of fire ground and 58% of non-fire emergency injuries. These are potentially preventable strains, sprains and muscle pain. Musculoskeletal injuries are likely due in part from overall fatigue associated with the strenuous tasks during fire ground and non-fire emergencies. The National Fire Protection Agency (NFPA) 1584 recovery protocol sets standards recommending recovery time if firefighters are likely to be working for more than one hour. Recommended recovery includes 10 or more minutes rest with adequate fluids and removal of their personnel protective equipment. Research has shown that a 20 minutes recovery period following physical activity in hot temperatures, such as a fire, does not return core body temperatures to baseline levels; however, it does return a firefighters rate of perceived exertion to baseline levels. Thus, this may give false understanding that a firefighter can return to activity when they are still at risk for a fatigue or heat related injury. It is therefore important that a proper work to rest protocols be determine for optimal recovery and injury reduction during both fire ground and non-fire related injuries. This presentation will discuss recovery work to rest protocols for firefighter recovery in various temperature environments.

AUTHORS

Kaitlin McGinnis (1)
Angela Burns (1)
Abigail Campbell (1)
Oluwagbemiga Dadematthews (1)
Aaron Parks (1)
(1) Auburn University (Auburn, United States)

THE IMPACT OF A LIVE STRUCTURAL FIRE ON FIREFIGHTER HYDRATION

PURPOSE

Structural firefighting is a highly stressful occupation with firefighters performing intense bouts of physical activity in environmental extremes while wearing impermeable, heavy and restrictive Personal Protective Equipment (PPE). The aim of this study was to investigate the impact of performing occupational tasks during an active structural fire on firefighters hydration status.

METHODS

Nine fully qualified firefighters (males = 7, age= 42.00±5.13 years, experience = 8.43±5.09 years; weight = 98.59±17.13 kg: females =2, age= 36.50±2.12 years, experience = 10.00±1.41 years; weight = 71.15±12.37 kg) completed a 15 minute live fire scenario while performing occupational tasks (victim and charged hose drags) in PPE (21 kg). Urine Specific Gravity (USG), body weight and tympanic membrane temperature were measured pre-scenario and at 0 and 20 minutes post-scenario. A repeated measures analysis of variance (ANOVA) was performed (pre-and two post-measures) with a post hoc Bonferroni analysis to determine where significance lay. Alpha levels were set at 0.05 a priori.

RESULTS

During the live fire the temperature in the structure ranged from 40.0 oC at 0.3m above the floor to 458.3oC at ceiling level (approx. 2.6m). The relative humidity was 53.1-58.6%. There was a significant ($f[1,6]=137.66$, $p<0.001$) decrease in body weight across the three time points (95.57±21.52 kg, 94.84±21.35 kg, 94.37±21.35 kg respectively) and an increase in tympanic membrane temperature ($f[1,6]=75688.22$, $p<0.001$) between both post measures (38.94±0.42oC, 37.76±0.45oC, respectively) and the pre measure (36.53±0.35oC). There was no significant change in USG post-scenario (1.016±0.010 au, 1.018±0.010, au, 1.018±0.009 au, respectively).

CONCLUSIONS

Short duration firefighting operations can cause significant fluid loss, as measured by change in body weight. This may be exacerbated by firefighters arriving on shift in a dehydrated state. The thermal effects of firefighting significantly increased firefighter tympanic membrane temperature.

OPERATIONAL RELEVANCE

Without cooling and rehydration strategies, the body temperature of firefighters may remain elevated and dehydration may continue for at least 20 minutes, even outside the fire event if the firefighters are required to remain in PPE.

AUTHORS

Robin Orr (1)
Adam Walker (2)
Ben Schram (1)
Richard Gorey (1)
Rodney Pope (3)

(1) Tactical Research Unit, Bond University (Robina, Australia); (2) Faculty of Health Sciences and Medicine, Bond University (Gold Coast, Australia); (3) School of Community Health, Charles Sturt University (Albury, Australia)

A PUBLIC HEALTH APPROACH TO INJURY PREVENTION AND WELLNESS IN THE FIRE SERVICE

Firefighters in the United States are public servants that serve as first responders to protect their community. As part of the strenuous job demands, high rates of both physical and mental health conditions are reported in the fire service. The common contributing factors to injury and illness in the fire service include both intrinsic and extrinsic risk factors such as sex and age, yet we must begin to view risk factors of health conditions through the lens of modifiable risk factors including fitness levels, neuromuscular control, hydration status, environmental work conditions, and emotional exposures. Firefighting presents high risks for sustaining a musculoskeletal injury with overexertion and strain accounting for 27.1% of all injuries. Moreover, mental health must be explored as 103 of the 196 firefighters that died in 2017 were due to suicide. This presentation will explore the Meuwisee Dynamic Model of Etiology to describe the cause of diseases most commonly noticed in the fire service. Additionally, the presentation will explore the role of prevention through the public health perspective. The goal of public health is to blend science and art to prevent health conditions, prolong life, and inform the community about making lifestyle choices to do so. Prevention strategies are described as primary, secondary, or tertiary depending on the level of influence in the disease prevention. The presentation will describe how taking a public health approach, including the socio-cultural factors of the fire service, must be considered for any healthcare innovation will be adopted or adapted to meet the needs for future physical performance. The goal of exploring injury and illness prevention is the cost-benefit to the organization focused on healthcare versus sick care. The impact of musculoskeletal injuries can negatively affect ones short and long-term career projects as a tactical athlete. Finally, the presentation will demonstrate ways in which wellness must be optimized using education at the individual, organization, community, and federal level to sustain a workforce, in this case the firefighters.

AUTHORS

Zachary Winkelmann (1)

(1) University of South Carolina (Columbia, United States)

TS26.
THE IMPLICATIONS OF EMERGING TECHNOLOGY ON THE MILITARY HUMAN PERFORMANCE IN THE NEXT DECADE

#ABS181

FEBRUARY 12, 2020

THE IMPACT OF EMERGING TECHNOLOGIES ON MILITARY HUMAN PERFORMANCE RESEARCHERS IN THE NEXT DECADE

PURPOSE

The pace of military modernisation and the emergence of new capabilities arising from technology innovation will lead to radical changes in the way that military operations are conducted, including the fundamental role of human combatants.

METHODS

Emerging technologies that are most likely to have a significant impact on military human performance requirements within the next decade were identified through technology horizon scanning, foresight, futures and force design studies, along with workshops with industry, academia and military subject matter experts.

RESULTS

The battlefield of the future will likely be populated by fewer human combatants, but these humans would be physically and cognitively augmented with enhanced capabilities to sense their environment, make sense of their environment, and interact and collaborate with one another, as well as with robots of various forms. As a result, human combatants would not only do things differently, but do different things compared to warfighters of today. For instance:

Autonomous and unmanned systems will remove the warfighter (or team with the warfighter) from dull, dangerous and dirty, and heavy, hot and hazardous environments. With the ability to learn and evolve themselves these capabilities will advance at an unprecedented rate.

Clothing and other equipment with embedded chips will be implanted, worn by, or used by the warfighter and connect to a network, enabling greater communication and new data-driven services (based on increased analytics capabilities) as well augmented reality environments.

Tailored gene therapy will enable the development of enhancements both physically and cognitively, beyond current human limits.

CONCLUSIONS

As a result of these disruptive forces, todays military human performance researchers need to pre-empt the emergence new technological developments to ensure they continue to provide a capability edge and help to prevent strategic surprise.

OPERATIONAL RELEVANCE

By developing an understanding of possible threats and opportunities, anticipating technological change and forecasting possible emerging technologies (including their convergence or fusion), the ICSPP research community can manoeuvre to prioritising research activities today in line with tomorrows human performance requirements.

AUTHORS

Dan Billing (1)

(1) Defence Science and Technology Group (Seoul, South Korea)

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TS26.
THE IMPLICATIONS OF EMERGING TECHNOLOGY ON THE MILITARY HUMAN PERFORMANCE IN THE NEXT DECADE

#ABS146

FEBRUARY 12, 2020

EXAMINATION OF HOW EMERGING TECHNOLOGIES MAY IMPACT MILITARY HUMAN PERFORMANCE REQUIREMENTS AT A STRATEGIC, OPERATIONAL AND TACTICAL LEVEL

PURPOSE

Training grounds and battlefields continue to become proliferated with emerging technologies purporting to enhance military tasks performance. Therefore, it is of fundamental importance to understand how, and by how much, these technologies impact the roles and human performance requirements of high-level, theatre-level and subtheatre-level commanders down to small units and individual soldiers.

METHODS

Methods for assessing performance of individuals and small units were identified through document searches followed by engagement with industry, military and government subject matter experts.

RESULTS

Most academic and defence scientific organisations examine military human performance using a Cartesian reductionist approach and traditional statistical analyses. That is, tightly controlled, repeated measures experiments that provide reliable and repeatable output metrics from grouped individual participants. While it is accepted that this approach has merit in regards experimental consistency it could be argued that the activities conducted are contrived and unrepresentative of ground truth thus limiting the generalisability of the findings. In addition, many Armies use training as a platform for assessing emerging capabilities. While exceptionally representative of ground truth, these activities have limited repeatability due to the focus on collective training objectives rather than data capture and analysis.

It is likely that emerging technologies will change battlefield roles and tasks at all levels. Indeed, new tasks will be created, old tasks eliminated, or at least performed less often, which will alter military human performance requirements. There will certainly be more synthetic (e.g. autonomous) systems that will be easier to measure and more predictable than biological (soldier) systems. This will require new or different methodologies to be developed including advanced analytic tools, such as artificial intelligence-assisted analysis and machine learning.

CONCLUSIONS

In order to fully understand the impact of emerging technologies, it is suggested that a more interdisciplinary, advanced-analytics approach is established. However, the transfer to the data age may require significant organisational change and it is critical that defence organisations have an endorsed strategy for the acceptance and implementation of advanced-analytical tools specific to the assessment of military human performance.

OPERATIONAL RELEVANCE

Understanding how, and by how much, emerging technologies may impact military human performance requirements is critical for evidence-based decision-making. The outputs from such activities would be exploited across many domains including concept and doctrine development, capability acquisitions, training and force development.

AUTHORS

Graham Fordy (1)

(1) Fordy Consulting Limited (Raumati Beach, New Zealand)

TS26.
THE IMPLICATIONS OF EMERGING TECHNOLOGY ON THE MILITARY HUMAN PERFORMANCE IN THE NEXT DECADE

#ABS366

FEBRUARY 12, 2020

MANAGING THE IMPACTS OF EMERGING TECHNOLOGY ON MILITARY HUMAN PERFORMANCE IN THE NEXT DECADE

PURPOSE

Augmenting technologies can provide soldiers with capabilities that far exceed those originally conceived for Superman, but there is also risk in technology dependence and development of strategies that are inconsistent with human tolerances and biology. The adoption of new technologies requires thoughtful and deliberate consideration of second order consequences.

METHODS

Several examples of emerging technologies to enhance human performance are discussed along with the risk mitigation strategies that must also be considered.

RESULTS

While personal electronics are enormously empowering tools, soldiers must be trained for the sudden loss of these capabilities in isolated or electronic warfare environments. This involves training of information access-dependent Millenials to be able to function in autonomous small unit operations, as well as specific skills such as navigation based on understanding the neurobiology of wayfinding. Real time physiological status monitoring (RT-PSM) can provide intelligence on the performance of our own soldiers but this can also fail, be blocked, or hacked. RT-PSM may be useful in training recruits and newly formed teams to perform optimally but simply an added cognitive burden in operational environments unless if it provides vital actionable information. Physiologically aware virtual agents may provide a trusted coach/advisor capability including machine assessment of soldier mental status and team performance, redistributing cognitive workload or modifying information presentation within teams but it remains to be discovered how this synthetic social structure will affect human mental resilience and team dynamics. Load carriage and speed of movement may be enhanced with assistive technologies such as exoskeleton powered boots, speeding a small unit over rough terrain; however, overdependence could reduce performance with musculoskeletal remodelling and atrophy.

CONCLUSIONS

Performance enhancement technologies should work with human biology and in no case should this consider attempts to improve human biology (a fools errand). Emerging technologies may greatly expand soldier capabilities but there are risks associated with overdependence, including failure to sustain the replaced skills and capabilities. Synthetic interactions with machines may reveal hitherto unknown aspects of social biology essential to human optimal functioning. In the future, we will use new technologies to accelerate and enhance training, but then should conduct operations with less dependence on those technologies.

OPERATIONAL RELEVANCE

Technology enhancement of human performance must be considered with respect to human biology. There is risk in soldier technology dependence especially against a technology-poor opponent.

AUTHORS

Karl Friedl (1)

(1) US Army Res Inst of Environ Med (Natick, United States)

HOW CAN MILITARY HUMAN PERFORMANCE RESEARCHERS HELP TO BETTER POSITION DEFENCE AGENCIES TO RESPOND TO THE STRATEGIC CHALLENGES ASSOCIATED WITH EMERGING TECHNOLOGIES?

PURPOSE

Given the different available emerging technologies and changing battlefield scenarios, it is important first of all to identify the strategic factors and challenges that defence organisations will need to respond to. Second, to identify and analyse the consequences those changes may have on physical and cognitive performance. Third, we must, as researchers, ask our self, "Are we focusing our research on the most important issues and areas?"

METHODS

Methods for identifying the strategic challenges and the potential consequences on human physical and cognitive performance were identified through document and open-source literature searches followed by engagement with military and scientific colleagues.

RESULTS

One key domain of emerging technologies is the development of human-machine teaming and human-artificial intelligence (AI) teaming which are intended to increase the pace of decision support and reduce the complexity of decision-making. Although the dismounted soldier may well serve as a multi-sensory node, from which data is transmitted, to enable operational and strategic level decision making the processes may become faster than human cognitive capacity,. especially when also having to operate in a human team. This could place a severe cognitive load on an individual.

Due to new technologies, such as weapon-mounted sensing, night vision equipment and body protective equipment, the load and burden (physiological, cognitive, biomedical and ergonomic) on the dismounted soldier continues to increase to an exceptionally high level. This is a paradox since the intent of using new technology (mostly) is to reduce the physical and/or cognitive burden. Currently, very limited research is focused on areas such as enabling supra-normal human function and performance. Focusing research on human performance, physical and cognitive, using mechanical capabilities, that enhance existing human capacity, will become increasingly important.

CONCLUSIONS

Emerging technologies give rise to many changes and challenges. In order to address these changes, an interdisciplinary approach is needed, where researchers are focusing their research on areas that enable supra-normal human function and performance.

OPERATIONAL RELEVANCE

Understanding the challenges and consequences of developing and embedding emerging technologies onto the battlefield is fundamentally important to inform strategic decision making. However, research focusing on these areas, through the lens of human performance, is critical to better position defence agencies to meet these challenges.

AUTHORS

Henriette Hasselstrom (1)
Henriette Hasselstrom (2)

(1) Centre for Military Physical Training, Danish Defence Medical Command, Denmark (Copenhagen, Denmark); (2) Danish Defence Medical Command, Center For Military Training (Copenhagen, Denmark)

NUMBER OF TRIALS REQUIRED TO RECORD TRUE PEAK FORCE ON ISOMETRIC MID-THIGH PULL IN YOUNG CANADIAN MILITARY RECRUITS

PURPOSE

The purpose of this research was to identify the ideal number of trials recorded to obtain a maximal peak force (PF) on an Isometric Mid-Thigh Pull (IMTP).

METHODS

Participants had a minimum of three months of strength training with qualified exercise specialist during basic military training prior to participating in this study. The sample consisted of 46 participants (43 males, 3 females) attempting the Developmental Period 1 Infantry course at the 4th Canadian Division Training Centre. Participants height was 177.2 (6.6) cm, weight was 78.9 (11.3) kg, waist circumference was 84.4 (7.8) cm and predicted V O2max was 52.4 (3.9) mL*kg-1*min-1. Participants performed 5 maximal IMTP trials, lasting 5 seconds with 20 seconds of rest between trials on a modified squat rig. Bar height was adjusted to ensure a hip angle between 140 150° and a knee angle between 120 – 130°. Participants were not given any unrecorded familiarisation trials. Grip on the bar was pronation-supination (mix) with favourable side for each participant. Ground reaction forces from each foot was recorded using two force platforms, and the results from each platform was summed to obtain a resultant force. Sampling rate was set at 50 Hz. Peak Force (PF) was identified as the maximal value recorded in Newtons (N). Analysis of variance was completed on PF from trials 1-5 using SPSS 24.

RESULTS

Highest mean PF recorded was 1725 (321) N, which represent 2.22 (0.39) times body weight. Mean PF declined by 8.5% ($p<0.01$) from trial 1 through trial 3 but stabilised afterwards. PF declined by a mean of 267 (101) N (15.8%) within the five trials. Within the first two trials, 38 of 46 (82.6%) participants recorded their highest PF value. By trial four, 43 out of 46 (93.5%) participants had recorded their highest PF values.

CONCLUSIONS

Based on this sample, it was observed that 82.6% of participants reached their highest PF on IMTP within 2 trials and 93.5% reach their highest PF on IMTP within 4 trials, with a 20sec rest period given between trials.

OPERATIONAL RELEVANCE

With the increase in popularity of IMTP to estimate overall body strength in military populations, trainers and scientist should record a minimum of two trials per participant in order to obtain true maximal PF.

AUTHORS

Etienne Chassé (1)
Eric Robitaille (2)
Scott Heipel (3)
Hans Christian Tingelstad (1)
Tara Reilly (1)

(1) Human Performance Research and Development, Directorate of Fitness, Personnel Support Programs, Canadian Forces Morale and Welfare Services, Government of Canada, Ottawa, Canada. (Ottawa, Canada); (2) 31 Canadian Forces Health Services Centre Detachment Meaford, 4th Canadian Division Training Centre, Meaford, Canada (Meaford, Canada); (3) Canadian Forces Morale & Welfare Services, 4th Canadian Division Training Centre, Meaford, Canada (Meaford, Canada)

TS27.
ISOMETRIC MID-THIGH PULL: POTENTIAL VALUE OF THIS FIELD EXPEDIENT TEST

#ABS373

FEBRUARY 12, 2020

RELATIONSHIP BETWEEN PHYSICAL PERFORMANCE AND MSKI IN AUSTRALIAN ARMY RECRUITS

PURPOSE

The study investigated the relationship between physical performance capacity and musculoskeletal injury (MSKI) in Australian Army recruits undertaking basic military training (BMT).

METHODS

428 recruits (350M/78F) were prospectively tracked across the Australian Army 12-week basic military training (BMT) course. Physical performance (multi-stage shuttle run test, push-ups, isometric mid-thigh pull, standing broad jump, medicine ball chest put) was assessed during weeks 1 and 8, whilst musculoskeletal injury data was collected over the entire course using existing reporting systems at the Army Recruit Training Centre. Injuries other than musculoskeletal injuries, for example blisters and cuts, were excluded from analysis. Binary logistic regression assessed the relationship between baseline physical performance and MSKI incidence over BMT. An independent samples t-test assessed differences in baseline (week 1) physical performance between the injured and non-injured groups. Statistical significance was set at $p<0.05$. Statistical analysis was performed in SPSS V25.

RESULTS

379 (88.6%; 312M/67F) recruits successfully completed BMT without recording an MSKI, whilst 49 recruits (11.4%; 38M/11F) sustained at least one MSKI over the 12-week BMT course. There were no differences in baseline physical performance between the injured and non-injured groups ($p>0.05$). Logistic regression showed no relationship between the five physical performance tests and MSKI incidence (RR; 0.92-1.00, $p>0.05$).

CONCLUSIONS

Contrary to previous research, no predictive relationship between physical performance and MSKI incidence was observed in the current study. It is likely that the small sample size in the current investigation, explains at least in part, the #ABSence of any relationships between physical performance and MSKI.

OPERATIONAL RELEVANCE

It is well understood MSKI risk is multi-factorial. It is suggested that these results demonstrate the importance of large sample sizes when determining the prognostic value of physical performance metrics in military recruits commencing BMT.

AUTHORS

Jace Drain (1)
Dean King (2)
Allan Mullins (2)
Jeffrey Langdon (2)
Brendan Bettess (2)
Blake Hart (2)
Ashley Morris (2)
Herbert Groeller (3)

(1) Defence Science and Technology Group (Port Melbourne, Australia); (2) 1st Recruit Training Battalion, Australian Army (Kapooka, Australia); (3) University of Wollongong, Wollongong, Australia, 2522 (Wollongong, Australia)

TS27.
ISOMETRIC MID-THIGH PULL: POTENTIAL VALUE OF THIS FIELD EXPEDIENT TEST

#ABS119

UTILITY OF AN ISOMETRIC MID-THIGH PULL TEST TO ASSESS NEUROMUSCULAR FATIGUE DURING AN URBAN OPERATIONS CASUALTY EVACUATION TASK

PURPOSE

Previous research has examined the physiological demands and resultant neuromuscular fatigue of operational tasks, typically through examining changes in measures of maximal voluntary contractions (MVC) and vertical jump height. The isometric mid-thigh pull (IMTP) test has been widely used as a performance measure, demonstrating its relationship to dynamic performance tasks and previously used fatigue measures. Compared to other measures, IMTP can be conducted in a field environment, requires limited coaching for correct technique, is quick to administer, and safe to perform. The objective of this study was to investigate the use of IMTP as a field-based assessment of neuromuscular fatigue following a specific combat-task; urban operations casualty evacuation (UO CASEVAC).

METHODS

Thirteen (7 male, 6 female) Canadian Army personnel (mean ± SD: age 32 ± 7 years, height 1.72 ± 0.75 m, body mass 79.8 ± 14.9 kg) completed a 5 km march wearing an external load of 35 kg followed by two UO CASEVAC tasks wearing an external load of 25 kg and carrying an additional 40 kg by hand. Peak force generated during IMTP was measured pre-, and post-UO CASEVAC task 1 and task 2. Peak force (IMTP) data were analysed using a 2 x 3 MANOVA with post-hoc, Bonferroni-corrected, independent-samples t-tests and further analysis of individual change in scores via calculation of the smallest detectable difference (SDD).

RESULTS

No significant mean changes in IMTP peak force were found for male or female participants. However, individual changes demonstrated a decline in force for the majority of participants, with some participants showing a reduction in force greater than the SDD. Mean change in peak force from pre UO CASEVAC 2 for female participants was greater than the SDD at-215±267 N.

CONCLUSIONS

Overall, the UO CASEVAC task did not significantly impair IMTP peak force in the group of male and female participants. It is unclear if this is due to limited sensitivity of the IMTP measure, or insufficient intensity or duration of the UO CASEVAC task to elicit a detectable decrement in force production. Future research should also include comparison to criterion measures such as MVC of isolated muscle groups.

OPERATIONAL RELEVANCE

Recent data, including that generated from this study, highlight the importance of muscular strength/power as a critical modifiable factor (over and above sex differences) for completion of combat-specific tasks. Therefore, there is a need to develop reliable and valid field-based measures to further investigate this.

AUTHORS

Sarah Needham-Beck (1)
Hans Christian Tingelstad (2)
Etienne Chassé (2)
Sam Blacker (1)
Tara Reilly (2)

(1) Occupational Performance Research Group, Institute of Sport, University of Chichester (Chichester, United Kingdom); (2) Human Performance Research and Development, Canadian Forces Morale and Welfare Services, Department of National Defence (Ottawa, Canada)

ISOMETRIC MID-THIGH PULL NORMATIVE DATA FOR OVER 1000 CANADIAN OFFICER CADETS

PURPOSE

Normative data for an Isometric Mid-Thigh Pull specific to a Canadian Officer Cadet population is required to define a scoring system for a newly deployed, six-component, Physical Performance Test.

METHODS

An extensive representative sample from all four years of Officer Cadets performed a maximal Isometric Mid-Thigh Pull on a custom-built rig consisting of a squat rack fixed to the floor. Participants stood with each foot on a separate force platform approximately shoulder-width apart with knee and hip angles of 130° and 150°, respectively. A slight external rotation of the hips was acceptable. An immovable 1 bar was held using a mixed grip with arms fully extended from the shoulder. Participants were instructed to pull as hard and as fast as possible and maintain the effort for three seconds. The force platforms recorded the trials at 60 Hertz and the resultant peak forces were calculated. Although many factors may be assessed using an Isometric Mid-Thigh Pull, such as time-to-peak, muscular endurance, and muscular imbalance, only peak resultant force is scored for the fitness evaluation.

RESULTS

482 Officer Cadets (384 male; 98 female) completed recorded Isometric Mid-Thigh Pulls. Peak force for male participants ranged from 955 to 2656 Newtons with an average of 1618±312 Newtons. Likewise, female participants peak forces ranged from 474 to 1554 Newtons with an average of 1066±236 Newtons. No relationship between academic year or age was identified with peak force.

CONCLUSIONS

Results from this study will inform scoring parameters for the Isometric Mid-Thigh Pull component of the newly deployed Physical Performance Test. This population specific sample is significant not only because it represents a large percentage of the total Canadian Officer Cadet population, but also because it is substantially larger than those of most other Isometric Mid-Thigh Pull studies. A 2018 (Brady, Harrison, & Comyns) review paper identified 26 studies on primarily collegiate athletes with a combined 633, mostly male, participants.

OPERATIONAL RELEVANCE

As part of a comprehensive fitness evaluation twice a year, all 1200-plus Officer Cadets at both of Canadas military universities will be assessed on an Isometric Mid-Thigh Pull because of its link to load bearing capacity and risk of injury. Therefore, standards appropriate to a military student must be established.

AUTHORS

Evan S Walsh (1)
Craig Palmer (2)
Stephane Robert (2)
Sébastien Beauregard (3)
Patrick Gagnon (1)

(1) Human Performance Research and Development, Directorate of Fitness, Personnel Support Programs, Canadian Forces Morale and Welfare Services, Government of Canada (Ottawa, Canada); (2) Physical Education Department, Royal Military College of Canada, Department of National Defence, Government of Canada (Kingston, Canada); (3) Collège militaire royal de Saint-Jean, Department of National Defence, Government of Canada (Saint-Jean-sur-Richelieu, Canada)

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MALES AND FEMALES RESPOND DIFFERENTLY OVER A 5 KM LOADED MARCH AND AFTER 10 WEEKS OF TRAINING

PURPOSE

In the military, males and females undergo the same physical training for the same roles despite known physiological differences between the sexes. Therefore, this research aimed to determine if physical and physiological adaptations are sex-specific in response to undertaking and training for load-carriage.

METHODS

15 males (22.6±1.5 years, 1.82±0.06 m, 84.1±6.9 kg) and 12 females (21.1±1.9 years, 1.67±0.08 m, 64.5±6 kg) participated. All met or exceeded Australian Army minimum standards for beep test, push-ups, and sit-ups; results served as baseline measures. Separately, participants conducted counter-movement and squat jumps on a force plate; females completed isometric mid-thigh pull (IMTP).

Testing was repeated after 10-weeks supervised periodised resistance training up to three times per week; the emphasis of training was on lower-body strength. Additionally, participants, unsupervised, conducted up to two loaded walking sessions per week; periodised for load, distance, and speed.

Pre and post, participants completed a 5-km march carrying 23-kg in 55-mins. This is the Australian Army physical employment standards minimum. Repeated measures ANOVAs tested for differences between sexes and the effect of training.

RESULTS

Males outperformed females in all tests other than sit-ups. There were favourable main effects of time for squat jump force, push ups, cardiovascular fitness, and rating of perceived exertion (RPE). There were interactions for push ups; males and females were different at the start and middle of the training but not by the end. Females improved at mid-and post-testing, compared to the start; while male improvements were only realised at the end of the training period. There was an interaction for cardiovascular response, males improved after 10-weeks, but females did not. Females improved IMTP after 10-weeks of training (1709(226) N v 1829(270 N)).

CONCLUSIONS

Both sexes felt the march was easier after training (RPE); other key changes clearly indicate a different response to the same training by males and females. Males improved cardiovascular fitness, females did not, suggesting that females need specific cardiovascular training. Considering upper-body strength (push-ups) females did improve, but males did not, suggesting that the initial stimulus is sufficient for females but not males. After training, a large difference still exists between the sexes and so to lessen this gap, females must be trained differently to males.

OPERATIONAL RELEVANCE

This research strongly indicates that male and female physical conditioning must be tailored to meet the specific requirements of each sex. Training sexes equally will not optimally prepare males and females for operational readiness.

AUTHORS

Tim Doyle (1)
Jodie Wills (1)
Daniel Glassbrook (1)
David Saxby (2)

(1) Macquarie University (Macquarie Park, NSW, Australia); (2) Griffith University (Gold Coast, Australia)

OPERATIONALIZING OPTIMAL PHYSICAL TRAINING STRATEGIES FOR THE SUCCESSFUL INTEGRATION OF WOMEN IN GROUND COMBAT ROLES

The physiological differences, particularly of upper-body strength and power, between women and men, and the rigors of combat-centric occu-pational demands would seem to place women at a significant disadvantage, as the international military opens up previously closed combat-arms military occupational specialties (MOSs) to women. This inherent disadvantage can be significantly mitigated by implementing effective and comprehensive physical training (PT) regimens for women targeting those fitness components most critical for those tasks considered most essential for solider war-fighting duties (i.e., strength and power). This presentation will overview seminal studies from the literature indicate that (a) a minimum of 6 months of periodized combined resistance/endurance training preparedness is recommended for untrained women considering entering combat-arms MOS training; (b) any comprehensive PT program should incorporate and emphasize progressive load carriage train-ing; (c) a greater emphasis on upper body on strength/power development in military women is needed; (d) heavy resistance training in the range of 38 repetition maximum sets should be incorporated into training programs to target type II motor units and muscle fibers (those fibers that produce the most force and have the greatest capacity to hypertrophy); (e) low-volume, high-intensity interval training should be considered as a time-efficient training method to improve aerobic fitness while protecting against lower-body musculoskeletal injuries; (f) flexible nonlinear periodized programs should be considered to best accommodate the unpredictability and operational functional needs of the military training environment; and (g) serious consideration should be given to revamping the manner in which the military conducts physical readiness training, with a departure from field expediency as the major criteria for determining PT policies. With an increased emphasis on the human dimension of soldiering and concerted strategic, operational, and tactical efforts to maximize individual physical readiness and performance, the science of training physiology exists to leverage and better physically prepare women as they enter more combat-centric occupations.

AUTHORS

Bradley Nindl (1)

(1) University of Pittsburgh (Pittsburgh, United States)

SEX-SPECIFIC CHANGES IN PHYSICAL PERFORMANCE FOLLOWING MILITARY TRAINING

Men and women joining the military undergo the same training, often in mixed-sex platoons. Given the physiological and physical performance differences between men and women, it is reasonable to question whether sex differences exist in the adaptation to military training and, therefore, whether sex-specific training should be employed to optimise training adaptations.

PURPOSE

To systematically review the literature evaluating changes in the physical performance of men and women following military training.

METHODS

Six database sources were searched in addition to extensive secondary searching. Primary prospective intervention studies (all designs) evaluating physical training interventions in military populations, reporting pre-to post-training changes in physical fitness outcomes for both women and men, were included.

RESULTS

We screened 3966 unique records. Twenty-nine studies (n = 37 study reports) were included, most of which were conducted in the USA and evaluated initial training for military recruits. Positive changes were more consistently observed in aerobic fitness and upper and whole-body strength outcomes than lower body strength, muscle power or muscle endurance outcomes, following physical training. Relative pre-to post-training changes for all outcome measures tended to be greater in women than men although few statistically significant sex by outcome/time interactions were observed.

CONCLUSIONS

Improvements in some, but not all, performance components were observed following a period of military training. Largely, these improvements were not significantly different between sexes. Further prospective research is needed to evaluate sex-specific differences in the response to physical training in controlled conditions to improve military physical training outcomes for both sexes.

OPERATIONAL RELEVANCE

Sex-specific military training may not be necessary to achieve some improvements in physical performance in both men and women but it is unknown whether this finding would hold true for trade-specific training and whether bespoke sex-specific training strategies may further enhance improvements in military physical performance.

AUTHORS

Sophie Wardle (1)

(1) UK MOD (United Kingdom)

TS28.
PHYSICAL TRAINING FOR MILITARY OPERATIONS: WHAT ARE THE REQUIREMENTS FOR SEX-SPECIFIC CONDITIONING

#ABS228

FEBRUARY 12, 2020

BIOMECHANICAL RESPONSES DURING A STANDARDISED LOAD CARRIAGE TASK ARE SEX-SPECIFIC

PURPOSE

Male and female soldiers have different physical strength and cardiovascular capacities that influence how well they perform crucial combat tasks (e.g., load carriage). Importantly, these capacities can be improved through tailored physical conditioning. Identifying sex-specific responses during load carriage will help tailor and inform physical training programs to address any strength and cardiovascular incapacities specific to males and females to ultimately improve job performance.

METHODS

Thirteen male (age 22.6±1.5 years, height 1.82±0.06 m, mass 84.1±6.9 kg) and eleven female civilians (age 21.1±1.9 years, height 1.65±0.06 m, mass 64.7±6 kg) were recruited. Participants met or exceeded the Australian Army Basic Fitness Assessment standards for recruits. A load carriage task, equal to the Australian Army All Corps physical employment standard (5 km at 5.5 kmh-1, wearing a 23 kg vest), was completed before and after a 10-week physical training intervention. Three-dimensional motion capture and ground reaction force data were acquired at the beginning and end of the load carriage task. Hip, knee, and ankle joint angles and moments were estimated respectively from inverse kinematics and dynamics using a generic-scaled model. A repeated measures two-way analysis of variance was conducted to test for the effects of sex, training and distance walked.

RESULTS

Compared to before the load carriage task, hip extension and flexion peak angles decreased, whereas, stride length, hip pose at heel strike, knee flexion first (0-40% gait) and second (41-100%) peak angle, knee pose at heel strike and torso flexion/extension increased after the 5 km walk. Hip adduction, internal rotation, and knee internal rotation angles significantly increased after the 5 km load carriage task for females but not males. Compared to before training, ankle joint contribution towards total positive power, ankle dorsiflexion and knee extension moments decreased after training, whereas, ankle joint contribution towards total negative power increased.

CONCLUSIONS

Current findings suggest males and females adapt differently over a 5 km walk in response to specific training; as demonstrated by different kinematic strategies adopted to meet load carriage demands. Therefore, sex-specific physical training should be considered to optimally train soldiers based on individual requirements.

OPERATIONAL RELEVANCE

Male and female biomechanical responses to a load carriage task differed over a 5km course. Such responses strongly indicate that physical training needs to be tailored to each sex to maximize benefits.

AUTHORS

Jodie Wills (1)
David Saxby (2)
Gavin Lenton (2)
Tim Doyle (1)

(1) Macquarie University (Sydney, Australia); (2) Griffith University (Gold Coast, Australia)

VISUOMOTOR PERFORMANCE IS MAINTAINED UNDER CONDITIONS OF MILITARY OPERATIONAL STRESS

INTRODUCTION

Military operational stress, involving sleep disruption, caloric restriction and physical exertion, may alter visuomotor function which is essential to executing operational tasks. We hypothesized that acute exposure to simulated military operational stress would compromise visuomotor performance and that baseline sleep may modulate performance decrements.

METHODS

Twenty-seven active duty and reserve status service members (26.0 ± 4.3 years) completed a 5-night, 5-day study assessing the effects of simulated military operational stress on cognitive resilience. On nights 1, 2 and 5, participants slept from 2300 0700. On nights 3 and 4, they slept from 0100 0300 and from 0500 0700. Psychometric testing occurred during the sleep disruption. Participants were allowed 100% baseline caloric need on days 1, 2 and 5 and 50% on days 3 and 4. A visuomotor battery was completed each day at ~1600. The battery contained 7 assessments of visuomotor function: visual clarity, perception span, near-far quickness, depth perception, contrast sensitivity, multiple object tracking and reaction time. Median splits were used to create high and low sleep efficiency (94.2%), percent stage 2 (50.4%), percent slow wave (13.9%) and percent rapid-eye movement (REM; 26.2%) sleep groups. Mixed model (2 x 3) ANOVAs were performed to assess differences in visuomotor performance between high and low sleep groups across days 2 (baseline), 4 (peak operational stress) and 5 (recovery).

RESULTS

No significant sleep x time interaction or main effects of time were observed for any visuomotor tasks. A main effect of REM sleep was observed for the perception span task ($F_{1,25} = 6.549$, $p = .017$, $n2p = .208$); performance was better in participants who spent a greater proportion of the night in REM sleep (43.7 vs 31.2). Performance did not differ between sleep groups for sleep efficiency, stage 2 or slow wave sleep.

CONCLUSIONS

Visuomotor performance was not compromised by acute exposure to simulated military operational stress. Increased REM sleep may contribute to improved performance on aspects of visuomotor performance such as the perception span task that involve working memory and perceptual attunement.

OPERATIONAL RELEVANCE

Military service members may be able to maintain visuomotor performance under acute exposure to military operational stress. Individual differences in REM sleep may relate to visuomotor resilience.

AUTHORS

Alice D. LaGoy (1)
Meaghan E. Beckner (1)
Shawn R. Eagle (1)
Aaron M. Sinnott (1)
William R. Conkright (1)
Bradley C. Nindl (1)
Anne Germain (2)
Fabio Ferrarelli (2)
Christopher Connaboy (1)

(1) University of Pittsburgh (Pittsburgh, United States); (2) University of Pittsburgh School of Medicine (Pittsburgh, United States)

A LONGITUDINAL, QUALITATIVE INVESTIGATION OF THE EMERGENCE OF TEAM RESILIENCE IN NEWLY FORMED TEAMS UNDERTAKING MILITARY TRAINING

PURPOSE

Team resilience reflects a teams ability to maintain or return quickly to optimal functioning following adversity exposure is essential to military performance. Unsurprisingly, military training programs include adversities that are designed to test this capacity of individuals and teams, yet there is little knowledge of personnels experiences of such events. The aim of this study was to explore perceptions of key emergent inputs, processes, and outcomes of newly formed military teams with respect to adversity experiences during military training.

METHODS

Participants included 32 male Australian military personnel undertaking an 18-month training program (26.25 years + 2.62). We adopted a longitudinal qualitative design in which participants shared their experiences of adversity at two time points during the training program. Focus groups consisted of 2-3 teams of 6-10 personnel, and were guided by a semi-structured interview protocol. We analyzed participants discourse using an abductive approach whereby perspectives were examined in accordance with our conceptual framework of team resilience, yet remained open to new themes that may disconfirm these preconceptions or reflect them in unique ways.

RESULTS

The nature of adversity reflected fear of removal from training course, uncertainty regarding task end point and performance levels, and performance pressure from team members. Key themes of inputs and mediators underpinning team resilience across time points included recognising teammates experiences of stress, fostering confidence from past shared experiences, and maintaining shared situational awareness. Key themes related to change underpinning the emergence of team resilience included developing preemptive strategies to mitigate potential adversities (e.g., anticipation of teammates behaviour), advancing in adaptive coping strategies (e.g., slowing down of team actions), and fostering trust within teammates during adversity.

CONCLUSIONS

These findings provide a first look at military personnels individual and shared experiences of adversity within a military training environment. Findings demonstrate the range and complexity of inputs and mediators underpinning team resilience emergence and offer an indication of the value of more directed approaches to team resilience development. Findings also indicate potentially unexpected challenges that may be more systematically targeted to enhance the development of team resources within future programs.

OPERATIONAL RELEVANCE

Knowledge of individuals experiences of adversity within training environments has the potential to inform targeted interventions for fostering collective capabilities to withstand or bounce back from adversity (e.g., collaborative systematic reflection of stress).

AUTHORS

Michael Chapman (1)
Philip Temby (2)
Benjamin Hoggan (2)
Monique Crane (3)
Nikos Ntoumanis (4)
Eleanor Quested (5)
Cecilie Thorgersen-Ntoumani (4)
Sharon Parker (6)
Kagan Ducker (1)

(1) School of Physiotherapy and Exercise Science, Curtin University (Perth, Australia); (2) Land Division, Defence Science and Technology (Adelaide, Australia); (3) School of Psychology, Macquarie University (Sydney, Australia); (4) School of Psychology, Curtin University (Perth, Australia); (5) School of Psychology, Curtin University (Perth, Australia); (6) Curtin Business School, Curtin University (Perth, Australia)

ON THE TEMPORAL DYNAMICS OF TEAM RESILIENCE: CONSENSUS EMERGENCE AND TEAM ROLE EXPERIENCES AND ORIENTATIONS

PURPOSE

Understanding the factors that influence military team resilience is an emerging area of research interest. As teams accrue collaborative experiences in dealing with stress and adversity, there is an expectation of consensus emergence, that is, individuals perceptions of the teams collective capabilities to withstand or bounce back from future events will converge over time. Our first aim was to test the degree of consensus emergence regarding perceptions of team resilience over an 8-week training program. Team composition is an essential foundation upon which team processes and outcomes are built, including consensus emergence. Individual differences in experiences in team roles and personal preferences are one index of team composition that have important implications for future role behaviour. Thus, our second aim was to examine the salience of individuals team role experiences and orientations for consensus emergence of team resilience.

METHODS

We recruited Australian Army personnel who were completing a 14-week initial employment training program. In total, 94 personnel (80 males, 6 females, 8 missing response; 20.96 years + 2.55) from 15 teams provided data for this study. Trainees self-reported their team role experiences and orientations at week 1, and weekly perceptions of their teams collective capability to withstand or bounce back from adversity from weeks 8-14 of the program (when activities focused on team dynamics within the context of occupational stressors). We examined the two research aims using consensus emergence modelling within a latent growth modelling framework.

RESULTS

Analyses indicated residual stability in perceptions of team resilience over time, which reflects no meaningful temporal change in the degree of consensus between team members. However, individual differences in team role experiences and preferences differentially influenced the degree of consensus emergence. First, teams with higher scores on these individual differences had lower consensus at the start of the study. Second, teams with higher levels of team building, innovation, and getting things done showed greater decreases in residual variation over time, consistent with consensus emergence.

CONCLUSIONS

These findings provide an initial insight into the temporal dynamics of collective belief systems that underpin team resilience, and individual difference factors that can optimise their evolution during training contexts. This knowledge can be used to guide training processes (e.g., emphasise shared experiences of stress and adversity) and the composition of newly formed teams.

OPERATIONAL RELEVANCE

The findings provide a basis for developing targeted interventions for enhancing the resilience of military teams to manage occupational demands.

AUTHORS

Daniel Gucciardi (1)
Michael Chapman (1)
Philip Temby (2)
Monique Crane (3)
Nikos Ntoumanis (1)
Eleanor Quested (1)
Cecilie Thøgersen-Ntoumani (1)
Sharon Parker (1)
Kagan Ducker (1)

(1) Curtin University (Australia); (2) Defence Science and Technology (Adelaide, Australia); (3) Macquarie University (Sydney, Australia)

THE PERFORMANCE TRIAD AND HEALTH OUTCOMES AMONG U.S. SOLDIERS

PURPOSE

Disconcerting trends in obesity pose a threat to force readiness, and spur military-specific paradigms that emphasize holistic health (e.g., Holistic Health and Fitness). We investigated how health behaviors (HB) cluster together and relate to other health characteristics among Soldiers.

METHODS

We used latent class analysis (LCA) on an Army-wide dataset (n=244,116) of respondents to the Global Assessment Tool (GAT), to derive common patterns of sleep, activity, and nutrition. We applied classifications from the LCA to a smaller dataset generated from a field study (n=329), and described differences across classes for blood markers, vitals, body measurements, Healthy Eating Index (HEI, generated from the Food Frequency Questionnaire), and performance outcomes.

RESULTS

Based on LCA, we classified participants as: 1)Soldiers with poor sleep, low activity, and poor nutrition (Poor HB group); 2) good sleep, high activity, and good nutrition (Good HB group); 3)poor sleep, high activity, and poor nutrition (Active-Only group); and 4)poor sleep, high activity, and good nutrition (Poor Sleep group).

Groups differed on many blood tests, with significant differences in cortisol ($F=3.24$, $p<0.05$) and Omega3 Index ($F=4.41$, $p<0.05$). Overall, the Good HB group had the best blood test results.

Fasting glucose levels, mean arterial pressure, body fat percent, and waist/hip measurements were lowest in the Good HB group compared to the other groups, but these differences were not significant.

Differences in the HEI were also observed, specifically for vegetable ($F=6.87$, $p<0.05$) and greens/bean ($F=7.76$, $p<0.05$) consumption, and total score ($F=13.15$, $p<0.05$). The Good HB and Poor Sleep groups had better nutritional habits compared to the Poor HB and Active-Only groups.

The Good HB and Poor Sleep groups had the highest APFT scores compared to the other groups. The Good HB group had a lower prevalence of MSK-I (40%) compared to the Poor HB group (70%), and less pain interference in usual activities than the Poor HB group ($F=11.83$, $p<0.05$).

CONCLUSIONS

The present study demonstrates how the combination of sleep, activity, and nutrition influences overall health. The Good HB and the Poor Sleep groups exhibited the best health behaviors and outcomes compared to the Poor HB and Active-Only groups. Future efforts may focus on programs and educational initiatives to improve sleep, activity, and nutrition among Soldiers.

OPERATIONAL RELEVANCE

A Soldiers physical performance is determined by combinations of multiple lifestyle health behaviors. Commanders must understand how health behaviors, such as sleep, activity, and nutrition, work together to influence performance.

AUTHORS

Jessica Kegel (1)
Josh Kazman (2)
Preetha Abraham (2)
Patricia Deuster (3)

(1) Consortium for Health and Military Performance, Department of Military and Emergency Medicine at Uniformed Services University of the Health Sciences; Henry M. Jackson Foundation for the Advancement of Military Medicine (United States); (2) Consortium for Health and Military Performance, Department of Military and Emergency Medicine at Uniformed Services University of the Health Sciences; Henry M. Jackson Foundation for the Advancement of Military Medicine (Bethesda, United States); (3) Consortium for Health and Military Performance, Department of Military and Emergency Medicine at Uniformed Services University of the Health Sciences (Bethesda, United States)

THE EFFECTS OF PHYSICAL STRESS AND RECOVERY ON COGNITIVE PERFORMANCE AND RESILIENCE DURING SURVIVAL TRAINING EXERCISE AMONG FINNISH SOLDIERS

PURPOSE

The aim of the present research was to examine the effects of physical stress and recovery during a SERE (survival, evasion, resistance, and escape) training exercise on soldiers cognitive performance and resilience.

METHODS

Thirty six male soldiers were exposed to strenuous physical and psychological stress during a 10 day winter survival exercise. Soldiers were divided into two groups (RECO, n=18 and EXP, n=18) randomly. RECO group had a 2-day rest in the middle of the field training whereas EXP group continued their training without the recovery period. We examined the effects of the cumulative physiological stress as well as the recovery period (RECO group) on soldiers cognitive performance and resilience using sustained attention to response (SART) and behavioral indication of resilience (BIRD) tests (see millisecond.com test library). Reaction times and number of commission and omission errors (SART) as well as by the number of dropouts (BIRD) were calculated. Subjects performed the tests 4 times using a tablet: before training (baseline), after 3 days of training (before rest period), after 5 days (after rest period) and after the exercise (after 1 day sleep at barracks after exercise). Data was analyzed using SPSS statistical package GLM Repeated Measures Analysis.

RESULTS

Significant effects of physical stress and recovery were observed both for cognitive performance and resilience. We found that number of omission errors, reaction times and number of dropouts (in all $p<.001$) increased during the course of training (1st till 3rd measure) but recovered close to the baseline after the experiment (4th measure). We also found that RECO group (the group that had the rest period in the middle of the training) made less omission errors ($p=.002$) and had less dropouts in the BIRD test ($p<.001$) than the EXP group.

CONCLUSIONS

As expected, physical stress had detrimental effects on cognitive performance and resilience. However, the decrease in performance seems to recover quite fast (1 night sleep after exercise) and can be reduced by providing short rest periods during exercise.

OPERATIONAL RELEVANCE

Cognitive performance (for example to make a decision to shoot or not to shoot) as well as resilience are important factors in successive operations and training. It is important to notice that soldiers cognitive performance and resilience usually decrease during long exercises and operations. However, the negative effects of can be reduced by even quite short periods of rest.

AUTHORS

Kari Kallinen (1)

(1) Finnish Defense Research Agency (Jarvenpaa, Finland)

EFFECTS OF ARMY PREGNANCY POSTPARTUM PHYSICAL TRAINING ON PHYSICAL FITNESS, BODY COMPOSITION, AND INJURY

PURPOSE

To examine the relationships between exercise participation in Army Pregnancy Postpartum Physical Training (P3T) and physical fitness, body composition, and injury.

METHODS

This investigation is part of a larger project to evaluate the effectiveness of P3T, a U.S. Army program designed to assist female Soldiers in meeting physical fitness and body composition standards within 180 days post-delivery. Enlisted Soldiers who had a live birth delivery between August 2017 and January 2018 were identified from military health records. Based on P3T attendance rosters, Soldiers were categorized into two participation groups: moderate-to-high (60% participation) and non-to-low (<60% participation). Outcomes of interest were failure rates of postpartum Army Physical Fitness Test (APFT) and Army Body Composition Program (ABCP) standards; postpartum recovery to pre-pregnancy (post-pre) APFT performance levels; and musculoskeletal injuries sustained during pregnancy and postpartum. T-test and 2 test were performed for P3T participant group comparisons.

RESULTS

A total of 596 enlisted Soldiers were identified; 42% (n=254) were moderate-to-high and 57% (n=342) were non-to-low participants. Reported APFT failure rates of moderate-to-high and non-to-low P3T participants were statistically similar (16% vs. 23%, p=0.174). Moderate-to-high participants showed statistically better postpartum recovery in 2-mile run time performance than non-to-low participants (post-pre mean difference: 1.50±4.77 minutes slower vs. 3.43±5.79 minutes slower, p=0.009); marginally statistically significantly better postpartum recovery in APFT sit-up performance (post-pre mean difference:-2.87 ±10.36 repetitions vs.-5.53±10.76 repetitions, p=0.081); and similar postpartum recovery in APFT push-up performance (post-pre mean difference:-3.29 ±10.13 repetitions vs.-2.83±12.48 repetitions, p=0.773). The postpartum ABCP failure rate was marginally statistically significantly lower for moderate-to-high participants compared to non-to-low participants (11% vs. 22%, p<0.058). Non-to-low P3T participants accounted for a greater proportion of high overweight and obese Soldiers than moderate-to-high P3T participants (34% vs. 20%, p<0.041). There were no statistically significant differences in the percentages of moderate-to-high and non-to-low participants who sustained a musculoskeletal injury during pregnancy (32% vs. 35%, p=0.530) and postpartum (31% vs. 28% p=0.415).

CONCLUSIONS

Moderate-to-high participation in P3T resulted in better postpartum recovery in 2-mile run time performance, marginally statistically significantly better postpartum recovery in sit-up performance, and a lower ABCP failure rate compared to non-to-low participation. Proportions of Soldiers sustaining a musculoskeletal injury during pregnancy and postpartum did not appear to differ between groups.

OPERATIONAL RELEVANCE

Given the potential benefits of P3T in achieving better outcomes in postpartum Soldiers physical performance and readiness, wider program adoption in other military populations should be considered.

AUTHORS

Esther Dada (1)
Maisha Toussaint (1)
Latoya Goncalves (1)
Lanna Forrest (2)
Bonnie Taylor (1)
Mimi Eng (1)
KaSaundra Oden (1)
Lisa Young (1)
Bruce Jones (1)

(1) U.S. Army Public Health Center (Aberdeen Proving Ground, United States); (2) Defense Health Agency (Aberdeen Proving Ground, United States)

MULTIFUNCTIONALIZED DUAL-ELECTROSPUN NANO-FIBROUS WEBS FOR PROTECTION AGAINST CHEMICAL AND BIOLOGICAL HAZARDS

PURPOSE

This project is aimed at combining particle filtration and self-detoxification functions in a liner material manufactured using electrospinning. This liner material is intended for protective clothing used by soldiers. The polymers used to produce the nano-fibrous webs are loaded with different chemically and biologically active nanoparticles for protecting dismounted soldiers from chemical, biological, radiological and nuclear (CBRNE)-type threats. Embedded adsorptive nanoparticles, such as magnesium oxide (MgO), calcium oxide, aluminum oxide, ferric oxide, and silver (Ag), offer an innovative way to achieve this type of protection while maintaining breathability and comfort. This study investigates the optimal loadings achievable with poly acrylonitrile (PAN) nanofibers.

METHODS

MgO and Ag nanoparticles were incorporated in separate PAN/dimethyl formaldehyde (DMF) solutions in different weight concentrations to prepare composite electrospun webs. A dual electrospinning set-up was used to manufacture the multifunctional comingled webs. The morphology of the fibers and the surface roughness and quality of the mats were examined by various techniques.

RESULTS

Processing parameters were determined to form defect-free mats. This was followed by investigating the optimal loadings of the constituents. The results show that 15wt% of MgO nanoparticles and up to 10wt% of Ag can be embedded in the PAN nanofibers without jeopardizing their morphology.

CONCLUSIONS

Electrospun samples containing high ratios of MgO and Ag nanoparticles have been successfully prepared with smooth/bead-free structures. In light of these findings, the next stage of the project will be to characterize the filtration and self-detoxification efficiency of the multifunctionalized dual-electrospun nanowebs.

OPERATIONAL RELEVANCE

With battle fields involving complex urban environments, the protection of dismounted soldiers against kinetic and non-kinetic threats often involves increased discomfort. The objective of this study is to develop a breathable membrane for CBRNE protection in aerosol form by combining the particle filtration and self-detoxification functions of a nanofiber web loaded with chemically and biologically-active nanoparticles. This composite nano-fibrous membrane is intended to serve as a liner in the multilayer protective clothing worn by dismounted soldiers. The higher level of comfort provided by this protective liner will have a positive impact on soldiers mental and physical health, and consequently on their performance.

AUTHORS

Mahsa Kalantari (1)
Cagri Ayranci (1)
Patricia Dolez (1)
(1) University of Alberta (Canada)

EFFECT OF A SUPERVISED PHYSICAL TRAINING ON PHYSICAL AND PHYSIOLOGICAL VARIABLES, DURING A SPECIAL OPERATIONS COURSE OF THE BRAZILIAN NAVY

PURPOSE

Special amphibious command course (C-Esp-ComAnf) prepares military personnel to the planning and execution of special operations of the Brazilian Navy Marine Corps. The aim of the study was to verify the effect of the physical training program (PTP) on physical and physiological variables of C-Esp-ComAnf candidates during the year 2018.

METHODS

34 male military personnel were included in this study. The following variables were evaluated pre and post-PTP: fat percentage (F%), lean mass Kg (LM), body mass index (BMI), 2400 m running test (VO2max), pull-ups test repetitions (PUT), full squats repetitions-2minutes (FST), arm push-ups repetitions (APUT), sit-ups repetitions-2minutes (SUT) and handgrip strength Kg (HS), 100 m swimming minutes:seconds (100mS), 12 min swimming meters (12mS), dynamic apnea meters (DA) and static apnea minutes:seconds (SA). The PTP was conducted lasting approximately eight weeks, five day/week, in two sessions/day. The duration of sessions varied from 68 to 180 min. They were consisted of continuous and interval swimming (32 and 11 training sessions, respectively), vertical float (19 training sessions), static and dynamic apnea (training sessions, respectively), continuous and interval running (16 and 2 training sessions, respectively), functional training (3 training sessions), strength training (26 training sessions), and other activities (4 training sessions). Students t-test was used to compare pre and post training values. Data were analyzed using the Graph Pad Prism 5. The level of significance considered was <0.05.

RESULTS

There were no differences in BMI (25.6±1.7 vs. 25.3±1.8, p=0.22) and HS (47.7±6.3 vs. 48.4±6.3, p=0.4143) after training. Significant differences were found for the following variables: F% (11.7±3.7 vs. 10.4±2.9, p=0.0002); LM (70.8±6.1 vs. 71.6±5.8, p=0.0221); VO2max (49.9±2.5 vs. 52.3±2 mLkg1min-1, p<0.0001); PUT (14.4±3.1 vs. 16.7±2.6, p<0.0001); FST (89.3±12.8 vs. 104.5±8.9, p<0.0001); APUT (41.5±8.1 vs. 48.3±7.2, p<0.0001); SUT (72.2±10.7 vs. 81±15.7, p=0.0002); 100mS (1:43±00:14 vs. 1:38±00:13, p=0.0005); 12mS (512.6±64.1 vs. 537.8±52, p=0.0166); DA (35.3±6.5 vs. 39.2±7.9, p=0.0051) and SA (1:48±00:46 vs. 2:09±00:51, p=0.0007).

CONCLUSIONS

The results of the current study suggest that approximately eight weeks of physical training program may be effective at increasing physical and physiological variables of C-Esp-ComAnf candidates.

OPERATIONAL RELEVANCE

The implementation of a PTP at the beginning of a special operations course enhanced the physical conditioning of the candidates. We suppose that it may positively influence the next phases, in which physical demands are strenuous.

AUTHORS

Maria Elisa Miranda (1)
Daniel Alves (2)
Allan Inoue (3)
Thiago Lopes (2)
Priscila Bunn (4)

(1) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science, Rio de Janeiro, Brazil; Exercise and Sport Sciences Postgraduate Program, Rio de Janeiro State University, Rio de Janeiro, Brazil (Brazil); (2) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science, Rio de Janeiro, Brazil; Operational Human Performance Postgraduate Program, Air Force University, Rio de Janeiro, Brazil (Rio de Janeiro, Brazil); (3) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science, Rio de Janeiro, Brazil; Exercise and Sport Sciences Postgraduate Program, Rio de Janeiro State University, Rio de Janeiro, Brazil; Operational Human Performance Postgraduate Program, Air Force University, Rio de Janeiro, Brazil; Exercise Psychophysiology Group, School of Arts, Sciences and Humanities, University of São Paulo, São Paulo, Brazil (Rio de Janeiro, Brazil); (4) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science, Rio de Janeiro, Brazil; Exercise and Sport Sciences Postgraduate Program, Rio de Janeiro State University, Rio de Janeiro, Brazil; Operational Human Performance Postgraduate Program, Air Force University, Rio de Janeiro, Brazil (Rio de Janeiro, Brazil)

IMPACT OF PHYSICAL ACTIVITY ON SOLDIERS PHYSICAL FITNESS AND BODY COMPOSITION DURING A CRISIS MANAGEMENT OPERATION

PURPOSE

Physical fitness of soldiers often decreases during demanding military operations (Nindl et al. 2013). The purpose of the present study was to investigate the impact of physical activity level prior to deployment on soldiers physical fitness and body composition during a 6-month crisis management operation in Lebanon.

METHODS

Voluntary male soldiers (n=63) participated in the study. Their mean age was 29.8±8.5 years, height 180.0±6.5 cm, body mass (BM) 79.4±8.2, BMI 24.5±2.3 and waist circumference (WC) 86.5±6.6 cm. Aerobic capacity was assessed by 3000 m running test. Muscle fitness tests consisted maximal standing long jump (SLJ), repeated sit-ups and push-ups (reps/60 s). Physical activity was assessed before the deployment by a single-item questionnaire on leisure-time vigorous physical activity (SIVAQ, Fogelholm et al. 2006). Think of the previous two months and consider all leisure-time physical activity with duration of at least 20 min. How frequently were you physically active? Based on SIVAQ, the soldiers were divided in low and high activity groups: 25.4% of soldiers were allocated to the low and 74.6% to high activity group. All measurements were implemented in the beginning and at the end of a 6-month deployment.

RESULTS

In the total subject group, the mean time of 3000 m running did not change (14.1 vs. 14.1 min) during the 6-month deployment. No changes were observed in body composition except for a decrease in WC (86.5 cm vs. 84.0 cm, $p<0.01$). Significant improvements were observed in SLJ (2.35 vs. 2.37 m, $p<0.05$), sit-ups (45 vs. 48 reps/min, $p<0.01$) and push-ups (40 vs. 45 reps/min, $p<0.01$). The soldiers with low initial physical activity improved their running time (-2.03±5.34 vs. 0.89±4.94%, $p<0.09$) and body fat percent (-0.74±2.25 vs. 0.37±1.79%, $p<0.05$) more than their high activity counterparts. No further differences were found between groups.

CONCLUSIONS

In general, the present study demonstrated no decreases in aerobic capacity and improvements in muscle fitness of the soldiers during the 6-month military operation. The soldiers with lower physical activity improved their running performance and had positive changes in body composition. In conclusion, it is important to promote regular physical training during the deployment by offering tailored training programs based on initial physical activity.

OPERATIONAL RELEVANCE

Regular physical training should be implemented by unit leaders during prolonged military operations to keep soldiers, especially passive ones, fit and active.

AUTHORS

Matti Santtila (1)

Kai Pihlainen (2)

Heikki Kyröläinen (3)

(1) National Defense University, Department of Military Pedagogy and Leadership (Espoo, Finland); (2) Defense Command, Training Division, Finnish Defense Forces (Helsinki, Finland); (3) University of Jyväskylä, Faculty of Sport and Health Sciences (Jyväskylä, Finland)

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THERMAL EFFECTS OF VARIABLE SOFT ARMOUR COVERAGE DURING A FIELD TRIAL

PURPOSE

A modular, scalable armour system which allows soldiers to vary the level of ballistic protection to suit operational risks may result in greater agility and less heat illness, leading to overall benefits to performance and mission success. This presentation presents the thermophysiological effects of varying soft armour coverage in the context of an outdoor field trial.

METHODS

Five soft armour conditions were evaluated, ranging from in-service armour to a minimal plate carrier. Canadian Regular Force infantry (N=30) wore soft armour in combination with ballistic plates and full fighting order. Participants completed one experimental session in each armour condition, with each experimental session consisting of two traversals of the CAN-LEAP mobility course and a 5 km outdoor march.

Participants wore a physiological monitoring system that recorded torso skin temperature, and a small number of participants ingested a capsule to record core body temperature. Participants also provided subjective thermal comfort and acceptability ratings. Torso skin temperature was analyzed in a Linear Mixed Effects model, and subjective thermal comfort measures were analyzed in a repeated measures ANOVA. For core body temperature only descriptive statistics were computed.

RESULTS

Torso skin temperature in the minimal coverage (plate carrier) condition was significantly lower than in all other conditions. This was the only armour condition to differ significantly from the in-service condition.

Ratings of thermal comfort acceptability found that the in-service armour was significantly less acceptable to participants than conditions with reduced armour coverage. Ratings of regional thermal discomfort found that the upper torso tended to experience the greatest discomfort. While 50-75% of participants found the in-service armour noticeably warm or warmer, this was true of less than 30% of participants for the minimal armour coverage condition.

Core body temperatures were fairly stable during periods of high activity, with modest temperature rises of < 1°C for 90% of participants. We observed core temperatures in excess of 39°C in 15% of those monitored.

CONCLUSIONS

Reductions in soft armour coverage produced significantly different levels of subjective thermal comfort to soldiers, even though measured skin temperatures were fairly insensitive to armour coverage levels.

OPERATIONAL RELEVANCE

These results show that soldiers thermal discomfort can be alleviated by reductions in soft armour coverage, and will inform the development of a modular, scalable armour decision aid to mitigate burden and optimize integrated survivability.

AUTHORS

Craig Burrell (1)
Carlie Sorgini (2)
Adrienne Sy (1)
Linda Bossi (1)

(1) Defence Research & Development Canada (Toronto, Canada); (2) Human Systems Incorporated (Guelph, ON, Canada)

AGING OF ARAMID FABRICS: EFFECT OF EXPOSURE TO HIGH TEMPERATURE, UV, AND LAUNDERING ON MECHANICAL PERFORMANCE

PURPOSE

Aramid fibers have revolutionized protective clothing. They offer high mechanical properties and heat/fire resistance combined with a low weight and reduced bulkiness compared to traditional materials. However, the various conditions the fibers are exposed to during the clothing lifetime will reduce their performance over time. In addition, considerable loss in performance may occur before any sign of damage is visible to the naked eye. A better understanding of the response of aramid fabrics to various aging conditions is thus critical to developing end-of-life monitoring strategies.

METHODS

Two fabrics made of 100% meta-aramid (Nomex®) and para-aramid (Kevlar®) fibers were subjected to different accelerated aging conditions applied individually. Thermal aging was conducted in an oven between 150 and 300°C for up to 500h. UV aging was performed under Xenon light at 0.68 W/m2 and 50°C. Series of 10, 20, 35, and 50 laundering cycles were carried out according to AATCC 135 for NFPA 1971 (60°C washing and tumble drying). The residual tear strength at different aging times was assessed using trapezoidal specimens. Where applicable, statistical significance was evaluated using ANOVA analysis.

RESULTS

Thermal aging caused a reduction in tear strength as a function of both aging time and temperature. For the p-aramid fabric, the loss in tear strength reached 50% after 150h at 150°C. The tear strength retention was 16% after 1h at 300°C. The m-aramid fabric retained 80% of its tear strength after 500h at 150°C and 75% after 1h at 300°C. UV aging caused the p-aramid fabric to lose 80% of its strength after 50h and more than 95% after 500h. On the other hand, the m-aramid fabric strength decreased by 63% after 50h and 85% after 500h. Finally, repeated launderings gradually reduced the p-aramid fabric tear strength, which dropped to about 40% of its initial value after 50 cycles. No significant effect was observed on the m-aramid fabric strength.

CONCLUSIONS

The results show that the mechanical performance of aramid fabrics may be strongly affected by exposure to aging conditions relevant to use in protective clothing. Different behaviors are exhibited by meta-and para-aramid fibers.

OPERATIONAL RELEVANCE

Aramid fibers play a major role in bringing soldiers the level of protection they need against various types of threats, e.g. p-aramid for ballistic protection and m-aramid for heat resistance. This research on aging is critical so that soldiers wearing protective clothing based on these high performance fibers know if their piece of equipment is still able to protect them.

AUTHORS

Patricia Dolez (1)
Namrata Tomer (2)
Yassine Malajati (2)

(1) University of Alberta (Edmonton, Canada); (2) Ecole de technologie supérieure (Montréal, Canada)

FIRE RESISTANT YARN SUITABLE FOR MILITARY UNDERGARMENT APPLICATION

PURPOSE

Non-melting or fire-resistant (FR) undergarments are critical for military personnel exposed to direct or indirect heat, for instance due to an explosive. Solutions currently available do not allow good moisture management and therefore are uncomfortable. This project aims at designing a new fabric to solve this issue. This new fabric is a double-faced knitted structure; it is fire resistant, antibacterial, comfortable, and offers an appropriate level of stretch. Core-spun yarn structures were selected with an elastic filament core and a shell with a blend of FR and antibacterial fibers. This structure can provide a protection of the elastic filaments against heat and flame by the FR fibers in the yarn shell.

METHODS

Two types of core-spun yarn were manufactured. The first yarn (Yarn-1) is composed of 100% inherently FR fibers over the elasthane core; it is considered for the outer face of the knitted fabric. For the inner face, a second yarn (Yarn-2) uses a blend of antibacterial and FR regenerated cellulose fibers (no melt/no drip) as a shell as it combines moisture management capability and antibacterial properties. A Lycra filament with a linear density of 40 deniers was used as the core for both yarns. The targeted yarn count was 30 Ne for both yarns to provide the required level of protection against heat and flame without being too bulky.

RESULTS

The yarn counts obtained were 28.4±0.3 and 28.6±0.4 Ne for the Yarn-1 and Yarn-2, respectively. Both yarns are highly stretchable; the elongation at break is 18% for Yarn-1 and 11% for Yarn-2. A higher level of non-uniformity and higher number of neps were observed in Yarn-2, which could be explained by the fact that this yarn is a blend of two fibers with different thicknesses. However, both yarns meet the requirements in terms of strength, uniformity, and elasticity for the knitted fabric production.

CONCLUSIONS

Two sets of core-spun yarns have been satisfactorily produced with the desired level of strength, uniformity, and elasticity to produce a double-faced knitted fabric that is fire resistant, antibacterial, and comfortable, and can be used for heat-resistant undergarments for military applications.

OPERATIONAL RELEVANCE

This project tackles a critical aspect of military life: combining protection without sacrificing comfort. The higher level of comfort of the FR undergarments provided with this new fabric will have a direct, positive impact on military personnels mental and physical health, and consequently on their performance.

AUTHORS

Mahsa Kalantari (1)
Jessica Buchinski (2)
Sébastien Couture (3)
Patricia Dolez (1)

(1) University of Alberta (Canada); (2) Jess Black Inc. (Edmonton, Canada); (3) FilSpec Inc. (Sherbrooke, Canada)

SELF-REPORTED LOSS OF MANUAL PERFORMANCE OF HAND AND DIGIT PERFORMANCE DURING COLD EXPOSURE IN MALE AND FEMALE SEARCH AND RESCUE WORKERS

PURPOSE

Females typically have smaller hand masses, surface areas and volumes but a greater surface area to hand volume than males. This predisposes them to faster hand cooling rates than males. The purpose of this study was to assess if there is a sex dependence for Search And Rescue (SAR) workers on their loss of manual performance in a matrix of cold exposure time versus ambient temperature.

Hypothesis: It was hypothesized that females, when compared to males, would lose their manual performance of tasks after shorter durations of cold exposures at given ambient temperatures.

METHODS

An online survey asked SAR respondents to report on gloves and mittens they currently employ in their rescue work. A matrix with 9 ambient temperatures from +5°C to 0°C to <-40°C and with 6 durations of cold exposure from 0 to-0.25 h to > 3 h was presented in the survey. Responses were given after what duration the respondent began to lose manual performance for each ambient temperature range. A chi-square test was employed to assess in the matrix if the frequency of loss in manual performance in the cold differed between sexes. The level of significance for chi-square tests was set at 0.05. The study was approved by the SFU Office of Research Ethics.

RESULTS

Nineteen males, 5 females, and 2 that preferred not to specify their sex completed the survey. Based on their morphology these 2 latter participants were grouped with the males. Across the ambient temperature ranges from +5°C to 0°C to <-40°C, with durations of exposure from 0 to 0.25 h to > 3 h, the frequency of self-reported decrements in manual performance were not significantly different ($0.13 < p < 0.98$) between male and female.

CONCLUSION

In conclusion, the hypothesis was rejected that females, when compared to males, would lose manual performance of tasks after shorter durations of cold exposure at given ambient temperatures.

OPERATIONAL RELEVANCE

Cold-induced decrements in manual tasks and hand cold injuries remains an ongoing problem while debilitating frostbite on the hands was evident in the Canadian Military troops as recently as January 2019. A Canadian military objective is to increase the number of females in their troops, consequently for troops deployed in arctic conditions it is of operational relevance to know if the decrements in manual performance are similar between the sexes.

AUTHORS

Amanda E Kirk (1)
Clara V Etter (2)
Elizabeth Gnatiuk (2)
Jacob, MT Cartwright (2)
Emily J Heaps (3)
Andrew S. Perrotta (2)
Ying K. Fang (2)
Matthew D White (4)

(1) Laboratory for Exercise and Environmental Physiology (Burnaby, Canada); (2) Laboratory for Exercise and Environmental Physiology, Department of Biomedical Physiology and Kinesiology, Simon Fraser University (Burnaby, BC, Canada); (3) Wilson School of Design, Kwantlen Polytechnic University (Richmond, BC, Canada); (4) Laboratory for Exercise and Environmental Physiology, Biomedical Physiology and Kinesiology, Simon Fraser University (Burnaby, BC, Canada)

USING WEARABLE EMG SENSORS TO DETECT ONSET OF MUSCLE FATIGUE WHILE WALKING WITH AN EXOSKELETON DURING A CHALLENGING URBAN MARCH: A CASE STUDY

PURPOSE

Development of muscle fatigue when walking with an exoskeleton can present safety issues related to balance control and mobility. In the laboratory, a reduction in the median frequency (MF) of the electromyography (EMG) power spectrum has been shown to be a good non-invasive early indicator of the development of muscle fatigue. With recent advances in wearable sensors, it is now feasible to measure EMG during real-world activities. Considering the complexity and repertoire of muscle activation patterns required to walk efficiently in an urban setting, the goal of this study was to determine if step-by-step MF measurement was sensitive enough to detect onset of muscle fatigue while walking with a passive weight-bearing exoskeleton during a challenging urban march. It was hypothesized that significant shifts in MF would be observed during bouts of demanding exercise (stairs, slope), but be very stable during the less demanding exercises such as level walking.

METHODS

One participant was instrumented with wireless EMG sensors (Delsys Trigno + Data logger) and continuously monitored during a march in Quebec City, Canada. The path length and level of difficulty was based on a training course used by Canadian soldiers during the 2018 Contested Urban Environment exercise, held in Sept 2018 in Montreal. Using self-selected gait speeds, participant negotiated a challenging urban path that consisted of 400 stairs (ascending/descending) and road navigation (5.2 km, 169 m elevation change) while wearing a weight-bearing exoskeleton and a 14.5 kg backpack.

RESULTS

During level walking, step-by-step MF remained within the 95% confidence interval of the initial 6-min baseline values. During upslope walking, MF was reduced suggesting fatigue in muscles recruited during the exercise. Change in MF was associated with a subjective impression of exertion.

CONCLUSIONS

As hypothesized, these results support the use of shifts in MF as a non-invasive and non-obstructive measure of muscle fatigue onset in complex situations (e.g. walking in a challenging urban environment with an exoskeleton).

OPERATIONAL RELEVANCE

This method can now be used as a feedback tool to warn soldiers of fatigue development, thereby improving safety during weight-bearing exercises with an exoskeleton. It can also be used as an evaluative tool to compare soldiers performance in different fatigue-developing conditions, such as wearing different ballistic protections, clothing, etc.

AUTHORS

Mathieu Bielmann (1)
Gabriel Diamond-Ouellette (1)
Miorie Le Quang (1)
Myriam Lauzon (1)
Jenna Marie Crocker (2)
Elyann Périard-Fournier (1)
Krista L. Best (1)
Laurent J. Bouyer (1)

(1) CIRRIS-Université Laval (Canada); (2) CIRRIS (Quebec City, Canada)

INVESTIGATING THE CHANGE IN ENERGY EXPENDITURE BEFORE AND AFTER FAMILIARIZATION WITH A PASSIVE LOAD-BEARING EXOSKELETON: A CASE SERIES

PURPOSE

Exoskeletons represent an emerging technology that has the potential to improve soldier performance on the field. The effect of passive load-bearing exoskeletons, capable of redistributing the weight of soldier-carried heavy loads on energy expenditure (EE) is of particular interest to the Canadian military. As EE is impacted by the weight of the exoskeleton on the soldier, additional payload and individual movement patterns during gait, assessing the impact of exoskeleton on soldiers EE can therefore be complex. The goal of this study was to quantify the impact of familiarization on EE. Our hypothesis is that EE is significantly decreased after a period of familiarization, regardless of gait speed.

METHODS

One expert and two naïve users walked on a treadmill at 8 speeds ranging from 1.8 to 6.0 km/h under 2 test conditions: 1) no exoskeleton, and 2) wearing a 3rd gen exoskeleton (EXO3). Expert user also completed the procedure using an exoskeleton that he was familiar with (EXO2). Exoskeletons were similar in terms of design and weight, but were fitted differently. Each walking trial consisted of 5 minutes of rest followed by 5 minutes of speed familiarization, and 5 minutes of steady state walking. Net metabolic rate was recorded and normalized by walking speed (J/kg*m) to provide the energy cost of locomotion.

RESULTS

For the expert user, EE during steady state walking was higher with EXO3 than EXO2, with smaller differences at higher speeds (4.8 km/h and more). For naïve users, preliminary results showed a higher EE with exoskeleton, with reduced EE after 9 days of familiarization.

CONCLUSIONS

This study supports the importance of familiarization periods upon provision of a load-bearing exoskeleton to minimize EE with both for expert and naïve users. Integrating a familiarization period can optimize use of a new device and permit the user to enhance efficient coordination patterns during walking. Given the variability among walking speeds with and without the exoskeleton, evaluations should consider individual users and the exoskeleton as one system.

OPERATIONAL RELEVANCE

These results suggest that regardless of their experience, soldiers should be properly familiarized with exoskeletons before EE is assessed. This will ensure accurate measure of actual impact on operational performance.

AUTHORS

Gabriel Diamond-Ouellette (1)
Alessandro Telonio (2)
Mylène Blanchette (2)
Jenna Crocker (1)
Laurent Bouyer (1)
Krista Best (1)

(1) Center for Interdisciplinary Research in Rehabilitation and Social Integration (CIRRIS) (L'assomption, Canada); (2) Mawashi Science & Technology (Sherbrooke, Canada)

2.2
EMERGING TECHNOLOGY TO ALLEVIATE BURDEN

#ABS056
POSTER PRESENTATION

FEBRUARY 13, 2020

3D PRINTING BALLISTICS FROM SAND A NOVEL ALTERNATIVE FOR TESTING GROUND DEBRIS FRAGMENTATION DAMAGE TO SOLDIERS

PURPOSE

Current testing standards for secondary fragmentation require the use of a Fragment Simulating Projectile (FSP) made from steel. These FSPs do not mimic the behavior of accelerated ground debris such as sand, gravel and rock ejected from, for example, an improvised explosive device (IED) buried below the surface. Although other groups have used materials other than steel (such as aluminum and rocks) to provide a more accurate replication of threats, we present the novel process of 3D-printing ballistic projectiles directly from silica sand. The main goal of the study was to surpass the recommended 160 m/s velocity for fragmentation testing.

METHODS

Four different designs were modelled using software and a binder jetting additive manufacturing process was used to fabricate projectiles from sand. Military standards such as MIL-DTL-46593 (Specifications for FSPs) and an air cannon were used to launch 3D-printed sand projectiles at single Kevlar sheets. The velocity of the projectiles was captured as well as the trajectory and impact using high speed videography. Textile analysis was conducted on the fibers to assess damage patterns.

RESULTS

The 3D-printed sand projectiles achieved speeds over 160 m/s, resulting in measurable damage to single Kevlar sheets including penetration. Other flight parameters such as yaw and rotation were captured. It was found that one design performed better in terms of velocity, rotation and impact, which is captured and presented within.

CONCLUSIONS

After four different designs of the 3D-printed projectiles, it was found that one design in particular achieved higher velocities and more efficient flight paths. The goal of 160 m/s was achieved for one design, followed by penetration of Kevlar fabric. This fundamental study shows the promise of adopting projectiles 3D-printed from ground debris for protective equipment testing.

OPERATIONAL RELEVANCE

Performance of soldiers in active duty is dependent on the protection they receive in combat. Although testing can be used to mimic the effects of ground fragmentation, there is no current method to reproduce a simple ballistic test from indigenous material. We provide a novel method to fabricate projectiles made directly from ground debris, as well as proof that the projectiles are stable in flight and impact protective materials to the point of damage. This technology is expected to mature quickly, allowing for increasing velocities and greater customization of testing for more realistic scenarios and different threat levels as compared to steel projectiles.

AUTHORS

Kevin Hodder (1)
Patricia Dolez (1)
Frederik Coghe (2)
Patricia Dolez (1)
Jean-Philippe Dionne (3)
Rick Chalaturnyk (1)

(1) University of Alberta (Edmonton, Canada); (2) Royal Military Academy (Brussels, Belgium); (3) Med-Eng (Ottawa, Canada)

INNOVATIVE COMPUTATIONAL MODELING A POWERFUL SURROGATE FOR EVALUATING THE PERFORMANCE OF MILITARY GEAR

PURPOSE

The procedures of developing or acquiring suitable military gear that improves survivability and functionality, are complex processes. As part of these processes, the durability of the gear to external loads is examined. However, due to ethical and practical considerations the effects of the relevant loads on the soldier's body and the biological tissues are not sufficiently understood. The purpose of the current work is to present the novel method of the computational modeling and its implementation as part of the decision making process of accepting new military gear.

METHODS

The computational modeling consists of a precise anatomical three-dimensional model of the relevant organ and the comprising tissues (Simpleware ScanIP Synopsys, CA, USA). The forces developed in the target tissues under the specific gear were analyzed by using finite element model (FEBio software suite, University of Utah, USA).

RESULTS

The computational model presents the deformations, strains and stresses that develop under the specific gear, enabling better design of the gear. For example, the strain on the brachial plexus that emerges from carrying heavy loads and causing palsy have been shown to be lessened by changing the backpack straps' configuration and material structure. Improved helmets' design to better protect brain tissue from blunt impact and the resulting brain trauma have been shown to be achieved by changing the materials constituting the helmet following the understanding of strain that develop in brain tissues.

CONCLUSIONS

This approach constitutes a quantitative, standardized and effective platform for objective and methodological comparisons between different systems and enables a more informed decision-making process in the development or procurement of new and improved military related personal equipment.

OPERATIONAL RELEVANCE

This study has immediate practical implications and high operational relevance. Using the innovative approach presented here, it will be possible to considerably shorten development and procurement processes and to carry out advanced experiments after initial evaluation using computational modeling. For example, the investigation of specific events, where soldiers were injured can benefit from the suggested analysis by understanding the mechanisms of injury, which could lead to improvements in the design of future military protective gear. Since the computational system includes an accurate anatomical description of the observed organ, it can also be used to study the development of injuries and specifically those that are prevalent in the military milieu, such as stress fractures.

AUTHORS

Yoram Epstein (1)
Maayan Lustig (2)
Amir Hadid (2)
Rinat Friedman (2)
Amit Gefen (2)

(1) Heller Institute of Medical Research, Sheba Medical Center, Tel Hashomer, Israel & Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel (Ramat Gan, Israel); (2) Department of Biomedical Engineering, Faculty of Engineering, Tel Aviv University, Tel Aviv, Israel (Tel Aviv, Israel)

THE EFFECTS OF CAFFEINE ON RUNNING PERFORMANCE AFTER ONE NIGHT OF TOTAL SLEEP DEPRIVATION

PURPOSE

Caffeine is well-known to reduce the cognitive decline related to sleep loss. However, little research has been done into the effects of caffeine on endurance performance after total sleep deprivation. The aim of this study is to investigate whether 6 mg · kg-1 of caffeine would enhance running performance after a night of total sleep deprivation.

METHODS

A double-blind, placebo-controlled, crossover design was used. We recruited healthy recreationally active males. Maximal oxygen consumption (VO2 max) was determined in visit 1. In visits 2 and 3 participants remained awake the whole night in the laboratory. The following morning subjects took a pill containing caffeine (CAFF) or placebo (PLA) before a running performance test. This consisted of a 30-minute run at 60% of their VO2 max (isotime), followed by a 30-minute time trial (TT). Speed and rating of perceived exertion (RPE) were recorded every five minutes. Paired T-test was used for time trial distance. Two-way (condition by time) within-within ANOVAs were used for RPE and speed recorded every 5 minutes during isotime and TT. Statistical significance was set at $p < 0.05$.

RESULTS

Data from 6 subjects that completed the study before #ABStract submission are shown. During isotime, RPE increased over time (main effect of time, $p = 0.042$). No interaction (condition by time) or significant main effect of condition were found.

During TT, no differences were found in time trial distance between conditions (CAFF = 5826 ± 906 m; PLA = 5660 ± 1149 m; $p = 0.382$). No significant main effect of condition on RPE ($p = 0.147$) and speed ($p = 0.153$) were found. RPE increased over time (main effect of time, $p < 0.001$). No significant increase of speed over time (main effect of time, $p = 0.165$). No interactions (condition by time) were found.

CONCLUSIONS

At this stage of data collection, the effect of caffeine is not clear. Some variables suggest that CAFF reduces RPE and increases speed during TT whilst others do not. Further data collection is required to draw a conclusion. This study is still ongoing so data will be updated before the conference.

OPERATIONAL RELEVANCE

If the hypothesis is confirmed after data collection, caffeine could be used to improve endurance performance in sleep-deprived soldiers.

AUTHORS

Borja Martinez-Gonzalez (1)
Samuele M Marcora (2)
Samuele M Marcora (2)

(1) Endurance Research Group, School of Sport and Exercise Sciences, University of Kent (Chatham, United Kingdom); (2) Department of Biomedical and Neuromotor Sciences, University of Bologna (Chatham, United Kingdom)

MENTAL FATIGUE RELATED TO BOTH TOTAL SLEEP DEPRIVATION AND TIME ON TASK: NOT THE SAME FOR SUSTAINED ATTENTION AND EXECUTIVE PROCESSES AND POOR BENEFIT OF CAFFEINE

PURPOSE

Mental Fatigue is commonly questioned regarding time on task (TOT) (Hockey, 2013;Pattyn et al., 2018) or sleep debt (SD) effect (Krause et al., 2017). No studies have investigatedcontributions of these two factors in the genesis of mental fatigue for different cognitive processes(sustained attention and executive functions). Moreover, beneficial effect of caffeine has never beeninvestigated regarding such question.

METHODS

24 right-handed and healthy subjects (18 to 50 years old), with a median chronotype andsleep need participated in a 2-experimental counter-balanced (placebo: PBO and caffeine: CAFE-2.5 mg/kg) total sleep deprivation protocol (TSD = 27 hours of continuous wakefulness). Subjectivesleepiness (KSS), sustained attention (PC-PVT), inhibition (Go-NoGo) and working memory (2N-Back)capabilities were tested each morning during BASE and TSD (10 min. test session from 9:15am to 10:15 am). Caffeine was ingested with a decaffeinated drink at 8:30 am.

RESULTS

KSS score (5.6±0.4 vs 3.2±0.3; $p<0.001$), number of Lapses (9.8±1.7 vs 0.4±0.2; $p<0.001$),mean response time (308±4.9 vs 260±9.4; $p<0.001$) in PVT, number of NoGo errors (6.4±0.4 vs3.1±0.3; $p<0.01$) and mean response time (RT: 336±24 vs 301±13; $p<0.01$) in Go-NoGo weresignificantly higher after TSD compared to BASE. Neither significant difference in the proportionof correct responses (0.92±0.015 vs 0.90±0.014; $p>0.15$) nor mean response time (592±49 vs640±28 ms, $p >$ 0,11), were observed in the 2N-Back task. Further analyses showed that TOTinteracts with TSD but in with different kinetics for PVT (after 3 min of task engagement), Go-NoGo (after 6 min of task engagement) and 2N-Back (after 8 min of task engagement). Finally, weshowed that number of Lapses was significantly lower (5.8±0.4 vs 9.8±1.7; $p<0.01$) in CAFEcondition compared with PBO with a delay in TOT-TSD interaction (after 5 min of taskengagement instead of 3) whereas other behavioural parameters were unchanged.

CONCLUSIONS

These results are in accordance with our previous ones showing a differential timing effect of TSD on cognitive processes (Arnal et al., 2015; Rabat et al., 2019). They also pointed out differential interactive effects of SD and TOT on sustained attention and executive processes. No overall benefit of caffeine raised the question of different neurobiological mechanisms related to cognitive deficits with SD and TOT.

OPERATIONAL RELEVANCE

This research point out that caffeine is neither sufficient to compensate from all sustained attention deficits nor inefficient to compensate from executive processes deficits related to a TSD situation.

AUTHORS

Mégane Erblang (1)
Arnaud Rabat (1)
Anita Vergez (2)
Michaël Quiquempoix (2)
Pascal Van Beers (2)
Mathias Guillard (2)
Catherine Drogou (2)
Mounir Chennaoui (2)
Fabien Sauvet (2)
Arnaud Rabat (2)

(1) IRBA (French Armed Forces Biomedical Research Institute) (Brétigny sur Orge, France); (2) IRBA (Brétigny sur Orge, France)

BENEFICIAL EFFECTS OF EXERCISE TRAINING ON COGNITIVE PERFORMANCES DURING TOTAL SLEEP DEPRIVATION IN HEALTHY SUBJECTS

Exercise training has been shown to improve learning and memory, and to protect against negative impact of sleep deprivation. We investigated effects of a 7 weeks moderate and high intensity interval exercise training on vigilance/sustained attention, inhibition processes and working memory during 40-h total sleep deprivation (TSD) in 16 healthy young men. The subjects were evaluated before (Baseline, BAS) and during (TSD) total sleep deprivation, and the day after a night of recovery sleep (Recovery, REC). Exercise training significantly decreased errors and increased speed assessed by the Psychomotor Vigilance Task (PVT) during TSD and REC while no difference was found on executive inhibition (Go-noGo task) and working memory (2-Back task) performances. The multiple sleep latency (MSLT) was higher during BAS and REC at post-exercise training, and no difference occurred on subjective sleepiness and daytime microsleeps over the 40-h TSD. The PVT speed was positively correlated with maximal oxygen consumption (VO2max) and maximal aerobic power (MAP) measured before entry in the in-laboratory TSD protocol, and stage 3 sleep duration measured during the first night in the in-laboratory TSD protocol (N-1). Exercise training effects on sleep were found during the night recovery (NREC) with lower Stage-3 sleep and higher REM sleep durations. An exercise training effect was also found on free IGF-I levels with lower levels during TSD at post-exercise training. In healthy young men, an exercise training reduced sleep pressure at baseline and protects against sustained attention deficits induced by TSD with persistent effect after one night of recovery sleep. Nevertheless, exercise training was not effective to reduce deficits of executive inhibition and working memory induced by TSD. (Clinical Trial: NCT02820649).

AUTHORS

Fabien Sauvet (1)
Pierrick Arnal (2)
Pierre Emmanuel Tardo-Dino (3)
Mégane Erblang (4)
Mathias Guillard (4)
Pascal Van Beers (4)
Arnaud Rabat (4)
Danielle Gomez (4)
Mounir Chennaoui (4)

(1) Fench armed forces biomedical research institute (IRBA) (France); (2) Dreem (Paris, France); (3) IRBA (Bretigny sur Orge, France); (4) IRBA; EA 7330 VIFASOM, Université Paris Descartes (Bretigny sur Orge, France)

SEAL QUALIFICATION TRAINING STUDENTS REPORT LOW CARBOHYDRATE INTAKE RELATIVE TO THE HIGH PHYSICAL TRAINING DEMAND

Sea, Air, and Land (SEAL) Qualification Training (SQT) students train hard in preparation for extreme physical and mental challenges that come with being a Navy SEAL Operator. Diet plays a key role in optimizing the response and recovery from training.

PURPOSE

To evaluate carbohydrate (CHO) and protein (PRO) intake relative to physical training volume/type and body composition.

METHODS

SQT Students (n=144, age=24.4±2.8yrs, height=179.4±7.5cm, weight=85.0±8.1kg, body fat% 13.9±4.1) participated in body composition assessment (BodPod) and completed both a 24-hour diet recall (ASA24, National Cancer Institute) and an investigator-guided physical activity questionnaire (exercise mode, sessions/week, duration/session, miles/session, weight of load carriage, power output). Total exercise volume (EV) was calculated using the MET-hour per week (MET-Hr) formula from the International Physical Activity Questionnaire (IPAQ): MET-Hr per week = MET level x hours of activity x events per week. The types of training activities (e.g., running, circuit training, etc.) were classified further based on the general exercise categories: endurance (ET), strength (ST), and sports/other (S/O). Spearman or Pearson correlation coefficients were calculated, as appropriate.

RESULTS

Mean EV was 78.0±44.4, ET 39.7±36.5, ST 30.5±16.3 and S/O 7.8±12.1 (MET-hours/week), with 99% (n=142) reporting high total EV (>25 MET-hours/ per week). Compared to the recommended CHO intake (6 g CHO/kg) for high EV, students (P<0.000) significantly under consumed CHO. There was a significant positive correlation between CHO and ET (r=0.169, p=0.042); however, 94% of students did not consume the recommended amount of CHO. Compared to the recommended PRO requirements for strength athletes (1.6 g/kg/day), mean PRO intake (1.9±0.8 g/kg) was significantly higher (P<0.00). There was a significant positive correlation between PRO intake and ST (r=0.259, p=0.002) and S/O (r=0.191, p=0.022). 24% of students consumed the recommended amount of PRO (1.6-2.0 g/kg/day), 35% exceeded and 41% consumed less than the recommended amount. Regarding body fat percentage (BF%), higher CHO intake was associated with a lower BF% (r=-0.198, p=0.017).

CONCLUSION

SQT Students in general did not consume enough CHO to meet the high EV, despite a higher CHO intake being associated with a lower BF%. PRO intake was associated with volume of ST and S/O with the majority of students consuming adequate or higher amounts of PRO needed to support their physical training.

OPERATIONAL RELEVANCE

In order to optimize the benefits from rigorous physical training programs, SQT Students may benefit from consuming more CHO whole foods. Supported by ONR N00014-11-1-0929.

AUTHORS

Kim Beals (1)
Mita Lovalekar (1)
Karen Keenan (2)
John Haubenstricker (3)
Kate Perlsweig (1)
Darcie Yount (1)
Bradley Nindl (1)

(1) University of Pittsburgh (Pittsburgh, United States); (2) Fitchburg State University (Fitchburgh, United States); (3) Loma Linda University (Loma Linda, United States)

RISK FACTORS FOR DEVELOPMENT OF LOWER LIMB OSTEOARTHRITIS IN PHYSICALLY-DEMANDING OCCUPATIONS: A CRITICAL REVIEW AND META-ANALYSIS

PURPOSE

Osteoarthritis (OA) is a common debilitating musculoskeletal condition of multifactorial aetiology. The aim of this systematic review was to 1) identify and critically review the findings of recent studies regarding the relationships between specific physically-demanding occupations or occupational tasks and the development of lower limb OA, and 2) determine other risk factors that might affect these relationships in personnel engaged in such occupations.

METHODS

A systematic search of three major literature databases was performed to identify studies published in the last 15 years which reported on occupational risk factors for the development of OA. Studies were included if they were in English, reported original human data, examined risk factors for lower limb OA in physically-demanding occupations, and included both clinical and radiological diagnostic criteria for OA in their participants. Critical appraisal of included studies, narrative synthesis and meta-analysis of key findings were conducted.

RESULTS

Twenty-eight studies were eligible for inclusion. Physically demanding occupations like farming, floor laying, and brick laying were associated with lower limb OA, particularly at the knee. Significantly contributing to the risk of knee OA were occupational tasks involving lifting heavy loads (>10kg/week) (odds ratio [OR]=1.52, 95% confidence interval [95%CI] 1.29 to 1.76), squatting/kneeling (OR=1.69, 95%CI 1.15 to 2.49), standing (>2hours/daily) (OR=1.32, 95%CI 1.12 to 1.55), standing (OR 1.22 95%CI 1.02 to 1.46) and walking (OR 1.40 95%CI 1.14 to 1.73). Lifting contributed significantly to the risk of hip OA (OR 1.35, 95%CI 1.16 to 1.57). The effects of occupational exposures appear to be magnified by previous injury and BMI >25kg/m2. Limitations in some included studies include lack of consistency in reporting exposure quantities, and not reporting specifics of exposures or the exposure duration.

CONCLUSION

Occupational tasks involving heavy lifting/carrying, squatting/kneeling, and standing appear to be detrimental to both knee and hip joints. Occupations over-exposed to these tasks, such as the military, are at higher risk of developing lower limb OA compared to less physically demanding occupations. High injury rates may contribute to the higher incidence of lower limb OA observed in defence personnel compared to civilians.

OPERATIONAL RELEVANCE

The occupational tasks associated with an increased risk of developing OA are common in the military. While it may be difficult to modify these occupational tasks in military personnel, treatment and management of OA and potential proactive solutions (e.g. nutritional supplementation) should be investigated concurrent to potential occupational task risk mitigation strategies.

AUTHORS

Elisa F.D. Canetti (1)
Ben Schram (1)
Robin Orr (1)
Joseph Knapik (1)
Rodney Pope (2)

(1) Tactical Research Unit, Bond University (Gold Coast, Australia); (2) Charles Sturt University (Albury, NSW, Australia)

THE DEFENCE OCCUPATIONAL FITNESS PROGRAMME (THE DOFIT): A PROCESS EVALUATION OF A 12-MONTH WEIGHT MANAGEMENT INTERVENTION FOR BRITISH MILITARY PERSONNEL

PURPOSE

Overweight and obesity prevalence is increasing in the British military, impacting on the health and injury-risk of Service Personnel (SP). An evidence-based, National Institute for Health and Care Excellence (NICE) best practice, person-centred, behaviour change weight management (WM) programme (DOfit) was developed to support overweight SP. The DOfit was delivered by Defence Health and Wellbeing Advisors (DHWA), who were Physical Training Instructors and Health Professionals trained to deliver health behaviour change WM interventions. A Process Evaluation approach was adopted to assess the effectiveness of the DHWA training and DOfit programme in supporting behaviour change to improve health outcomes in the military.

METHODS

The RE-AIM Evaluation Framework was used to assess: the development, reach and adoption of a Public Health workforce training (DHWA); the efficacy of a programme planned to provide NICE WM support (DOfit); the extent to which the military organisational environment supported SP to act on their DOfit knowledge, skills and competencies; and compliance of the delivered DOfit intervention with NICE key performance indicators (KPI) for tier-2 WM interventions. The DOfit programme was evaluated relative to changes in aerobic fitness, waist circumference, body weight, nutrition knowledge, Quality of Life (QoL) and self-esteem in a cohort of (n=156) participants. Education focused on improving fitness, eating behaviour, dietary quality, alcohol consumption, and sleep. Participants were provided with on-going monitoring and support. Follow-up measures were taken at week-12 (n=115) and 12-months (n=51).

RESULTS

A workforce of 405 DHWAs have been trained and 53 DOfit courses have been initiated, involving circa 650 SP. DOfit participation was associated with 9.2 (10.5)% improved aerobic fitness, 3.5 (4.8)% decreased waist circumference, and 2.4 (6.1)% decreased weight at 12-months ($P<0.05$). Nutrition knowledge, QoL and self-esteem also improved. The DOfit Programme was generally compliant with NICE tier-2 WM services KPIs. Chain of Command (CoC) support was deemed essential for DOfit programme efficacy. DHWAs were effective change agents in delivering person-centred, WM support to SP. DOfit programme efficacy was dependent upon participant engagement, the aptitude and ability of the DHWA-trained DOfit deliverer, and CoC support.

CONCLUSIONS

The DHWA training and DOfit programme provided an effective military occupational health WM intervention. Addressing participant stigmatisation from peers and leaders, developing more healthful military environments to support healthful behaviour choices, and promoting explicit Defence Health Leadership would improve intervention outcomes.

OPERATIONAL RELEVANCE

Supporting healthy body weight in SP enhances physical and mental fitness, reduces injury risk, and would maximise deployability and operational effectiveness.

AUTHORS

Joanne Fallowfield (1)
Trish Davey (1)
Juliette Harmer (1)
Rachel Leiper (2)
Tracey Dorée (3)
Frances Gunner (1)
Matthew Arlow (4)
Nicola Sides (5)
Anneliese Shaw (1)

(1) Institute of Naval Medicine, Ministry of Defence (Alverstoke, United Kingdom); (2) Regional Medical Centre, RAF Halton, Ministry of Defence (Aylesbury, United Kingdom); (3) Headquarters Home Command, Ministry of Defence (Aldershot, United Kingdom); (4) Headquarters Force Troops Command, Ministry of Defence (Upavon, United Kingdom); (5) Army Headquarters, Ministry of Defence (Andover, United Kingdom)

DIETARY SUPPLEMENTS USE AMONG POLISH SOLDIERS OF SPECIAL FORCES, LAND FORCES AND NAVY

PURPOSE

The aim of the study was to compare the use of dietary supplements by Polish soldiers of Special Forces (SF), Land Forces (LF) and Navy (NA).

METHODS

Five hundred thirty eight soldiers (SF = 200; LF = 224; NA = 114) aged 31±7 completed a dietary supplements frequency questionnaire. Respondents could select one of eight categories regarding the consumption frequency and daily frequencies of nine supplements groups were calculated using the following values for reported frequencies: never or almost never – 0.003, once a quarter or less often – 0.01,once a month or less often – 0.03, a few times a month – 0.08, once a week – 0.14, several times a week – 0.57, every day – 1, several times a day – 2. Chi2 test was used to compare the use of dietary supplements and Kruskall Wallis test was used to compare daily frequencies of supplements between selected types of troops. Significance level of = 0.05 was assumed.

RESULTS

Dietary supplements use was reported by 50% of SF soldiers, 38% of LF soldiers and 27% of NA soldiers ($p < 0.001$). Most commonly used dietary supplements were vitamins and supplements intended for people practicing sports. Among the soldiers who used dietary supplements, statistically significant differences in daily frequency between types of troops were noticed in the case of 7 out of the 9 listed groups of supplements: vitamins ($p = 0.012$), preparations containing minerals ($p = 0.001$), vitamin and mineral preparations ($p = 0.001$), omega-3 fatty acids ($p < 0.001$), omega-6 fatty acids ($p = 0.001$), preparations intended for people practicing sports ($p < 0.001$), preparations that accelerate the regeneration of joint cartilage and used in the treatment of musculoskeletal injuries ($p < 0.001$), slimming preparations ($p = 0.272$), and preparations used to improve the condition of the skin, hair or nails ($p = 0.324$).

CONCLUSIONS

Soldiers, like civilians, use large amounts of dietary supplements, especially vitamins and preparations intended for people practicing.

OPERATIONAL RELEVANCE

The increase in the use of dietary supplements by soldiers may increase their physical condition, but in the case of overdose may also pose a health risk. That is why it is so important to monitor the use of dietary supplements by Polish army soldiers.

AUTHORS

Jerzy Bertrandt (1)
Tomasz Lepionka (2)
Roman Lakomy (2)
Tomasz Lepionka (2)
Ewa Szarska (3)
Ewelina Maculewicz (3)
Andrzej Tomczak (4)
Anna Anyzewska (2)

(1) Military Institute of Hygiene and Epidemiology (Warsaw, Poland); (2) Laboratory of Food and Nutrition Hygiene, Military Institute of Hygiene and Epidemiology (Warsaw, Poland); (3) Laboratory of Physiology, Military Institute of Hygiene and Epidemiology (Warsaw, Poland); (4) The War Studies University in Warsaw, Faculty of National Security, Department of Security Education (Warsaw, Poland)

RHABDOMYOLYSIS CASES IN MILITARY: A SYSTEMATIC REVIEW

PURPOSE

Rhabdomyolysis is a syndrome characterized by muscle necrosis and the release of intracellular muscle constituents. The severity of the disease ranges from asymptomatic elevations in serum muscle enzymes to potentially life-threatening diseases. In this sense, the aim of this study was to analyze the main risk factors and clinical profile of rhabdomyolysis cases in military personnel of the Armed Forces undergoing physical or military combat-specific training.

METHODS

A systematic review was performed searching for studies that reported cases of military affected by the syndrome. The protocol followed the "Preferred Reporting Items for Systematic Reviews and Meta-Analyzes" (PRISMA) guidelines. Only the studies that presented individual values of each rhabdomyolysis case were included. The search was performed from May 4 to 16, 2019, at the Medline, Cochrane, Lilacs, Scielo, Web of Science, Scopus, Cinahl, SportDiscuss, Science Direct, PEDro bases, with a period of 10 years from 2019 and without filter of languages. The descriptors Rhabdomyolysis" and "Military" were used, and their synonyms. From 128 studies found in all databases, 24 duplicates were excluded, 63 were excluded because they were studies with civilians, incomplete and/or inconclusive studies, confusing "exertional heat stroke" with rhabdomyolysis. Forty-one studies were selected for complete reading, and 28 discarded because not met inclusion criteria. In the end, 13 studies were included.

RESULTS

It was analyzed 49 individual cases of rhabdomyolysis. From these, it was possible to identify the main factors that contributed to the development of the syndrome: physical training (53.06%), and military combat-specific training (38.78%). The diagnosis of genetic diseases was present in 10.20% of cases. The use of drugs or dietary supplements to attend the demand generated by physical exertion was observed in 20.41% of cases. Most of the cases occurred in male militaries. Just three cases occurred in female. The peak of Creatine Kinase (CK) ranged from 1040 to 410755. Some cases (36.73%) reported renal function altered. Few cases presented information on the volume and intensity of physical training, hydration level during activities, ambient temperature and amount of equipment used during military maneuvers that were relevant to the onset of the syndrome.

CONCLUSION

Rhabdomyolysis remains a problem during periods of military training or physical training in the military environment.

OPERATIONAL RELEVANCE

Knowing better the profile of Rhabdomyolysis cases, chiefs and physical fitness managers could use this knowledgement in their programs of prevention of Rhabdomyolysis.

AUTHORS

Eduardo Borba Neves (1)
Guilherme Henrique Mattos Dantas (2)
Rodrigo Gomes de Souza Vale (2)
Rodolfo Alkmim Moreira Nunes (2)
Gustavo Casimiro Lopes (2)
Danielli Braga de Mello (3)

(1) Brazilian Army Research Institute of Physical Fitness (Rio de Janeiro, Brazil); (2) Rio de Janeiro State University (Rio de Janeiro, Brazil); (3) Brazilian Army Physical Education School (Rio de Janeiro, Brazil)

BARRIERS TO PHYSICAL ACTIVITY AT CFB HALIFAX

PURPOSE

To determine barriers to physical activity (PA) amongst the entire Defence Team at CFB Halifax, with a special focus on members of the Navy.

METHODS

The data collection tool used was an online survey. The survey was open to all CFB Halifax Defence Team members. Participants were questioned on topics related to barriers to PA. Descriptive analysis was performed to determine the most common barriers to PA.

RESULTS

14% of military respondents said that they were never, or only sometimes, given time for PA. When asked to identify barriers to PA, the most common response (37%) was an inability to spend time away from work due to a heavy workload. Another 20% of respondents identified a lack of access to gym facilities as a major barrier to PA. When asked about mandatory unit physical activity/training, 66% of respondents identified that their unit does not schedule any sort of mandatory PA sessions.

With regards to PA during Navy deployments, 51% of respondents identified that there were never any PSP staff deployed with their ship, with 17% identifying this as a barrier to PA. Another major barrier to PA during deployment was a lack of sleep/fatigue (54%).

CONCLUSIONS

There are many areas in which CFB Halifax, and the Navy as a whole, can improve with regards to PA. Increasing the frequency in which members are permitted to participate in PA is integral to improving overall health. This change requires engagement from all levels of command, with our next steps involving discussions with leadership to determine feasible solutions to this issue. One option to consider is increased mandatory unit PA, as levels are currently quite low. Improvement in PSP staff deployment rates is also an option as PSP staff help to provide consistency and expertise in physical activity training and programming.

OPERATIONAL RELEVANCE

74% of Regular Force personnel are classified as either overweight or obese. Excess weight is a major contributing factor to many chronic diseases, and in turn, can negatively impact the operational readiness of CAF personnel. PA is one way in which to combat excessive weight/weight gain and the diseases associated with excess weight. Addressing environmental and policy issues that impact access to PA will help to improve CAF performance and ensure that personnel maintain universality of service.

AUTHORS

Samantha Noseworthy (1)
CPO1 Tim Blonde (2)
Isaac Habib (3)
Maj Dan Trudel (4)
Capt Bonnie Nadeau (5)
Capt Chelsey Llewellyn (5)
Stacey Robichaud (6)

(1) Health Promotion Services – CFB Halifax (Halifax, Canada); (2) MARLANT – CFB Halifax (Halifax, Canada); (3) PSP – CFB Halifax (Halifax, Canada); (4) CF Health Services – CFB Halifax (Halifax, Canada); (5) 12 Wing Shearwater (Shearwater, Canada); (6) PSP – CFB Halifax (Halifax, Canada)

UNIT ALCOHOL ADVISORS: AN EVALUATION OF THE IMPLEMENTATION OF ALCOHOL BRIEF INTERVENTIONS INTO THE BRITISH ARMY

PURPOSE

Alcohol consumption remains a problem within the British Army. Service personnel (SP) drink above national recommended limits, increasing their risk to health. An evidence-based alcohol brief intervention (ABI), modelled on National Institute for Health and Care Excellence best practice, was developed to support SP drinking at harmful levels. The intervention was delivered by training unit alcohol advisors (UAAs) in each unit to deliver ABIs.

METHODS

10 Army units were involved in the trial; five units implementing ABIs through trained UAAs, and five units acting as the control. Throughout the Pilot, multiple evaluative measures were taken. This rigorous evaluation process was applied to best understand each aspect of the intervention, including training, briefing, support and resources. This was assessed through measures of action, performance and effect. The summate of these evaluative measures were used to provide recommendations to refine the UAA intervention in preparation for roll-out to the wider Army.

A bespoke alcohol behaviours survey was distributed at baseline (n=1,153) and again at four months (n=712). The survey included a number of standardised measures including the Alcohol Use Disorder Identification Test-Consumption (AUDIT-C) and a revised version of the Drinking Motive Questionnaire (DMQ). Other measures included demographics, perceptions of individual health risk and drinking behaviours, motivations to drink or #ABStain, and wider consequences of drinking alcohol. Focus groups were conducted with individuals from the five trial units.

RESULTS

80% of SP were found to be drinking at harmful levels. Furthermore, SP reported risky behaviours which has the potential to impact on performance, including smoking when they do not usually (31.7%), failure to stay alert when working (20.5%) and inability to complete routine military duties (16.6%). Although a score reduction was observed over the trial, it was not significant. Analysis was also carried out into the motivations, attitudes and behaviours surrounding alcohol consumption. Although the need for implementing UAAs into the Army was understood, the messaging surrounding its introduction required careful consideration to avoid potential resistance from recipients if they felt the approach was overly paternalistic. The messaging also needed to address concerns of SP, such as finance and weight.

CONCLUSIONS

Following this evaluation, it was agreed that UAA was suitable for this military setting and should be implemented throughout the British Army.

OPERATIONAL RELEVANCE

Alcohol consumption is harmful to health, behaviour and performance. UAA supports the Armys own Improving Behaviours strategy within the Maximising Talent portfolio.

AUTHORS
Nicola Sides (1)
Mohammed Fertout (1)
Oliver Quantick (1)
(1) British Army (United Kingdom)

THE EFFECT OF CHANGES IN STEP LENGTH ON HIP JOINT LOADING IN MEN AND WOMEN

PURPOSE

Marching in-step is a requirement for military personnel and requires soldiers to maintain specific speeds and step lengths (SL) for prolonged periods, often whilst carrying heavy loads. Current UK guidelines for a Tactical Advance to Battle specify a marching speed of 1.8m/s, which is, for many, at or above the individuals preferred transition speed to running. Marching at imposed speed and SL can increase the factors associated with lower limb injury risk, particularly hip stress fractures; likely as a function of stature, and, therefore sex, as walking parameters are related to leg length. This study aims to determine if changes to preferred step length affect sagittal and frontal plane hip joint loading during unloaded walking at 1.8m/s.

METHODS

Eighteen (nine women) participants were asked to walk overground at 1.8m/s, monitored by timing gates. Individual preferred step length was determined and then adjusted by 0, ±10%, ±20% and ±30%, using acoustic and visual cues. A minimum of five trials were recorded for each participant. Synchronised kinematics (10 VICON T20 motion analysis cameras), kinetics (four Kistler force plates embedded in the laboratory floor) and surface electromyography (Delsys Trigno) were collected and processed in Vicon Nexus (2.7.1) and Visual3D (V6.01.35). Between-sex and within-condition differences in peak internal hip joint moments of the sagittal and frontal plane were analysed using two-way repeated measures ANOVA and post-hoc Bonferroni tests (SPSS V25.0.0.1).

RESULTS

Peak hip adductor moments were significantly higher for females ($F(1,9)=6.4$, $p=0.032$, $p2=0.42$). Significant differences between SL conditions were observed in peak hip extensor ($F(6,54)=2.5$, $p=0.033$, $p2=0.22$) and adductor moments ($F(1.8,16.1)=4.7$, $p=0.027$, $p2=0.34$), with values at the extremes (±30%) greater than those at the preferred SL. Post-hoc tests identified significantly higher peak adductor moments for +20%SL versus preferred SL. No significant interactions between sex and condition were detected.

CONCLUSIONS

The U-shaped relationship of peak hip extensor and adductor moments with SL suggests that deviating from a preferred walking gait may increase hip joint loading. Given this relationship, without knowing preferred SL it is not possible to estimate whether an #ABSolute change in SL will decrease or increase hip joint loading.

OPERATIONAL RELEVANCE

Military personnel vary by height and limb length but operate in an integrated manner. Injury management strategies should consider the influence of spatiotemporal characteristics on lower limb biomechanics.

AUTHORS

Niamh Gill (1)
Kirsten Hollands (1)
Anmin Liu (1)
Dale Walker (1)
Andrew Roberts (2)
Thomas O'Leary (2)
Julie Greeves (2)
Richard Jones (1)

(1) University of Salford (Salford, United Kingdom); (2) Army Personnel Research Capability (Andover, United Kingdom)

CHANGES IN GROUND REACTION FORCES DURING DYNAMIC LOAD CARRIAGE MANEUVERS

Knowledge of the effect of load on ground reaction forces (GRF) during short dynamic movements is sparse, limiting our understanding of how load affects musculoskeletal injury risk in Soldiers.

PURPOSE

To quantify changes in GRFs during dynamic tasks performed under different loading conditions and characterize the relationship between increased load and GRFs.

METHODS

Twenty-four male military personnel (age: 20.2±3.0yrs, height: 1.77±0.53m, weight 80.3±11.3kg) completed three sessions each with a different load configuration: light (~6kg), medium (15% BW) and heavy (30% BW). Five tasks were performed during each session: run (RUN), single-leg cut (CUT), drop landing (LAND), walk-to-run (WTR) and run-to-walk (RTW). For the all tasks, GRF data were recorded for three successful trials from a pair of force platforms embedded in the floor. GRF parameters, including peak vertical GRF (vGRF), vertical loading rate (VLR), peak anterior and posterior GRF (aGRF, pGRF) were calculated and averaged across the three successful trials to create a subject-based mean. Then, each subject-based was submitted to separate repeated measures ANOVA to test the effect of load for each dependent variable. Significance was set a priori at 0.05.

RESULTS

Peak vGRF significantly increased between 5% and 10% with each load for all tasks ($p<0.001$). Peak aGRF significantly increased up to 8% with each load in the RUN and up to 30% in the RTW tasks ($p<0.02$). Peak pGRF significantly increased up to 9% with each load in the CUT task ($p<0.02$). VLR significantly increased with load in the RUN (up to 13%), CUT (up to 12%), and WTR (up to 18%) tasks ($p<0.05$). For all significant main effects within-subject contrasts found significant ($p<0.02$) linear relationships with load.

CONCLUSIONS

For most tasks, peak GRFs and VLR increased linearly between 5% and 15% with each addition of load. While these increases are only a percentage of the load, these findings have implications for future modeling and simulation work that aims to estimate how to scale GRFs to depict operationally relevant conditions. These simulations can be used to understand potential musculoskeletal injury risk with increased load and mitigation strategies.

OPERATIONAL RELEVANCE

GRFs provide essential insight into the mechanisms of lower extremity injury risk. By understanding how GRFs change during dynamic load carriage movements, we can generate computer simulations that use operationally relevant load and task configurations to investigate musculoskeletal injury risk during combat operations without exposing Soldiers to injury. This information may drive future recommendations for mission load limits.

AUTHORS

Kari Loverro (1)
Jonathan Kaplan (1)
Tyler Brown (2)
John Ramsay (1)

(1) Combat Capabilities Development Command – Soldier Center (Natick, United States); (2) Boise State University (Boise, United States)

SEX DIFFERENCES IN THE TIBIAL MACRO-AND MICROSTRUCTURE ADAPTATIONS TO ARDUOUS MILITARY TRAINING

Basic military training increases the density and size of the tibia in both men and women; the microstructural adaptations are less well understood. Differences in bone structure and circulating sex-steroid concentrations could contribute to differences in the skeletal adaptations to mechanical loading between men and women, but it is unknown whether there are sex differences in the tibial adaptations to basic military training.

PURPOSE

To investigate sex differences in tibial macro-and microstructure adaptations to basic military training.

METHODS

Tibial volumetric bone mineral density (vBMD), geometry and microarchitecture were measured using high-resolution peripheral quantitative computed tomography in nine male (mean ± SD, age 26 ± 3 years, height 1.82 ± 0.06 m, body mass 84.7 ± 7.6 kg) and 10 female British Army officer cadets (mean ± SD, age 25 ± 3 years, height 1.72 ± 0.05 m, body mass 67.0 ± 6.1 kg). Scans of the metaphysis (4% site) and diaphysis (30% site) were performed before (week 1) and after (week 14) the first 14 weeks of basic military training. Data were analysed with a 2 × 2 mixed-design ANOVA.

RESULTS

At the metaphysis, trabecular volume (1.2 ± 2.3%) and cortical area were greater (1.6 ± 1.7%), and cortical vBMD was lower (0.7 ± 0.7%) at week 14 then week 1 in both men and women (all P 0.045); total and trabecular vBMD, trabecular thickness and spacing, and cortical thickness, perimeter, porosity and pore diameter were not different between time-points (all P 0.064). At the diaphysis, cortical vBMD, area, thickness, perimeter, porosity and pore diameter were not different between time-points (P 0.179). There were no differences between men and women for any outcome in response to training (sex × time interaction, all P 0.129). At the metaphysis, trabecular vBMD, volume and thickness, and cortical area, thickness, perimeter, porosity and pore diameter were greater in men compared with women at both time-points (all P 0.036). At the diaphysis, cortical vBMD was greater, and cortical area, thickness and perimeter were lower in women than men at both time-points (all P 0.003).

CONCLUSION

Baseline differences in bone indices, but not pattern of adaptation, may contribute to the increased risk of stress fracture for women compared with men.

OPERATIONAL RELEVANCE

Better understanding sex differences in tibial characteristics and the tibial adaptations to military training may help to reduce the risk of stress fracture.

AUTHORS

Thomas O'Leary (1)
Sophie Wardle (1)
Robert Gifford (2)
Rebecca Double (1)
Julie Greeves (1)

(1) British Army (United Kingdom); (2) University of Edinburgh (Edinburgh, United Kingdom)

GENERATING RESILIENCE TO INJURIES THROUGH TRAINING (GRIT)

PURPOSE

To determine the feasibility of integrating standardized marching/training into the Developmental Period 1 Infantryman course (DP1), and determine any differences between standardized and usual marching/training in measures of fitness and musculoskeletal injury (MSKI).

METHODS

Candidates scheduled for DP1 from April 2019 March 2020 will be invited to participate, those on medical employment limitations (MEL) >5 days will be excluded. Consenting candidates will complete fitness measures associated with MSKI (Y balance, ankle dorsiflexion, isometric mid-thigh pull, crossover hop & FORCE) and an MSKI questionnaire 7 weeks before, 1 week before & 5 weeks into their DP1. Based on arrival candidates will be loaded onto a DP1 completing standardized or usual marching/training. Standardized marching/training will be led by fitness staff and integrates best practices in improving fitness and reducing MSKI in soldiers for 60 minutes/day, 6 days/week x 11 weeks. Usual marching/training will be led by DP1 staff and offered at their discretion. Evaluation of recruitment, outcome and intervention processes on operational capacity will determine study feasibility, while descriptive statistics will determine differences in fitness & MSKI.

RESULTS

To date 63 participants have been recruited, 35 (35/40=88%) were loaded onto a DP1 completing standardized marching/training (Mean 22±3years, 25.9±2.8kg/m2) and 28 (28/33=85%) onto a DP1 completing usual marching/training (Mean 22±3years, 24.5±3.1kg/m2). Several participants requested confirmation of data anonymity prior to outcome collection. Estimated time to collect outcomes was sufficient, but required additional human and material resources for efficiency. Operational priorities limited delivery of the standardized marching/training duration by 3 weeks. Operational scheduling conflicts resulted in 80% adherence to standardized marching/training components. DP1, fitness & medical staff agreed that the study posed a manageable demand on operational capacity. To date there are no significant differences between groups in fitness measures or self-reported MSKI. However, 13 MSKI have been reported to medical staff by usual group participants (mean MEL 7.3 days) while only 6 were reported by standardized group participants (mean MEL 1.3 days).

CONCLUSION

Despite some operational challenges, the GRIT study is emerging as a feasible method to deliver standardized marching/training to infantry candidates. While to date there are no statistically significant differences between groups in fitness measures, the standardized group has reported fewer MSKI and MEL days.

OPERATIONAL RELEVANCE

The GRIT study appears to be a feasible method of delivering standardized marching/training to infantry candidates and to date demonstrates fewer MSKI and MEL days than usual marching/training.

AUTHORS

Eric Robitaille (1)
Hans Christian Tinglestad (2)
Scott Heipel (2)
Tara Reilly (2)
Vanessa Larter (1)
Etienne Chasse (2)

(1) Canadian Forces Health Services (Meaford, Canada); (2) Canadian Forces Morale & Welfare Services (Ottawa, Canada)

CLINICAL WORKLOAD OVERVIEW OF THE PHYSIOTHERAPY SERVICES PROVIDED BY DEPLOYED CANADIAN ARMED FORCES (CAF) PHYSIOTHERAPY OFFICERS (PTO) DURING OPERATION REASSURANCE

PURPOSE

1. Observe referral numbers, medical employment limitations (MELs), and days lost due to injury during Operation (OP) Reassurance Rotation (ROTO) 0 to ROTO 1; and

2. Describe the injury profiles from all nations for ROTO 1, 2 and compare to CAF non-deployed profiles.

METHODS

This descriptive study observes data documenting MELs and days lost due to musculoskeletal injury (MSKI) from ROTO 0 (July, 2017 – January, 2018) and ROTO 1 (January, 2018 – July, 2018) of OP Reassurance. ROTO 0 did not employ a PTO whereas ROTO 1 deployed a PTO for the purpose of assessing and treating MSKIs. Data was recorded in the Disease Injury Surveillance System by medical staff. Injury profiles were compiled from assessments conducted by the PTOs during ROTO 1 and 2 (July, 2018 – January, 2019). Injuries were categorized by body part for all nations. Additionally, recurrence and mechanism of injury was collected for CAF members.

RESULTS

MSKI assessments increased from ROTO 1 (n=300) to ROTO 2 (n=439). Only 40% of personnel assessed for MSKI during ROTO 0 returned to full duty prior to re-deployment compared to 77% from ROTO 1. Additionally, the number of days lost per member due to MSKIs decreased from 1.9 to 1.2 and the percent of days lost decreased from 69% to 34%. The most frequent MSKI assessments, for all nations during ROTOs 1 and 2, related to the back, knee and shoulder. The order of prevalence did vary between nations. Comparison of deployed to non-deployed CAF MSKI profiles demonstrated similar findings. MSKIs amongst CAF members deployed during Op REASSURANCE have been most often attributed to physical training, work, or were of insidious onset.

CONCLUSION

Although the number of MSKI assessments increased from ROTO 0 to ROTO 1, the rate of return to full-duty while deployed was increased and the frequency of MELs attributed to MSKIs was decreased. Similar injury profiles were observed amongst all nations for ROTO 1 and 2. Additionally, deployed CAF injury profiles were similar to those of non-deployed personnel. Further research would assist with determining appropriate deployments for, as well as the health and economic impact of, CAF PTOs.

OPERATIONAL RELEVANCE

MSKI is frequently reported by military personnel. Access to deployed PTOs may contribute to reduced MELs and duty days lost. Injury profiles are similar between nations as well as between deployed and non-deployed CAF members.

AUTHORS

Adam Hannaford (1)
Raymond Trudel (2)
Chelsea Jones (3)
Doug Gross (4)
Suzette Bremault-Phillips (5)

(1) Canadian Forces Health Services, 1 Field Ambulance, CFB Edmonton, Edmonton, Alberta (Edmonton, Canada); (2) I/C Physiotherapy, Canadian Forces Health Services, Canadian Forces Health Services Centre (Atlantic), CFB Halifax, Halifax, Nova Scotia (Halifax, Canada); (3) Occupational Therapist, Canadian Forces Health Services, 1 Field Ambulance, CFB Edmonton, Edmonton, Alberta; Heroes in Mind, Advocacy and Research Consortium (HiMARC), Faculty of Rehabilitation Medicine, University of Alberta, Edmonton, Alberta (Edmonton, Canada); (4) Professor, Faculty of Rehabilitation Medicine, University of Alberta, Edmonton, Alberta (Edmonton, Canada); (5) Associate Professor, Faculty of Rehabilitation Medicine, University of Alberta, Edmonton, Alberta; Director, Heroes in Mind, Advocacy and Research Consortium (HiMARC) (Edmonton, Canada)

3.2 PREVENTION/ REDUCTION IN MSKI

#ABS039

FEBRUARY 13, 2020

PREVALENCE AND BODY DISTRIBUTION OF MUSCULOSKELETAL SYMPTOMS IN BRAZILIAN ARMY

PURPOSE

Musculoskeletal injuries caused by military combat-specific or physical training are a constant concern in all Armed Forces. This study aimed to identify the prevalence and body distribution of musculoskeletal symptoms in the Brazilian Army military based in the South and Southeast regions of Brazil.

METHODS

The sample of 1798 was randomly selected among Army soldiers from the South and Southeast regions of Brazil, aged between 19 and 49 years, were stratified by the Army Military Command, sex, age, rank, and type of activity (Operational and not operational). Data collection was done from June to July 2018, in three cities: Rio de Janeiro (state of Rio de Janeiro), Porto Alegre and Santa Maria (both in state of Rio Grande do Sul). From this sample, 657 volunteers filled out the Nordic Musculoskeletal Questionnaire. An epidemiological analysis was performed, and the chi-square test was used to compare the injury prevalence among body sites with a significance level of 95%.

RESULTS

In the last 12 months, from nine body sites studied, the most affected were: spine with a prevalence of 42.51% (lumbar = 29.88% and thoracic = 12.63%), knee with 26.48% and shoulders with 20.40%. Regarding the pain intensity, into a 0 to 10 scale, the highest values were observed in lumbar spine 5.49, knee 4.74 and shoulders 4.49. Musculoskeletal symptoms in these 3 sites caused 9.13%, 8.52% and 5.48% of #ABSenteeism, respectively. And the same sites were those which motivated the highest rates of medical attendance. The Chi-square test showed a significant difference (p-value <0.001) of musculoskeletal symptoms among body sites studied. In the last seven days, considering the time period in analysis, similar results were observed. Spine presented a prevalence of 23.14% (lumbar = 16.74% and thoracic = 6.39%), knee with 14.46% and shoulders with 11.11%.

CONCLUSIONS

It was observed a moderate prevalence of musculoskeletal symptoms. In both time periods evaluated (12 months and 7 days), the most affected areas were: spine, knee, and shoulders.

OPERATIONAL RELEVANCE

Chiefs and physical fitness managers can use results of this study to improve their programs of physical training, mainly increase the strengthening the core muscles, proprioception and strengthening of the legs, in order to prevent musculoskeletal symptoms in the most affected body sites. Thus, with these changes, it is expected that the Brazilian Army can increase the life quality of its members and reduce #ABSenteeism.

AUTHORS

Eduardo Borba Neves (1)
Antônio Márcio dos Santos Valente (1)
Rafael Melo de Oliveira (1)
Fábio Alves Machado Gomes (1)
Marco Antônio Muniz Lippert (1)

(1) Brazilian Army Research Institute of Physical Fitness (Brazil)

ASSESSMENT OF SINGLE-LIMB COMPETENCY AND ASYMMETRY IN LOWER AND UPPER BODY LIMBS USING MOTOR CONTROL SCREEN IN OFFICER CADET CANDIDATES

PURPOSE

Basic movements performed by soldiers during operations and training commonly involves actions, such as crawling and climbing, which require single-limb competency and capability. Motor control screen (MCS) assesses an individuals single limb ability to stabilize, balance and control movement while carrying their body weight. Therefore, the purpose of this study is to assess the single-limb competency and detect asymmetry for both lower and upper body limbs for Royal Brunei Armed Forces Officer Cadet candidates using MCS assessments.

METHODS

Sequence and test protocol for MCS were conducted according to the established procedures1,2 for 83 Officer Cadet candidates (age:25.1±1.4y, height:1.6±0.1m, weight:62.0±8.0kg). Prior to MCS, candidates were required to pass specific clearing tests. Candidates must reach a distance of more than two times the foot length to pass the MCS assessment. The body region is regarded as asymmetrical if difference between their reach is more than 4cm. Descriptive analyses were performed using Microsoft Excel.

RESULTS

Two candidates experienced pain during the ankle clearing test and did not proceed with lower body MCS. 42% of the candidates (n=81) passed MCS for both left and right lower limbs, while 22% passed for only one limb and 36% failed for both sides. 33% of candidates showed presence of lower body asymmetry. For upper body MCS, 87% of the candidates (n=83) passed for both upper limbs, while 7% passed for only one limb and 6% failed for both sides. Upper limb asymmetry was also detected in 41% of the candidates.

CONCLUSION

Half of the candidates did not pass the lower body MCS which suggests weakness in their ability to control movement while balancing on one leg leading to poor single-limb competency. More than a third of the candidates tested also showed asymmetry between left and right lower limbs. Thus, poor single-limb competency combined with presence of asymmetry suggests that candidates are at a higher risk of sustaining lower limb musculoskeletal injuries during their military training.

OPERATIONAL RELEVANCE

These baseline values collected can assist planners in the review and modification of training programmes in order to reduce the risk of injuries during training. Additionally, MCS can potentially be incorporated as a screening tool to assess risk of injuries for future Officer Cadets.

AUTHORS

Dr Dayangku Nurhayatul Filzah Pengiran Damit (1)

Michelle Charlene Basir (1)

Alisa Lau (1)

Amalina A'liah Gapor (1)

Nursazwilla Rosdie (1)

Noreffendy Ali (1)

(1) Performance Optimisation Centre, Royal Brunei Armed Forces (Brunei)

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3.2 PREVENTION/ REDUCTION IN MSKI

#ABS077

FEBRUARY 13, 2020

IMPACT OF A SINGLE INJURY PREVENTION INSTRUCTIONAL SESSION ON THE INCIDENCE OF INJURY AMONG U.S. ARMY ROTC CADETS

PURPOSE

To examine the impact of injury prevention training on the incidence of injuries in United States Army Reserve Officers Training Corps (ROTC) cadets at a Midwestern university.

METHODS

Seventy-nine Army ROTC cadets (age: 20±2 years, body mass: 73.57±12.60 kg, height: 172.88±9.50 cm, 26 females, 53 males) from a large Midwestern university provided informed consent to participate in the study during the Fall 2018 academic semester. Cadets within the program from the previous year served as the historic control group. A 75-minute injury prevention class covering etiology of overuse injuries, common risk factors, and recommended interventions was taught to the cadets at the start of the semester. A second, 45-minute class covering various modifications to physical training programming for injury prevention was taught to those cadets in leadership roles. Injury data were recorded during both semesters were collected from athletic trainers working with the ROTC program. Chi square tests of independence were performed between the two groups based on the nominal categories of body region, sex, and whether the injury was caused by acute or cumulative trauma.

RESULTS

No change in the number of injuries occurred between the control (n = 16) and intervention (n = 15) groups. No statistical significance between the groups was found based on body region injured (2 (9) = 9.38, p = 0.403) or sex (2 (1) = 2.78, p = 0.095). A statistically significant difference existed between the two groups based on the type of injury (2 (1) = 3.89, p = 0.049). In the historic control, 11 cumulative traumatic injuries occurred while 4 cumulative injuries occurred in the experimental group.

CONCLUSIONS

The results of this study demonstrated no impact of injury prevention training as the sole intervention on the incidence of injuries in ROTC cadets. A shift from primarily overuse injuries to primarily acute injuries did occur, warranting further research on this topic.

OPERATIONAL RELEVANCE

Musculoskeletal injuries are one of the leading health concerns for U.S. military populations. A majority of MSKI are overuse injuries connected to physical training. This study suggests that injury prevention education may decrease the incidence of chronic injuries. The U.S. Defense Oversight Council considers education to be a mandatory component of all injury prevention efforts; however, little research has been conducted to determine the best type, optimal amount, or the impact of training on injury incidence.

AUTHORS

Joshua Wooldridge (1)
Todd McLoda (2)
Noelle Selkow (2)

(1) University of Nevada, Las Vegas (Las Vegas, United States); (2) Illinois State University (Normal, Illinois, United States)

OPERATIONAL STRESSES ASSOCIATED WITH OBSERVING CASUALTIES IMPACTS ON THE NEURAL REGULATION OF THE AUTONOMIC NERVOUS SYSTEM

PURPOSE

We evaluated the utility of a simple posture-shift challenge to test for changes in autonomic regulation of cardiac output in soldiers. Recovery of autonomic balance at rest is an indicator of resilient neural control of stress physiology. Cumulative psychological trauma is theorized to alter autonomic regulation toward sympathetic hyperarousal thereby reducing cognitive and behavioral flexibility.

METHODS

Beat-to-beat heart rate (HR) data were collected continuously from soldiers across a sequence of seven postural shifts (sit to stand), beginning and ending with the seated posture. The HR signal was processed to extract respiratory sinus arrhythmia (RSA), an indicator of cardiac vagal tone and parasympathetic inhibition of cardiac output. Soldiers (N=26) reported the casualty rates in their units during combat deployments [no casualties (20%), 1-5% (57%), and > 5% (23%)]. Mixed effects models were used to examine the effect of casualty exposure and posture over time, with a random effect term to include between-subject variability.

RESULTS

The postural challenge revealed a main effect of position on RSA and HR, reducing parasympathetic tone in response to each stand and thus raising HR, then a return to basal level of RSA and HR during each seated segment. The hypothesized interaction between magnitude of casualty exposure and RSA level in the recovery period was observed. There was a significant interaction of time and casualty exposure in which >5% casualty exposure predicted poorer cardiac vagal recovery at the final assessment ($p = .043$). Any casualty exposure (1-5% and >5% groups) was also associated with lower heart period (i.e., faster HR) across multiple sitting and standing postures (sit1, stand1, stand3) compared to soldiers reporting no casualty exposure.

CONCLUSIONS

Exposure to higher casualty rates is correlated with blunted recovery of parasympathetic tone after mild physical challenge (posture shift). Soldiers with high levels of casualty exposure exhibit faster resting heart rates that remain faster across three cycles of sit-stand. Prior exposure to casualties was linked to larger reductions in, and smaller recovery of, cardiac vagal tone across each posture shift.

OPERATIONAL RELEVANCE

Autonomic balance in resting adults is dominated by parasympathetic inhibition of sympathetic arousal. Cognitive and behavioral flexibility, physical health, and psychological resilience is supported by efficient regulation of this vagal brake. We show that exposure to traumatic stress altered this natural balance and have demonstrated a simple procedure for quantifying this shift in neurophysiological regulation that could transform soldier monitoring for readiness and resilience.

AUTHORS

Amy J. Haufler (1)
Gregory F. Lewis (2)
Jacek Kolacz (3)
Stephen Porges (4)

(1) Johns Hopkins University Applied Physics Laboratory (Laurel, United States); (2) Intelligent Systems Engineering, Indiana University Bloomington (Bloomington, United States); (3) Kinsey Institute, Indiana University Bloomington, Bloomington (Bloomington, United States); (4) BrainBody Center for Psychophysiology and Bioengineering, Department of Psychiatry, University of North Carolina (Chapel Hill, United States)

A NOVEL ASSESSMENT FOR SWIMMING AEROBIC CAPACITY IN PHYSICALLY ACTIVE HELICOPTER RESCUE PARAMEDICS

PURPOSE

Physiologically demanding occupations require non-discriminatory physical tests to assess an individuals ability to perform their job. Intensive Care Flight Paramedics (ICFP) complete physically demanding helicopter winch rescues to access patients over land and in water. While these individuals are not trained for elite swimming, their swim performance must be assessed. To do this, we know that physiological demand can be determined by oxygen consumption (VO2), where VO2 is expressed as a percentage of maximal oxygen consumption (VO2max), defining the relative sub-maximal workload. Due to known differences in VO2max between swimming tests and running on a treadmill, it is unknown whether ICFPs can obtain the same VO2max when swimming compared to running. We hypothesize that the VO2max obtained from a certified treadmill protocol is significantly greater than that obtained from a novel water protocol.

METHODS

Fourteen ICFP (two females; age 44.3 y [SD 5.4], mass 80.0 kg [SD 12.6], height 1.79 m [0.06] were recruited. All participants completed a running and swimming VO2max test in a randomized order. The running VO2max test was a standard incremental exercise test. The swim VO2max test was adapted to this population from the elite test protocol used at Australian Institute of Sport. Participants completed 3 stages: low intensity (300 m), moderate intensity (200m), and maximal intensity (100m). Fractional concentration of expired oxygen and carbon dioxide, heart rate and blood lactate were collected at the end of each stage.

RESULTS

Running VO2max (48.8 ± 5.3 mL.kg.-1.min-1) was not significantly different to VO2max obtained during the swimming protocol (48.9 ± 5.9 mL.kg.-1.min-1; P>0.05). These results were reflected by no difference in lactate (running: 12.3 ± 0.9 mmol.L-1; swimming: 13.6 ± 1.1 mmol.L-1; P>0.05). However heart rate was significantly higher at the completing of the running test (184 ± 2 beats.min-1) compared to swimming (179 ± 3 beats.min-1; P<0.05).

CONCLUSION AND OPERATIONAL RELEVANCE

The main finding of this project was that no difference in maximal oxygen consumption was observed between swimming and running in non-elite swimmers. This has significant implications for expressing physiological task requirements as a percentage of VO2max, indicating the use of running VO2max for relative VO2 of swimming tasks as acceptable. Since some military and paramilitary specialist roles require swim-based tasks, this work is relevant for the development of swim-based assessments for physically demanding occupations in a physically active but non-elite population.

AUTHORS

Joanne Caldwell (1)
Ella Horton (1)
Kelly-Ann Bowles (1)
Ben Meadley (2)

(1) Monash University (Clayton, Australia); (2) Monash University, Ambulance Victoria (Melbourne, Australia)

EFFECT OF LONG-DISTANCE MARCH WHILE CARRYING DIFFERENT WEAPONS – MACHINE GUN OR RIFLE WEAPONS – IN POSTURAL CONTROL

PURPOSE

to compare the effect of the 12km military march carrying the individual combat equipment (ICE) and two weapons of different weight (rifle or machine gun), in the orthostatic postural balance.

METHODS

Thirty military men (26.67 ± 1.86 years) were randomly assigned to two different loading conditions ICE+rifle (25.63 ± 0.44kg) and ICE+machine gun (31.73 ± 0.24kg) for performing a 12km march. Stabilometric data were measured by a force platform (BERTEC, USA), with the subjects standing for 80s in orthostatic position, at six moments: before march (without load, NOL-0, and with load, L-0), with load after 4km (L-4), 8km (L-8), 12km (L-12) and no load after 12km (NOL-12). For each moment, three trials were performed and the variables average was evaluated in a 80s interval (first 20s were discarded). The following variables were analyzed: mean velocity (VL) and standard deviation (SD) in the medio-lateral (ML) and antero-posterior (AP) directions; and sway area. The experimental procedure was approved by the local Research and Ethics Committee.

STATISTICAL ANALYSIS

a multivariate analysis of variance (MANOVA) test was applied, followed by the Sidak post-hoc test. The factors time (moments) and load (rifle and machine gun) were considered. The level of significance was =0.05 and the SPSS software was used for all analysis.

RESULTS

There was only a significant effect for the factor time [F(25,840)=1.803; p=0.010]. The post-hoc showed an increase in the sway area, VLML, VLAP and DPML, between NOL-0 and L-8 and NOL-0 and L-12 moments; and there was a decrease in the VLML, VLAP and DPML between the L-8 and NOL-12. Neither load conditions nor the interaction between time and load were found on the stabilometric variables by MANOVA.

CONCLUSION

The results showed greater body sway post 8km and 12km of march and no effect of carrying different military equipment. However, the sample of physically well-conditioned soldiers may have been a relevant factor in the #ABSence of significant differences between the evaluated loads.

OPERATIONAL RELEVANCE

Military training should include activities aiming the reduction of body sway after long-distance marches, since this study showed that the postural control is affected by this operational activity. Furthermore, for a physically well-conditioned troop, the machine gun is as well tolerated as the riffle, in relation to postural control. Therefore, investigations about postural balance can facilitate the development of an adequate military physical training program, and the reduction of injury risk arising from this activity.

AUTHORS

Ricardo Alexandre Falcão (1)
Míriam Raquel Meira Mainenti (2)
Adriane Mara de Souza Muniz (1)
Luis Aureliano Imbiriba Silva (3)

(1) Escola de Educação Física do Exército, Rio de Janeiro (EsEFEx), Brasil. (Rio de Janeiro, Brazil); (2) Escola de Educação Física do Exército, Rio de Janeiro (EsEFEx), Brasil (Rio de Janeiro, Brazil); (3) Escola de Educação Física e Desportos da Universidade Federal do Rio de Janeiro (EEFD/UFRJ), Rio de Janeiro, Brasil. (Rio de Janeiro, Brazil)

RELIABILITY OF A HIGH-INTENSITY MILITARY TASK SIMULATION TEST

PURPOSE

Physical demands in operational environments and measurements of physical fitness have been identified as the most important research priorities in the military.1 For developing job-related task simulation tests, the present purpose was to determine the reliability of a high-intensity military simulation test (MST)2.

METHODS

Seventeen male cadets volunteered to participate. MST was performed with combat gear including a rifle replica and consisted of 4x6.2 m rushes, 11.3 m low crawl, 21.8 m sprint, 21.8 sprint with 3x40 cm obstacles, lifting and carrying two 16 kg kettlebells 4x2.5 m, 42.4 m zigzag run followed by casualty evacuation of a 65 kg mannequin for 24 m, and finally a sprint of 45 m. The total length of the MST track was 242.5 m. MST was performed three times with a minimum of 48 hours of recovery between trials. Before each trial, the participants completed MST with submaximal intensity for warm-up and familiarization. Blood lactate and a rating of perceived exertion (RPE, 620) were recorded immediately after each trial.

RESULTS

The mean MST times for the first, second, and third trial were 108.5±8.6, 103.3±6.6 and 98.4±6.5 s, respectively. Blood lactates were 14.8±2.7, 17.0±1.8, 15.9±2.1 mmol·L-1 and RPE values 18±1, 19±1, 19±1, respectively. Repeated measures ANOVA showed significant improvement in the MST time between every trial ($p<0.05$ for both). The intraclass correlation coefficient was 0.58 (95%CI: 0.030.84) between the first and second trial and 0.74 (95% CI: 0.060.94) between the second and third trial.

CONCLUSIONS

The improvement in MST time in every trial suggested a significant learning effect, especially between the first and second trials. ICC demonstrated, however, moderate reliability between the second and third trial. Due to the complex nature of MST, several familiarization trials are required and three trials may not be enough to determine the reliability of MST. In conclusion, MST may have a logical relationship with soldiers occupational physical demands, and it could be translated into a task-related predictive test when special attention is paid to familiarization procedures.

OPERATIONAL RELEVANCE

Military task simulation tests provide high face validity when compared to generic fitness tests, and can be used to obtain more information about #ABSolute job-related military physical performance and operational readiness.

AUTHORS

Joonas Helén (1)
Keijo Häkkinen (2)
Kai Pihlainen (3)
Jani Vaara (4)
Tommi Ojanen (5)
Heikki Kyröläinen (6)

(1) National Defence University, Department of Leadership and Military Pedagogy (Helsinki, Finland); (2) University of Jyväskylä, Faculty of Sport and Health Sciences, P.O. Box 35 (VIV), 40014 University of Jyväskylä, Finland (Jyväskylä, Finland); (3) Defence Command, Training Division, Finnish Defence Forces, P.O. Box 919, 00131 Helsinki, Finland (Helsinki, Finland); (4) National Defence University, Department of Leadership and Military Pedagogy, P.O. Box 7, 00861 Helsinki, Finland (Helsinki, Finland); (5) Finnish Defence Research Agency, Human Performance Division, P.O. Box 5, 04401 Järvenpää, Finland (Järvenpää, Finland); (6) University of Jyväskylä, Faculty of Sport and Health Sciences, P.O. Box 35 (VIV), 40014 University of Jyväskylä, Finland / National Defence University, Department of Leadership and Military Pedagogy, P.O. Box 7, 00861 Helsinki, Finland (Jyväskylä, Finland)

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TASK GROUPING BY PRIMARY PHYSICAL ACTIONS; A TECHNIQUE FOR DEVELOPING PHYSICAL EMPLOYMENT STANDARDS

PURPOSE

An objective and scientific Job Task Analysis (JTA) provides the basis for establishing legally defensible Physical Employment Standards (PES). The JTA is used to identify and describe common and essential physically demanding job tasks performed in a role. Once the job tasks have been quantified, criterion-referenced physical tests are developed to simulate the physical requirements of performing the job tasks. However, the JTA often generates greater numbers of specific job tasks than can practicably be developed into tests. Scrutiny of the JTA often reveals similarities in Primary Physical Actions (PPA) that are used to successfully complete job tasks. The purpose of this paper is to describe a conceptual framework which can be used to condense and/or consolidate a broad spectrum of physically demanding tasks to inform physical test development for PES. Method: Job tasks generated from JTA using subjective (e.g. workshops, surveys) and objective (e.g. notational analysis, physiological responses) measurements completed with military and emergency service organisations were reviewed. The researchers used descriptions of the job tasks to propose PPA groupings which could subsequently be used to inform the development of criterion-referenced physical tests.

RESULTS

The following 15 generic PPA groupings are proposed from scrutinising the JTA which could be used to inform the development of criterion-referenced physical tests: Personal load carriage (sustained); Personal load carriage (intermittent high-intensity); Lateral drag/pull/push at an anatomical height; Lateral drag/pull/push at a fixed height; Lift to an anatomical height; Seated/crouching/kneeling lift; Lift and carry (one height); Lift and carry (multiple heights); Lift and hold at an anatomical height; Lift and hold at a fixed height; Lower and hold at a fixed height; Lower and hold at an anatomical height; Dig; Repetitive hammer/strike and Ratchet/crank/winch/pump.

CONCLUSION

The approach of using PPA to group job tasks provides a standardised method to condense, combine and consolidate a range of job tasks to first decide upon suitable physical tests, and subsequently produce PES that are implementable for complex organisations, balance resource requirements and appropriately measure an individuals physical capability to perform job tasks. This paper presents the basis for a generic PPA grouping framework however, bespoke PPA groupings would likely be needed for specific occupational settings.

OPERATIONAL RELEVANCE

This framework can be used in the early phases of PES development when summarising information from a JTA to create criterion-referenced physical tests for use in military and emergency service settings.

AUTHORS

Katrina Hinde (1)
Stephen Myers (1)
Andrew Siddal (1)
Sarah Needham-Beck (1)
Sam Blacker (1)

(1) University of Chichester (Chichester, United Kingdom)

PHYSICAL LOADING OF TANK CREW DURING A 4-DAY MILITARY FIELD EXERCISE

PURPOSE

Task specific analyses of military tasks have been documented to some extent but there are still several tasks for which physical demands are not widely known. The purpose was to investigate physical loading of a battle tank crew during the combat phase of field exercises.

METHODS

A total of 32 soldiers (8 tanks) took part in battle tank exercises. Body composition (InBody 720, Biospace, Korea), waist circumference (WC), and physical performance (standing long jump (SLJ), sit-ups, push-ups, 12-min running test) and maximal heart rate (HR) were studied before the field exercises. During the 4-day exercise, physical loading was studied using HR (Firstbeat Bodyguard 2, Firstbeat Technologies, Finland) and physical activity (Hookie AM20, Traxmeet, Finland) monitoring along with follow-up of changes in body mass, perceived ratio of physical and mental exertion (RPE), and energy expenditure. Energy intake assessments were based on daily food diaries.

RESULTS

Mean±SD fat% and WC were 12.8±4.9% and 82±6 cm. Soldiers ran 2438±259 m in 12-min, jumped 235±17cm in SLJ, and performed 44±8 reps/min in sit-up and 39±17reps/min in push-up tests. During the combat phase, which lasted about 29 hours in total, mean maximal HR was 150±10 bpm (76±5%max) while average HR was 47±4%max. Only a small part (12±5%) of physical activity was moderate or vigorous while (41±9%) of the time was sedentary. The average energy expenditure during the 4-day field exercise was 4382±783kcal/day, and energy intake (2887±337 kcal/day), which led to negative energy balance (1501±783 kcal/day). At the same time, body mass decreased by 0.9±0.8 kg (1.1%). Furthermore, the average RPE of the battle tank crew was 10±2. The different roles, however, varied in terms of physical loading: tank commanders and loaders had higher HR and RPE values as compared to drivers and gunners. Mental stress was also higher in tank commanders than in other tank crew members.

CONCLUSIONS

The present tank crew succeeded well in their tasks and maintained a reserve for possible more strenuous and longer lasting battle phases during the military exercise. Physical and mental loading of tank commanders was higher as compared to drivers and gunners, while loaders had to lift and load heavy ammunition, which was observed as increased physiological responses.

OPERATIONAL RELEVANCE

It is important to know how members of the tank crew are specifically loaded as it may facilitate selection for tasks and allow for development of their future physical training.

AUTHORS

Heikki Kyröläinen (1)
Antti Heiskanen (2)
Jani Vaara (2)
Tommi Ojanen (3)
Kai Pihlainen (4)

(1) Faculty of Sport and Health Sciences, University of Jyväskylä (Jyväskylä, Finland); (2) Department of Leadership and Military Pedagogy, National Defence University (Hämeenlinna, Finland); (3) Finnish Defence Research Agency (Tuusula, Finland); (4) Training Division, Defence Command (Helsinki, Finland)

METHODOLOGICAL CONSIDERATIONS FOR USING URINE DERIVED N-TERMINAL FRAGMENT TITIN TO DETERMINE EXERCISE INDUCED MUSCLE DAMAGE

PURPOSE

Load carriage can lead to exercise induced muscle damage (EIMD), and increase the risk of musculoskeletal injury. N-terminal fragment titin, measured in urine, has been suggested to be a non-invasive marker of EIMD and therefore has potential utility as a measure to quantify EIMD in occupational settings. The aim of this study was to assess hydration status and sample handling effects on urine titin, before and after running.

METHODS

Twenty volunteers provided a urine sample when hydrated and following a 16-hour period of fluid restriction to induce hypohydration. Samples were centrifuged and frozen at-80°C immediately (A), centrifuged immediately, stored for 12 hours at 4°C, frozen at-80°C (B), stored for 12 hours at 4°C, centrifuged and frozen at-80°C (C), stored at room temperature for 12 hours, centrifuged and frozen at-80°C (D). Twenty separate volunteers provided a urine sample and completed a countermovement jump and rated their muscle soreness before, immediately after, and at 24 hours and 48 hours after running a half-marathon race. Titin was quantified using an enzyme linked immunosorbent assay (ELISA) and expressed as an #ABSolute concentration (ng.mL-1) and normalised to urine creatinine concentration (T/Cr; ng.mL.dL-1).

RESULTS

#ABSolute titin concentration was elevated after fluid restriction (hypohydrated, 9.53 ± 11.32 ng.mL-1; hydrated, 3.03 ± 2.53 ng.mL-1, p=0.014). Normalising titin to creatinine reduces, but does not remove effects of hydration status (hydrated T/Cr: 0.06 ± 0.08 ng.mL.dL-1, hypohydrated T/Cr: 0.16 ± 0.24 ng.mL.dL-1, p=0.11). Storage at room temperature (D) before processing reduced titin recovery from dehydrated samples (D, 7.39 ± 7.21 ng.mL-1; A, 9.53 ± 11.31 ng.mL-1, p=0.046), with no other differences in recovery observed. Titin increased from pre-race concentrations (2.47 ± 2.76 ng.mL-1) at 24 (21.13 ± 17.05 ng.mL-1, $p < 0.0001$) and 48 hours (10.81 ± 13.34 ng.mL-1, p=0.006) after running the half-marathon, but were not related to decrements in countermovement jump indices or subjective soreness.

CONCLUSIONS

Normalising titin to creatinine concentration reduces the impact of hypohydration on the measurement, and immediate storage at 4°C before sample processing and freezing is recommended. Titin was increased at 24 and 48 hours after a half marathon but was not related to changes in muscle function or soreness.

OPERATIONAL RELEVANCE

The quantification of N-fragment titin may offer a non-invasive secondary marker of EIMD that could be used to quantify EIMD in occupational settings. Future work should establish the utility and relevance of titin to muscle function

AUTHORS

Ben Lee (1)
Victoria Edwards (1)
Julianne Doherty (1)
Milena Banic (1)
Tess Flood (1)
Stephen McGuire (1)
Sam Blacker (1)
Stephen Myers (1)
Rianne Costello (1)

(1) Occupational Performance Research Group, Institute of Sport (Chichester, United Kingdom)

RECORDED EMERGENCIES TO DETERMINE TASK CHARACTERISTICS IN PHYSICALLY DEMANDING OCCUPATIONS

PURPOSE

Helicopter winch rescue, performed by Intensive Care flight Paramedics (ICFP) requires personnel to be winched into difficult to reach terrain or into water not readily accessed from shore or boat. Each winch rescue emergency will vary depending on location, terrain, number of casualties, required equipment and the number of paramedics able to assist. In addition, water rescue situations are highly variable due to patient compliance, sea state and swell, weather conditions, patient location and swim distance. Therefore to develop appropriate physical employment standards for this occupation, a standardised method for determining the minimal acceptable task characteristics was required.

METHODS

Utilising four years (2014-2018) of recorded data from every winch rescue operation reported during that period, specific task characteristics were categorised into Equipment Level (0: no equipment; 1: partial equipment (28.1 kg); 2: All equipment (43.4 kg)) and Criterion ((1: Insertion near patient (single patient); 2: Moderate rescue (>100 m distance); 3: Significant rescue (>500 m distance; 2-3 patients)) for overland tasks. For water winch rescue, these tasks were categorised by equipment level (1: partial equipment (15 kg); 2: All equipment (17 kg)) and Criterion ((1: Insertion near patient (single patient); 2: Moderate rescue (>10 m distance); 3: Significant rescue (>50 m distance; 2-3 patients)).

RESULTS

During this period, 105 overland tasks and 14 water winch tasks were reported. Of the overland tasks, 90 cases were team based with the most reported as insertion near patient (Criterion 1). There were 6 cases documented as requiring significant exertion covering a distance greater than 500 m with 3 or more patients (criterion 3) while carrying all equipment (level 2). For water rescue tasks, 4 (28.5%) individual rescues were documented as having significant exertion with a swim distance of more than 50 m (criterion 3) while carrying all equipment (Level 2).

CONCLUSION AND OPERATIONAL RELEVANCE

Winch rescue scenarios are highly variable and therefore utilising reported data obtained from previous emergency situations is an effective way to determine job requirements. Although the critical tasks (category 3, level 1) were performed less frequently for both overland and swim rescues, these incidences did occur and therefore ICFP personnel must possess the required physical capacity for these tasks. This forms a method for determining task characteristics in the development of physical employment standards and could be applied to a range of physically demanding occupations.

AUTHORS

Joanne Caldwell (1)
Ben Meadley (2)
Ben Meadley (2)
Kelly-Ann Bowles (3)
Joanne Caldwell (4)

(1) Monash University (Clayton, Australia); (2) Monash University and Ambulance Victoria (Australia); (3) Monash University (Melbourne, Australia); (4) Lecturer (Melbourne, Australia)

PHYSIOLOGICAL EFFECT OF LONG-DISTANCE MARCH WHILE CARRYING MACHINE GUN OR RIFLE WEAPONS

PURPOSE

Load carriage in long distance walking is one of the most frequent activities among military operations. Although there are many studies in this area, they mainly discuss the load carriage specifically in a backpack and not in other military equipment. The objective of this study was to compare physiological differences between carrying a machine gun or a rifle during a 12km military march. Furthermore, it was investigated if the percentage of the total body mass transported (%BMT) was correlated to the physiological responses.

METHODS

Thirty military men (26.67 ± 1.86 years) using their individual combat equipment (ICE) were randomly assigned to two conditions ICE+rifle (25.63 ± 0.44kg) and ICE+machine gun (31.73 ± 0.24kg) for a 12km march. Heart rate was tracked throughout all the activity by a V800 cardiac monitor (Polar, Finland). The blood lactate concentration was assessed by the Accutrend Plus analyzer (Roche, Portugal) before and immediately after 12km march, and the rating of perceived exertion (RPE) was asked each 500m. Mean heart rate (HR), HR variation (maximum HR – HR before march), mean RPE and lactate variation (final – beginning level) were the dependent variables of this study. Both groups were compared by the Student's T (Mean HR) or Mann Whitney test (HR variation, lactate variation and mean RPE), according to each variable distribution. Additionally, the Pearson correlation coefficient (Mean HR) or Spearman (HR variation, lactate variation and mean RPE) was applied for the whole sample (n=30) to correlate physiological variables and%BMT (SPSS, $p<0.05$).

RESULTS

Mean HR (122 vs. 110bpm) and HR variation (80 vs. 60bpm) were significantly higher for ICE+machine gun group. No statistical difference was found for lactate variation and mean RPE. The correlations showed that%BMT was correlated significantly with mean HR ($r=0.59$, $p=0.002$), HR variation ($r=0.40$, $p=0.044$) and mean RPE ($r=0.47$, $p=0.009$).

CONCLUSION:

Performing long distance military march with the machine gun showed greater cardiovascular effort than using a rifle. Moreover, higher values of%BMT are correlated with greater cardiovascular response and greater RPE.

OPERATIONAL RELEVANCE

The results of this study may contribute to the decision-making process, for example, military personnel that usually carry a machine gun during operational walking should improve their aerobic training with more emphasis than those that usually carry a rifle. Additionality, the weight carried by each soldier should be defined considering his%BMT to ensure similar cardiovascular demand for all components of the military fraction.

AUTHORS

Míriam Raquel Meira Mainenti (1)
Ricardo Alexandre Falcão (2)
Bruno Trassi Fernandes Silva de Souza (3)
Lucas Vieira Coelho dos Santos (3)
Adriane Mara de Souza Muniz (3)
Luis Aureliano Imbiriba Silva (4)

(1) Escola de Educação Física do Exército – EsEFEx (Brazil); (2) Escola de Educação Física do Exército (EsEFEx) and Escola de Educação Física e Desportos da Universidade Federal do Rio de Janeiro (EEFD/UFRJ) (Rio de Janeiro, Brazil); (3) Escola de Educação Física do Exército (EsEFEx) (Rio de Janeiro, Brazil); (4) Escola de Educação Física e Desportos da Universidade Federal do Rio de Janeiro (EEFD/UFRJ) (Rio de Janeiro, Brazil)

REPEATED MANUAL MATERIAL HANDLING (LIFTING AND SHIFTING): IS IT ALL THE SAME?

PURPOSE

Repeated manual material handling (RMMH), e.g. loading equipment, is a physically demanding task common across military occupations. The purpose of this study was to investigate the physiological demands of a range of RMMH tasks performed by Royal Australian Air Force (RAAF) personnel.

METHODS

As part of the development of physical employment standards (PES) for the RAAF, mean oxygen consumption (VO2), mean heart rate (HR), and rating of perceived exertion (RPE; Borg 6-20 scale) were collected on incumbent personnel performing a range of occupationally-relevant RMMH tasks (or simulations thereof). A random-effects meta-analysis was performed on these outcomes, with weighted-average and 90% confidence intervals (90%CI) and prediction intervals (90%PI) calculated. Only tasks deemed criterion tasks through the PES process and classified as RMMH (repeatedly lifting and/or carrying items) were included. Descriptive data [mean ± SD or median (range)] were calculated for the number of participants, the number of lifts/carries, and the minimum and maximum mass lifted/carried.

RESULTS

Ten RMMH criterion tasks (all from different workgroups) were included in the analysis, which in total comprised data from 84 personnel (8 ± 2 participants per task). The median sampling duration (min:s) was 11:30 (6:13 48:14), while the median number of items handled was 32 (6 >100). The median lightest mass handled was 7.9 kg (1.2 17.5 kg), whereas the median heaviest mass handled was 24.6 kg (11.1 31.8 kg). Mean VO2 was 1.81 L.min-1 (90%CI 1.60 2.03 L.min-1; 90%PI 1.11 2.51 L.min-1), corresponding to 56 ± 15% predicted VO2max. Mean HR was 129 beats.min-1 (90%CI 121 138 beats.min-1; 90%PI 104 155 beats.min-1) and mean RPE was 13 (somewhat hard; 90%CI 13 14; 90%PI 11 16).

CONCLUSIONS

Although criterion RMMH task parameters vary across RAAF workgroups, 80% of the tasks examined elicited a mean VO2 of 1.5 2.5 L.min-1 and involved handling items in excess of 20 kg. Thus, these tasks are moderately demanding in terms of cardiorespiratory requirements while also necessitating whole-body muscular endurance and strength.

OPERATIONAL RELEVANCE

These data provide RMMH reference values for the establishment of PES for military organisations, as well as for future investigations into RMMH tasks. Furthermore, these data suggest that a single RAAF-wide PES assessment simulating RMMH, with adjustable parameters (e.g. duration, item mass, number/frequency of lifts, carry distance, lift height), may be implemented to assess the cardiorespiratory and muscular requirements as well as actual performance of RMMH tasks.

AUTHORS

Scott Michael (1)
Herbert Groeller (1)
Greg Carstairs (2)
Jace Drain (2)

(1) University of Wollongong (Australia); (2) Defence Science and Technology Group (Fishermans Bend, Australia)

THE EFFECT OF ALTERING STRIDE PATTERN DURING A SET WALKING SPEED ON BIOMECHANICAL AND PHYSIOLOGICAL RESPONSES TO LOAD CARRIAGE: AN INVESTIGATION BETWEEN MALES AND FEMALES

PURPOSE

The purpose of this study was to determine if altering stride frequency (SF) during a set walking speed affects biomechanical or physiological aspects of load carriage between males and females.

METHODS

The study was a mixed model design assessing five different SFs (Self-selected [SS]; +10%SS; +20%SS;-10%SS;-20%SS) when walking at 4.2 km.h-1 with a 15 kg backpack; each stage lasted five minutes, totalling 25 minutes exercise. Participants (10 males, 10 females) anthropometric measurements and maximum oxygen uptake (VO2max) were established. In the first stage participants walked at a SSSF; subsequent stages were counterbalanced. A visual metronome was placed at eye level to control SF. Biomechanical data were collected during the final two minutes of each stage. Steady state oxygen consumption (VO2) and heart rate (HR) were sampled in the final minute of each stage. A mixed model ANOVA with Bonferroni post hoc tests and effect sizes using Cohens d (d) were run.

RESULTS

On average males were 8% taller, 23% heavier, 19% leaner and had 22% greater VO2max. Irrespective of sex VO2 was significantly ($p<0.05$) greater during-20%SS (1.46 [0.29] L.min-1) and +20%SS (1.39 [0.26] L.min-1) compared to SS (1.28 [0.18] L.min-1). HR, irrespective of sex, was significantly ($p<0.05$) higher during each of the other four stages compared to SS. The interaction demonstrated that females had significantly higher ($p<0.05$) HR than males at all stages except SS. Males demonstrated significantly ($p<0.05$) higher VO2 at-20%SS (1.60 [0.27] L.min-1) and-10%SS (1.43 [0.17] L.min-1) than females (1.31 [0.23] L.min 1 and 1.21 [0.21] L.min-1 respectively). Females were working at a significantly ($p<0.05$) greater percentage of their VO2max throughout the stages. Hip range of motion was greater in females and knee range of motion was greater in males; no significant differences ($p<0.05$) were found across SF or between males and females.

CONCLUSIONS

Physiological demands increased when SF was manipulated around SS. This has energy efficiency implications for those who have to walk at the frequency of others. The physical demand placed on females is greater than for males when not working at SS.

OPERATIONAL RELEVANCE

These data demonstrate that even at light loads, similar to those experienced in the first phases of training, physical demand increases when SF is altered above or below SS. This has implications on all individuals, especially females, who walk in sections to a frequency that is not their preferred.

AUTHORS

Gemma Milligan (1)

Emily Paines (1)

Joseph O'Halloran (1)

(1) University of Portsmouth (Cambridge Road, Portsmouth, United Kingdom)

CHARACTERIZATION OF PHYSICAL, PHYSIOLOGICAL AND PSYCHOLOGICAL RESPONSES DURING SPECIAL OPERATIONS FORCES OPERATOR QUALIFICATION TRAINING TO INFORM OPTIMIZATION STRATEGIES

PURPOSE

Special Operations Forces (SOF) Operator candidates undergo rigorous qualification training which includes progressively demanding training packages over one year. Periods of training expose candidates to multiple operational stressors including high energy expenditure, heavy load carriage, reduced sleep, caloric deficit and extreme environmental conditions. To optimize candidate performance, mitigate injury risk, and promote recovery, multidisciplinary health practitioners have implemented strategies based on best practices and anecdotal evidence of maladaptation. The purpose of this study was to characterize the physical, physiological and psychological responses during SOF Operator qualification training to provide evidence to inform optimization strategies moving forward.

METHODS

A battery of non-invasive field-based tests were utilized to monitor body composition, salivary Testosterone (T) and Cortisol (C), lower body power, handgrip strength, resting heart rate and hydration status. Mood state and musculoskeletal discomfort were measured via questionnaires. Measures were collected on 12 male candidates before and after training, and at thirteen critical junctures between physically demanding training packages.

RESULTS

Body mass fluctuated in periods of free-feeding (+2.5%) and caloric deficit (-1.5%) compared to pre-training measures. Elevated levels of salivary T (+20.4 to 34.5%) were sustained, with the exception of a period of high operational stress, where increased salivary C (+78.8%) and decreased T:C ratio (-44.1%) were also observed. During this period, the abbreviated profile of mood states revealed a disturbed mood state with a mean score of 110.8, and the Cornell musculoskeletal discomfort questionnaire revealed increased incidence of lower body discomfort. All measures returned to baseline post-training, except for lower body power (-13.0%) and handgrip strength (-23.9%), which steadily declined throughout training and remained reduced post-training (p.001).

CONCLUSIONS

Results provided health practitioners with evidence of acute adaptations in candidates for targeted strategies in the domains of nutrition performance, mental performance and injury prevention. Pre-and post-measures of lower body power and handgrip strength may be sufficient to assess effects on physical performance; however, additional evidence is required to determine if observed performance stagnation is due to insufficient targeted training stimulus or possible overreaching.

OPERATIONAL RELEVANCE

A focused and non-invasive battery of field-based tests can be utilized to monitor training in order to inform optimization strategies against the consequences of arduous SOF training. The application of targeted evidence-based strategies endeavours to reduce qualification training attrition, initiate career longevity, and enhance the operational capacity and effectiveness of newly qualified SOF Operators as they integrate into a high readiness unit.

AUTHORS

Anna Smyth (1)
Sylvie Fortier (1)
Conor MacDonald (1)
Kyle Gordon (1)
Mark Carlson (1)

(1) Canadian Forces Morale and Welfare Services (Ottawa, Canada)

CRITICAL TASKS FROM THE GLOBAL WAR ON TERROR A COMBAT-RELEVANT JOB TASK ANALYSIS

PURPOSE

Job task analyses (JTAs) are the foundation for physical employment standards (PES). JTAs serve as the genesis for soldier assessments and guide training endeavors. US PES have been criticized for their lack of combat-relevance. Efforts to improve their ecological validity have been made; yet, some assessments are rooted in JTAs that fail to assess task-importance in a combat-relevant manner. Our study aimed to identify critical tasks (CT) performed in a combat-environment by evaluating responses to a combat-relevant JTA taken by veterans from the Global War on Terror.

METHODS

A SWAT officer JTA was modified by a retired US Army Sergeant First Class and 8 subject matter experts (SME). SME were selected based on internationally-recognized criteria for assessing military tasks. The JTA was distributed via an online survey. Participants (n=137;deployments=1.9;missions=126.8) rated 19 tasks for frequency (0=never, 1=sometimes, 2=about half the time, 3=most of the time, 4=always) and importance (1=not important, 2=moderately important, 3=very important, 4=mission-essential, 5=vital to survive). A criticality score was generated for each task [Criticality=(2*Importance)+Frequency]. CT were identified if the mean criticality score 5.00 and/or mean importance rating 3.00.

RESULTS

Seventeen CT were identified via criticality and 11 for importance. The top 5 tasks were the same for both and included Aim, fire, or prepare to fire your weapon in support of operations (criticality=11.2±2.0;importance=4.7±0.7), Maintain a tactical position for an extended period of time (criticality=9.9±2.7;importance=3.9±1.0), Control breathing for marksmanship or tactical advantage (criticality=9.6±2.5;importance=4.1±1.0), Sprint all-out for <30 seconds in a single or repeated bout (criticality=9.4±2.7;importance=4.2±1.1, and Sprint, jump, or dive under combat load (criticality=8.9±2.9;importance=4.0±1.2).

CONCLUSIONS

CT were either tasks that were anaerobic in nature or tactical proficiencies with a weapon. More CT were identified via criticality compared to importance, which is more sensitive for detecting CT that are less important but occur frequently. While nearly all tasks were identified via criticality, this approach may not be pragmatic in PES development given a large number of task simulations. However, the CT we identified are likely performed simultaneously in combat-environments. Worldwide, fighting forces routinely evaluate similar tasks; yet, few do so simultaneously. Failure to combine these elements into a singular evaluation may limit the ability to assess combat-effectiveness.

OPERATIONAL RELEVANCE

Military leaders aiming to increase soldier-readiness and survivability should emphasize training and evaluating the CT we identified for increased mission-success. Concurrent physical and tactical simulations/assessments should be considered to mimic the combat-environment to support mission-success and enhance survivability.

AUTHORS

Jesse Stein (1)
Timothy Hepler (1)
Katie Heinrich (1)

(1) Kansas State University (Manhattan, United States)

A JOB TASK ANALYSIS OF BRITISH ARMY DOG HANDLERS

PURPOSE

To identify and characterise critical, physically demanding tasks completed by dog handlers in the British Army.

METHODS

A well-established task analysis framework was applied to identify critical occupational tasks. A rank-stratified selection of dog handlers with a range of experience and operational deployments attended a workshop where they identified Common Military Tasks (CMT) and Role-Specific Tasks (RST) that were both physically demanding and critical to their role. Task descriptions from the workshop were embedded in an online survey where respondents were asked to rate on a Likert Scale the identified CMTs and RSTs for: Frequency of Completion (from never to very frequently (e.g. multiple times daily)), Importance of Task to Their Role (from not important to critical) and Physical Demand (from very light to maximum). Workshop and survey findings were verified through observations of RSTs in a training establishment, completing notational analysis and recording details of the physical actions performed (e.g. types of movement, equipment sizes/masses and clothing worn).

RESULTS

The survey was completed by 9% of all currently serving dog handlers. Nine CMTs were identified, including loaded marching and patrolling, tactical movement during rural and urban operations, casualty extractions (drag, stretcher carry, and vertical extraction from a vehicle top hatch), manual preparation of defensive positions (digging and laying sandbags), and light manual handling during equipment preparation and replenishment. Seven RSTs were identified and related to manual handling-type tasks such as specialist equipment loading onto vehicles/ helicopters, setting up field kennels, and lifting and carrying military working dogs. Although the CMTs and RSTs were deemed important for the role, most were completed only infrequently (monthly) or very infrequently (rarely, annually). The RSTs identified as having the highest physical demand were primarily single heavy lifts, repeated lifts of lighter loads, or combined lift and carry tasks.

CONCLUSIONS

Dog handlers identified additional RSTs that were of equal importance, and requiring different primary physical actions, to CMTs required by the role. These RSTs predominantly involve lifting and manual handling-type activity, which may not be adequately tested in current routine fitness testing.

OPERATIONAL RELEVANCE

Alongside specialist technical training of dog handlers, a task analysis suggests that additional manual handling and lifting tasks may be an appropriate addition to fitness testing for this role.

AUTHORS

Faye Walker (1)
Sam Blacker (1)
Sarah Needham-Beck (1)
Katrina Hinde (1)
Andrew Siddall (1)
Anne Fieldhouse (2)
Julie Greeves (2)
Mark Rayson (3)
Steve Myers (1)

(1) Occupational Performance Research Group, Institute of Sport, University of Chichester (Chichester, United Kingdom); (2) Department of Army Health and Physical Performance Research, Army HQ (Andover, United Kingdom); (3) Mark Rayson Consulting Ltd (Bristol, United Kingdom)

CORE BODY TEMPERATURE DOES NOT CHANGE DURING ACCLIMATIZATION TO 4300 M ALTITUDE AND IS NOT ASSOCIATED WITH ACUTE MOUNTAIN SICKNESS

PURPOSE

Reductions in body temperature have been observed in both animals and humans following acute and chronic exposure to hypoxia. Paradoxically, others have reported an increase in body temperature at altitude which has been associated with the occurrence of acute mountain sickness (AMS). Discrepancies may be related to differing temperature sites and methodologies (e.g., oral, rectal; spot, continuous). The purpose of this study was to use ingestible thermometer pills to determine whether core body temperature (Tcr) changes over 12 days of exposure to 4300 m altitude and whether or not this change or lack thereof is related to AMS symptomatology.

METHODS

Seventeen healthy lowlanders (5 females, 12 males, mean±SD, age 23±2 yr, body weight 73±3 kg) completed sea level (SL, 0 m) baseline testing and then 12 days atop Pikes Peak (PP, 4300 m). Volunteers moved about freely inside the research facilities (ambient temperature, 19±2 °C). On days 2 (PP2), 6 (PP6), and 11 (PP11) volunteers completed a 20-min steady state exercise bout and 5 km self-paced run on a treadmill. Tcr was also collected overs 24 hours on these days. The Environmental Symptoms Questionnaire was utilized to assess the prevalence and severity of AMS using the cerebral factor score (AMS-C). If AMS-C was 0.7, individuals were considered sick.

RESULTS

Mean Tcr did not differ ($p > 0.05$) between SL (37.25±0.36 °C), PP2 (37.30±0.35 °C), PP6 (37.43±0.32 °C) and PP11 (37.39±0.38 °C). The severity of AMS increased from SL (0.09±0.16) to PP2 (0.83±0.72), and decreased from PP2 to PP6 (0.16±0.13) and PP11 (0.11±0.18). Similarly, the prevalence of AMS increased from SL (0%) to PP2 (47%) and decreased from PP2 to PP6 (0%) and PP11 (6%). There were no correlations for Tcr and AMS-C severity scores at PP2 (r=0.13), PP6 (r=0.08), and PP11(r=0.06). The mean Tcr of sick versus not-sick did not differ on PP2 (37.47±0.30 vs. 37.20±0.30°C), PP6 (37.5±0.31°C not-sick) or PP11 (37.15±0.00 vs. 37.40±0.39°C).

CONCLUSIONS

These results suggest there is no change in mean daily Tcr as measured by ingestible thermometer pill during acclimatization to 4300 m in free-ranging humans. AMS is not associated with elevations in Tcr during altitude acclimatization.

OPERATIONAL RELEVANCE

AMS is a potential impediment to Warfighter performance at altitude. Tcr should not be used as a predictor of AMS.

AUTHORS

Alexander Welles (1)
Mark Buller (1)
Beth Beidleman (1)

(1) U.S. Army Research Institute of Environmental Medicine (Natick, United States)

MEASURING PROTEIN TURNOVER IN THE FIELD; IMPLICATIONS FOR MILITARY RESEARCH

PURPOSE

Protein turnover, the balance between protein synthesis and breakdown, is the metabolic process regulating skeletal muscle mass. Military training, characterised by prolonged periods of intense physical activity and sub-optimal nutrition, may compromise protein balance. Chronic negative protein balance contributes to skeletal muscle mass loss, which may impair physical performance and increase musculoskeletal injury risk. Protein turnover can be measured at the whole-body or tissue level with several stable isotope methods. The purpose of this narrative review is to provide an overview of the suitability of these methods for field research.

METHODS

Published original and review articles were retrieved from three databases (PubMed, EBSCOhost and Google Scholar). The reference lists of all relevant articles were searched for additional literature.

RESULTS

Two principal methods of measuring protein turnover are precursor and end-product methods. The precursor method is considered the gold-standard method for measuring acute skeletal muscle protein turnover. Advances in an end-product method, involving the ingestion of heavy water, enables measurement of chronic (over several weeks) skeletal muscle protein turnover, which is more appropriate for free-living activities. Both methods require invasive procedures, such as the infusion of amino acid tracers and muscle biopsies to assess uptake of the tracer into tissue, limiting their use in field research. Whole-body protein turnover can be measured with an end-product method involving the ingestion of 15N-glycine and the subsequent measurement of urinary ammonia and urea. The time period of measuring protein turnover is dependent on the kinetics of the labelled nitrogen and the selection of the end-product. Most nitrogen-labelled ammonia is excreted 9 to 12 hours after dosing but excretion of labelled urea is much slower, with excretion essentially complete after 24 hours of dosing. A blood sample performed between 9 to-12 hours after dosing can quantify labelled urea, or alternatively, a 24 hour urine collection period can be used.

CONCLUSIONS

The end-product method, involving the ingestion of 15N-glycine and the collection of urine samples is a practical method for measuring whole-body protein turnover in the field.

OPERATIONAL RELEVANCE

Use of the end-product method will improve our understanding of protein kinetics during conditions of high physiological stress in free-living environments, such as military training.

AUTHORS

Katrina Hinde (1)
Thomas O'Leary (2)
Julie Greeves (2)
Sophie Wardle (2)

(1) University of Chichester (Chichester, United Kingdom); (2) Department of Army Health and Physical Performance Research, Army Headquarters, (Andover, United Kingdom)

CARDIOVASCULAR RESPONSES OF LOAD CARRIAGE IN FEMALE AND MALE SOLDIERS

PURPOSE

The capability of load carriage is essential for military personnel since they are often required to carry external load. In planning operations, it is important to know the time a soldier can sustain a given work-rate without fatigue. The purpose of this study was to examine differences between load (combat gear; CG) and no load (NL), in female and male soldiers on oxygen consumption (VO2) and heart rate (HR) during a graded treadmill protocol.

METHODS

18 volunteer soldiers (9 women), performed a graded treadmill test with and without CG. Treadmill stages included speeds of 5.4 and 8 km/h at 0% incline and increased 2% (3 min stages) until exhaustion. Paired t-tests were used to analyze the effect of load with no load and unpaired t-tests were used to analyze sex-differences. Due to multiple t-tests alpha-level was set at p0.01.

RESULTS

All soldiers completed 4 stages with both NL and CG, where time to exhaustion with NL was significantly longer ($p<0.001$) for all (women 11.5±2.2 min, men 10.2±2.7 min). Comparing NL and CG at submaximal stages, #ABSolute VO2 (L/min) were higher with CG for both sexes, which disappeared for relative VO2 (ml/kg/min). However, #ABSolute and relative VO2peak was lower with CG for both sexes ($p<0.01$), except for womens #ABSolute VO2peak ($p=0.09$). Submaximal HRs were higher ($p<0.01$), but peak HR was the same between NL and CG, for both women and men. Female soldiers were lighter than men but had different work positions so personal CG weighed more (16.2±3.3 kg; 25% of body mass [%BM]) than mens CG (12.5±1.6 kg; 16%BM; $p<0.01$). At submaximal stages, there were no correlations ($r<0.15$) between added load (%BM) and change in VO2 between CG and NL, but at maximal levels, a moderate correlation ($r=0.55$; $p=0.02$) was found between load (%BM) and change in VO2peak between NL and CG.

CONCLUSIONS

Load carriage affects soldiers physical capacity. CG shortens time to exhaustion, increases oxygen demands for a given submaximal load, and mostly lowers VO2peak. Carrying a higher load relative to BM was associated with a larger VO2 decrease between CG and NL at peak workload, an association not seen at submaximal work levels.

OPERATIONAL RELEVANCE

To plan and manage operations, it is necessary to know workload limits for soldiers to predict maximum sustainable worktime. Assessing soldiers work performance without load carriage will overestimate their maximum work capacity, possibly leading to increased fatigue and impaired operational effectiveness.

AUTHORS

Jonas Larsson (1)
Magnus Dencker (2)
Ann Bremander (3)
Charlotte Olsson (3)

(1) Lunds University (Sweden); (2) Lund University (Lund, Sweden); (3) Halmstad University (Halmstad, Sweden)

KINEMATIC AND KINETIC SEX-BY-LOAD INTERACTIONS DO NOT EXIST DURING MILITARY LOAD CARRIAGE

PURPOSE

Investigate sex-by-load interactions of joint kinematics and kinetics during overground load carriage.

METHODS

Fifteen females (age: 25.1 ± 6.1 y, height: 1.65 ± 0.07 m, body mass: 61.5 ± 6.9 kg) and 15 males (age: 22.3 ± 2.3 y, height: 1.79 ± 0.07 m, body mass: 74.2 ± 8.5 kg) completed three load-carriage conditions of incremental external load (0%, 20% and 40% body mass) at a self-selected walking speed (3.5-5.8 km/h). The external load was distributed equally between the front and back in a weighted vest. A three-dimensional motion capture system (Vicon Motion Systems Ltd; 100 Hz) and a force plate (AMTI; 1000 Hz) recorded marker trajectories and ground reaction forces for three trials of each condition, respectively. Sagittal plane lower-limb joint kinematics and kinetics of the hip, knee, and ankle were calculated using a lower-body direct kinematic model. Internal joint moments and vertical ground reaction forces were normalised to body mass. Split-plot analyses of variance (=.05) were conducted in jamovi (v. 0.9, The jamovi project) to assess sex-by-load interactions.

RESULTS

There were no significant sex differences or sex-by-load interactions for any kinematic or kinetic variable ($p > .05$); the effect of load was therefore reanalysed using a one-way repeated measures analysis of variance with the data from males and females combined. Peak ankle plantarflexion, ankle dorsiflexion, knee flexion, and hip flexion angles increased with increasing load ($p < .05$). There were no differences in peak hip extension angles between load conditions ($p = .204$). Peak vertical ground reaction force, ankle plantarflexion, knee extension, and hip flexion joint moments increased with the incremental loads ($p < .05$).

CONCLUSIONS

These results extend previous findings, demonstrating that neither gait kinematics nor normalised ground/joint kinetics differ between men and women while carrying loads up to 40% of body mass at self-selected walking speeds. The increase in sagittal plane joint flexion angles with incremental load is a suggested strategy that helps #ABSorb ground reaction forces and reduce injury risk related to load carriage. However, the increase in joint flexion angles and associated joint moments will likely result in an increase in metabolic demand.

OPERATIONAL RELEVANCE

Females and males respond similarly to increased relative loads during torso-borne load carriage at self-selected walking speeds. Rather than movement proficiency, training programs for female soldiers may be designed to focus on strength adaptations to improve load carriage performance and reduce injury risk.

AUTHORS

Kane Middleton (1)
Danielle Vickery-Howe (1)
Ben Dascombe (2)
Anthea Clarke (1)
Jace Drain (3)

(1) School of Allied Health, Human Service and Sport, La Trobe University (Australia); (2) School of Environmental & Life Sciences, University of Newcastle (Ourimbah, Australia); (3) Land Division, Defence Science and Technology Group (Fishermans Bend, Australia)

A COMPARISON OF THE PHYSIOLOGICAL DEMAND DURING TREADMILL AND OVERGROUND LOAD CARRIAGE

PURPOSE

Determine whether there are differences in physiological demand between treadmill and overground load carriage across a range of torso-borne loads at a self-selected walking speed.

METHODS

Thirty healthy adults (15 males, 15 females; age: 23.7 ± 4.8 y, height: 1.73 ± 0.98 m, body mass: 67.9 ± 10.0 kg; predicted VO2max 46.8 ± 4.6 mL·kg-1·min-1, mean ± SD) completed three 10-min load carriage trials that each comprised of three incremental loads (0%, 20% and 40% body mass). Self-selected walking speed was 4.7 ± 0.4 km·hr-1, 4.7 ± 0.5 km·hr-1 and 4.6 ± 0.5 km·hr-1 for each incremented load, respectively. This was determined during familiarisation while walking overground and applied across both surfaces (treadmill and overground). Once familiarised, the first surface condition was randomised. The control load (0% body mass) was performed first, followed by the 20% and 40% body mass loads respectively, with 10-min passive rest between conditions. The torso-borne load was distributed equally between front and back. Oxygen consumption was measured with a portable gas analysis system (Oxycon Mobile, Jaeger). Additional physiological and perceptual variables (heart rate, rating of perceived exertion, ventilation) were also measured. Two-way analysis of variance was used to assess external load × surface interactions. Statistical significance was set at $p<0.05$.

RESULTS

There was a significant load x surface interaction for oxygen consumption ($p<0.001$) whereby VO2 was significantly higher on the treadmill compared with overground at 20% body mass (mean difference (MD) standard error (SE); MD = 1.54 mL·kg-1·min-1, SE = 0.2 mL·kg-1·min-1) and 40% body mass (MD = 1.08 mL·kg-1·min-1, SE = 0.2 mL·kg-1·min-1). A significantly higher demand for heart rate (MD = 5 beats·min-1, SE = 1.2 beats·min-1), rating of perceived exertion (MD = 0.28, SE = 0.1), and ventilation (MD = 2.43 L·min-1, SE = 0.2 L·min-1) was observed in treadmill load carriage compared with overground load carriage ($p<0.05$). Heart rate, rating of perceived exertion and ventilation increased with an increase in load ($p<0.05$).

CONCLUSION

Treadmill walking elicits higher energy expenditure at self-selected walking speeds of approximately 4.7 km·h-1 when compared with overground walking with external loads of 0-40% body mass.

OPERATIONAL RELEVANCE

The current results show that work-to-rest guidelines prescribed from treadmill-based load carriage may need to be adjusted to ensure operational suitability during overground walking. Further research is required to determine whether a correction factor can be applied.

AUTHORS

Danielle Vickery-Howe (1)
Jace Drain (2)
Anthea Clarke (1)
Ben Dascombe (3)
Joel McWilliam (1)
Kane Middleton (1)

(1) School of Allied Health, Human Services and Sport, La Trobe University (Bundoora, Australia); (2) Land Division, Defence Science and Technology Group (Fishermans Bend, Australia); (3) School of Environmental & Life Sciences, University of Newcastle (Ourimbah, Australia)

PHYSICAL DEMANDS OF CONTINUOUS CARDIOPULMONARY RESUSCITATION

PURPOSE

Canadian military members are expected to partake cardiopulmonary resuscitation (CPR) training every three years. The purpose of this study was to compare the demands of 120s and 75s cycles of compression-only CPR drawn from a military essential task scenario.

METHODS

The sample consisted of 20 Canadian Armed Forces members (11 males; 9 females). Participants age was 34.0 (10.2) years old, body weight was 81.6 (20.2) kg, height was 173.0 (10.5) cm, and estimated V O2 max was 3.2 (0.7) L*min-1. Participants were asked to perform a CPR scenario on a training dummy (LittleAnne) at 120 beats per min without breaths; once with four cycles of 120s of continuous compressions, followed by 120s of rest for a total of 16 min, and again with six cycles of 75s of compressions and 75s of rest, for a total of 15 min. V O2 was measured continuously using a TrueOne metabolic system. Highest 20s averages in V O2 were identified for each cycle and participant. Rate of perceived exertion (RPE) was recorded on a 6-20 BORG scale following the completion of each cycle. Compression force was measured using force platforms (Vernier Software & Technology) which were positioned below the dummy and recorded vertical force in Newtons (N) at a sampling rate of 50 Hz. The different methodologies for each variable were compared using an ANOVA and a Mann-Whitney U Test, which were performed on IBM SPSS 24. Alpha was set at p=0.05.

RESULTS

The participants completed 239.6 (1.2) compressions per cycle during the 120s cycles and 149.9 (2.5) compressions during the 75s cycles. The peak V O2 recorded was 1.54 (0.50) L*min-1 (49% V O2max) for the 120s cycles and was 1.47 (0.54) L*min-1 (43% V O2max) for the 75s cycles (p=0.54). The RPE were 12.5 (1.7) and 12.0 (1.9) for the 120s and 75s cycles, respectively (p=0.07). There was a significant increase in RPE from the first to the last cycle in both conditions (p<0.01).The compression forces observed were 612.2 (79.8) N and 662.0 (194.4) N for the 120s and 75s cycles, respectively (p=0.54). These represent 78 (18)% and 84 (19)% of bodyweight and are both above the minimum required compression force reported in the literature.

CONCLUSION

Both compression conditions elicit very similar responses in V O2, RPE and compression force.

OP RELEVANCE

CPR training should implement usage of compression force and duration for which efficient compressions are maintained as tools to accompany proper CPR technique.

AUTHORS

Etienne Chassé (1)
Danielle Joshi (1)
Evan S Walsh (1)
Rachel Blacklock (1)
Barry Stockbrugger (1)
Kerry Ann Dow (2)
Daniel Théoret (1)

(1) Human Performance Research and Development, Directorate of Fitness, Personnel Support Programs, Canadian Forces Morale and Welfare Services, Government of Canada, Ottawa, Canada. (Ottawa, Canada); (2) Directorate of Fitness, Personnel Support Programs, Canadian Forces Morale and Welfare Services, Government of Canada, Ottawa, Canada. (Ottawa, Canada)

STRESS AND FATIGUE ASSESSMENT IN FIRST RESPONDERS USING HEART RATE VARIABILITY: A SYSTEMATIC REVIEW

PURPOSE

First responders and tactical operations personnel perform arduous tasks, often for extended periods of time that place cumulative stress on the body. Without adequate recovery, these individuals may be at risk of entering a maladaptive state that may predispose them to chronic negative health outcomes. Heart rate variability (HRV) has been proposed as a method for monitoring physiological status by representing autonomic nervous system activation. The aim of this systematic review was to investigate the utility of HRV to monitor stress and fatigue among first responders and tactical operators.

METHODS

The databases Academic Search Complete, MEDLINE complete, PsycINFO, SPORTDiscus and Scopus were searched for manuscripts published up to 5th November 2018. Inclusion criteria: English language; original peer reviewed research published 1985; human participants, currently employed or completing the task(s) of a first responder or tactical operator; and not suffering from a psychological disorder.

RESULTS

Of the 297 articles that met the inclusion criteria, 63 were included for full text assessment. Articles were classified based on single or repeated stressor exposure and the time of HRV assessment (baseline, during stressor, post stressor). Articles were also classified according to the duration of the stressor and recovery period (30 min – 3 days).

Singular stressful events (20 min – 24 hours) elicited a reduction in HRV from baseline to during the event. Longer stressor exposure was associated with reduced HRV post stressor for extended durations. Supine and standing HRV assessment occasionally provided differing HRV results from the same stress exposure. In repeated stressor contexts, improvements in cardiorespiratory fitness or reduced markers of physical stress elicited increased HRV at subsequent resting measures. Lower resting HRV is associated with lower situational awareness and impaired decision-making performance in marksmanship and navigation tasks.

CONCLUSIONS

HRV appears sensitive to acute stressor exposure and subsequent recovery of first responders and tactical operators. Higher resting HRV is associated with adequate recovery, improved physical fitness, reduced markers of stress and improved decision-making performance. More research is required to investigate the suitability of HRV as a measure for the assessment of chronic stress and fatigue management in first responder and tactical operators.

OPERATIONAL RELEVANCE

HRV is a potential method for assessing physiological responses to acute stressful events and may inform the recovery time course for first responders and tactical operators. Reduced resting HRV is associated with impaired decision-making performance, marksmanship performance, navigation task performance and situational awareness.

AUTHORS

Sean Corrigan (1)
Spencer Roberts (1)
Stuart Warmington (1)
Jace Drain (2)
Luana Main (1)

(1) Deakin University (Cardinia, Australia); (2) Defence Science and Technology Group (Fishermans Bend, Australia)

PHYSIOLOGICAL LOADING OF FIGHTER PILOTS DURING MILITARY EXERCISE

PURPOSE

The aim of the study was to investigate fighter pilots heart rate (HR) and heart rate variability (HRV) during a 3-day period of military exercise (ME) and to further compare pilots physiological loading between three ME days and three non-flying days (control period).

METHODS

The study population consisted of 20 volunteer Finnish Air Force (FINAF) fighter pilots who participated in the Revontuli 2018 ME in Northern Finland. HR and HRV were investigated on 3 days (control period) before ME and on 3 days during ME, respectively. During the control period, pilots only had light desk-job duties, whereas during ME, each pilot flew a minimum of 2 sorties per day with F/A 18 Hornet fighter aircraft. The pilots physiological loading was measured with HR and HRV with heart rate devices (Firstbeat Bodyguard 2, Firstbeat Technologies OY, Jyväskylä, Finland). Time domain (e.g. RMSSD) and frequency domain (e.g. HF and LF power) analyses were utilized when analyzing HRV data. In addition, Baevskys stress index was calculated.

RESULTS

During ME, the HR and all HRV results were quite stable in day-to-day comparisons. The mean (±SD) averaged HR (75 ±8 vs. 83 ±7 bpm) and maximal HR (125 ±16 vs. 148 ±16 bpm) differed ($p<0.001$) between the workdays during the control and ME periods. Furthermore, RMSSD was higher during the control period than during ME (48±11 ms vs. 29±9 ms, $p<0.001$), HF power was higher (28±8 vs. 20±8 ms2, $p<0.001$), and LF power lower (72±8 vs. 80±8 ms2, $p<0.001$), and the Baevskys stress index was lower (4.5±1.7 vs. 8.3±17, $p<0.001$), respectively.

CONCLUSIONS

According to the present findings, two ME flights per day did not cause remarkable physiological loading to the fighter pilots. However, flight duties are more stressful, observed as higher sympathetic activation, as compared to desk jobs, among pilots. The fighter pilots overall loading, especially in terms of cardiac autonomic modulation, was relatively low, which might be due to low flight intensity of the investigated ME.

OPERATIONAL RELEVANCE

The fighter pilot recourse is extremely important operationally. Therefore, it is important to understand the physiological loading of the flight duties, which enables the air force to keep pilots in fit to fly.

AUTHORS

Tuomas Honkanen (1)
Ville Kirijatshenko (2)
Tommi Ojanen (3)
Matti Mäntysaari (1)
Heikki Kyröläinen (4)

(1) Centre for Military Medicine, Helsinki, Finland (Helsinki, Finland); (2) Karelia Air Command, Toivala, Finland (Toivala, Finland); (3) Finnish Defense Research Agency, Tuusula, Finland (Tuusula, Finland); (4) Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland (Jyväskylä, Finland)

PERSONALISED PRE-DEPLOYMENT ACCLIMATION RESILIENCE USING CLIMATE CHAMBERS AND BIG DATA FOR THE EXTREME COLD

PURPOSE

Canadian Armed Forces personnel can be deployed to extremely cold locations such as the Arctic or Northern Canada. Injuries can be reduced through adaption of physiological responses and/or mitigating negative physiological responses to harsh environments with pre-deployment training. Natural environments for climatic stress cannot be controlled or repeated. The Ontario Tech Universitys ACE Facility climatic chambers enable controlled dynamic climates supporting standardised and repeatable training scenarios. Military training exercises within controlled climates provides great potential for development of pre-deployment acclimation strategies and techniques for individual assessment of resilience to certain weather conditions. Repeat exposure supports resilience development and improvement.

A two-hour deployment scenario was designed to demonstrate controlled climate pre-deployment acclimation resilience assessment and development within ACE. Three climatic chambers were connected through Transfer Bay to form an integrated controlled climate scene that was set to-200C and 50km winds were introduced in the Climatic Wind Tunnel near the end of the two-hour simulation. Snow was generated before the start of the simulation to create a snow base. The Large Climatic Chamber contained a two-storey building structure. The scenario enabled repeat door breach, hazardous materials containment and casualty extraction simulation exercises within the building structure interspersed with periods of inactivity over two hours. A reusable door prop enabled repeatable door breach activities.

Durham College Firefighter – Pre-Service, Education and Training program students served as an analogue for military personnel. They possess standard issue protective clothing for the conditions.

Participant physiology, activity and climate data were collected and integrated within a Big Data AI platform called Athena. Measurement of baseline physiology and deviation from baseline during initial acclimation, simulation activities and periods of inactivity enabled individual resilience assessment.

Personalised activity-based resilience assessment summaries were created to report resilience for each participant within the extreme cold.

This research, for a DND IDEaS research contract demonstrates personalised resilience assessment and development for adaption of physiological responses and/or mitigate negative physiological responses to harsh environments using climatic chambers, Big Data and AI.

Military personnel can be deployed to the extreme cold during operations other than combat such as peacekeeping, aid to civil powers, policing, humanitarian aid missions, disaster relief, supporting domestic and international training and development goals. This work proposes to increase resilience in the preparation of military personnel. Preparing them to be deployed under extreme climatic conditions prior to actual deployment leading to improved military personnel physical/cognitive performance in the moment and longitudinally.

AUTHORS

Carolyn McGregor (1)
F. Michael Williams-Bell (2)
Brendan Bonnis (3)

(1) Ontario Tech University; University of Technology Sydney (Canada); (2) Ontario Tech University; Durham College (ON, Canada); (3) Independent Scholar (ON, Canada)

DISTANCES TRAVELLED DURING RECRUIT PHYSICAL TRAINING: A DROP IN THE BUCKET

PURPOSE

Distances travelled during military recruit physical training (PT), be it walking, marching or running, are often the focus of injury mitigation strategies. However, these distances are not considered in relation to the entire recruit training program. The aim of this study was to quantify distances walked, marched, and run by recruits across the entire Army recruit training program and to establish the contribution of PT to these totals.

METHODS

As part of a larger project, an Army recruit training program was provided. This program was subjected to a desktop analysis. The desktop analysis drew on daily course programs, PT programs, military training manuals, and instructions, and subject matter experts to account for distances traversed per day and each week. Observation of selected training days of the courses complemented the desktop analysis as a means of data triangulation.

RESULTS

A total distance of 463,163 m was covered over the 12-week program (5,789 m/day) of which PT constituted 56,593 m (12.06%) consisting of 16,993 m walking (30.02%), 22,500 m marching (39.76%) and 17,100 m (30.22%) running. Across the weeks, PT constituted between 0% to 25.5% of the weekly distance travelled. The largest weekly distance was covered in Week 11 at 59,440 m covered with PT contributing 1.3% of the distance in that week of field training and battle efficiency assessments. In addition, over the 12-week period, the trainees traversed a minimum of 10,665 stairs. The observations indicated that, when considering the incidental activity and predicted number of stairs, the desktop analysis findings were conservative. However, the distances covered during PT were similar to those reported in the PT programs and assessed in the desktop analysis.

CONCLUSIONS

While PT does impart a notable amount of distance and lower limb loading during recruit training, other activities, like marching to and from lessons, walking around the area and to the mess, military drill on the drill square and field training and exercises can contribute around 90% of the distances moved on foot. These incidental distances are lower than those observed and reported in other literature and as such are likely conservative.

OPERATIONAL RELEVANCE

If distances traversed on foot are to be reduced to mitigate the potential for lower limb injury, distances covered outside of PT must be considered and reduced.

AUTHORS

Robin Orr (1)
Ben Schram (1)
Elissa Canetti (1)
Rod Pope (2)

(1) Tactical Research Unit, Bond University (Robina, Australia); (2) Charles Sturt University (Albury, Australia)

AN AI SYSTEM FOR REAL-TIME INDIVIDUALIZED CORE BODY TEMPERATURE ESTIMATION

PURPOSE

Heat injuries, which present a persistent threat to U.S. Armed Forces, could potentially be prevented by detecting a rise in core body temperature (Tc)an early indicator of an impending heat injury. However, assessing Tc requires invasive technologies. Therefore, the Army is developing a hardware/software system to estimate Tc and provide an early warning based on non-invasive measurements.

METHODS

We developed a real-time, individualized early warning system centered on an artificial intelligence (AI) algorithm, which continually adapts to an individuals physiological response to exertional and environmental heat stressors and provides personalized estimates of Tc in real time. The AI algorithm takes an individuals physiological measurements (physical activity, heart rate, and skin temperature) and environmental measurements (temperature and humidity) as inputs and, after each set of measurements, automatically adapts the model parameters to customize the Tc estimates to the individuals heat-stress response. We simulated real-time operation by training the algorithm to learn the physiological response of 166 subjects from three distinct studies, with each subject exposed to different exertional and environmental conditions. We also performed sensitivity analyses to assess the algorithms operation with missing or unreliable measurements.

RESULTS

The AI algorithm accurately estimated the Tc of each subject in real time, even when the same subject was exposed to different exertional and environmental conditions. The average Pearsons correlation between the AI-estimated Tc and the measured Tc for 246 temperature profiles for the 166 subjects was 0.82 [standard deviation (SD) = 0.16]. Across subjects, the average error between the AI-estimated Tc and the measured Tc was 0.33 degrees Celsius (deg) (SD = 0.18 deg). For the 22 subjects whose Tc exceeded 38.5 deg, a lower threshold for heat-injury risk, the error was only 0.25 deg (SD = 0.20 deg). The algorithm was robust against missing and unreliable data, yielding modestly larger errors (3 to 13%) for missing skin temperature (100%), partially missing heart rate (40%), and noise-laden heart rate (1 to 24%).

CONCLUSIONS

We developed an AI algorithm that provides accurate, real-time, individualized estimates of Tc that serve as reliable surrogates for invasive Tc measurements, even with corrupted non-invasive measurements.

OPERATIONAL RELEVANCE

Heat-related injuries pose a threat to the health and operational effectiveness of Warfighters, who are exposed to exertional and environmental heat-stress factors during deployment and training in hot and humid environments. Our algorithm, already integrated into a hardware/software system, will help reduce the risk of heat injuries during training and military operations.

AUTHORS

Srinivas Laxminarayan (1)
Jaques Reifman (2)
Vinet Rakesh (1)
Josh Kazman (3)
Ran Yanovich (4)
Itay Ketko (4)
Yoram Epstein (5)
Shawnda Morrison (6)
Jaques Reifman (2)

(1) Department of Defense Biotechnology High Performance Computing Software Applications Institute, Telemedicine and Advanced Technology Research Center, U.S. Army Medical Research and Development Command; The Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc. (Fort Detrick, United States); (2) Department of Defense Biotechnology High Performance Computing Software Applications Institute, Telemedicine and Advanced Technology Research Center, U.S. Army Medical Research and Development Command (Fort Detrick, United States); (3) Department of Military and Emergency Medicine, Uniformed Services University of the Health Sciences (Bethesda, United States); (4) The Israel Defense Forces Institute of Military Physiology; Heller Institute of Medical Research, Sheba Medical Center (Ramat Gan, Israel); (5) Heller Institute of Medical Research, Sheba Medical Center; Sackler Faculty of Medicine, Tel Aviv University (Ramat Gan, Israel); (6) University of Otago, School of Physical Education, Sport and Exercise Sciences; University of Primorska, Faculty of Health Sciences, Slovenia (Dunedin, New Zealand)

CHARACTERIZING CANADIAN ARMED FORCES SECTION ADVANCE TO CONTACT

PURPOSE

The purpose of this study was to: 1) characterize Canadian Armed Forces (CAF) section advance to contact (section attack) training in a naturalistic setting; and 2) determine if there are bound characteristic differences between movement segments, load conditions, and section roles.

METHOD

Twenty-three CAF dismounted infantry soldiers were recruited to participate in this study. Participants conducted frontal section attacks while wearing full fighting order with designated section role modular fighting rig and rifle; total weight carried ranged from 17.77-25.34 kg. Fire and movement segments (section, group, and team), load conditions (no added weight and 3.8 kg added weight), and section roles (commander, grenadier, gunner, and rifleman) were evaluated. Each soldier wore a measurement unit on their upper back. Using a modified algorithm by Silk & Billing (2013), bound characteristics were extracted: distance, time, peak velocity, time to peak velocity per bound, and number of bounds. A linear mixed effects model was applied, significance was determined at =.05.

RESULTS

There was a significant interaction between movement segments and load for time, time to peak velocity, and bound count. Significant main effects of: movement segments for bound distance, time taken, peak velocity, time to peak velocity, and bound count; load condition for distance; and role for distance, time, time to peak velocity, and bound count were also found. Movement segments changed bound characteristics as soldiers took less and shorter bounds in distance and time closer to the enemy. With additional load, soldiers bounded longer distances and, in group and team movement, longer periods of time. Gunners performed differently from all other roles with the most differences when compared to rifleman; gunners were slower when travelling and took longer distances.

CONCLUSIONS

Summarizing longer bound time and distance as increased exposure to the enemy, results from this study suggest that soldiers were more exposed when they carried additional weights of 3.8 kg in group and fire team movements or had the role of gunner. Soldiers were less exposed to the enemy as they progressed towards fire team movements.

OPERATIONAL RELEVANCE

Section attacks are central to soldiers, especially dismounted infantry, as it involves situational awareness, communication, and weapon handling amongst other critical skills. Characterizing how CAF soldiers move will help determine how physical performance changes and how to improve performance and reduce risk as well as provide comparison to Canadian allies (Silk 2013).

AUTHORS

Lois Adrienne Sy (1)
Cerys McGuinness (1)
Andrew Morton (2)
Thomas Karakolis (1)
Linda Bossi (1)

(1) Defence Research and Development Canada (Canada); (2) Human Systems Incorporated (Guelph, Canada)

REFERENCE

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MULTIMETHOD MODELING FOR MILITARY FIELD RESEARCH: COMPARING FREQUENTIST AND BAYESIAN PARADIGMS

PURPOSE

To compare and contrast two analytical inference frameworks, frequentist linear regression versus simple Bayesian linear regression, to gain insight into the advantages of alternative statistical techniques when investigating small sample sizes and small effects.

METHODS

Four U.S. Navy SEALs and/or support divers who were tasked with cold-water training participated in this study. To mimic cold water at a depth of 50 feet of sea water, the Ocean Simulation Facility (OSF) at the Navy Experimental Diving Unit was utilized. Core temperature readings were collected approximately every 30 minutes over the course of two dives on two separate days. Following data collection, two statistical analyses were conducted to include a frequentist linear regression model and a simple Bayesian regression model using non-informative priors and a Monte Carlo simulation of 10,000 samples to compute the Bayesian estimates. Both models were used to predict the operators change in core temperature over the course of the two dives.

RESULTS

Results from the two models were nearly identical; frequentist: = 37.949 0.011x, Bayesian: = 37.950 0.011x. Further, 95% confidence intervals and standard errors (se) for the frequentist model included b0 = 37.7856 to 38.112, se = 0.080; and b1 =-0.013 to-0.009, se = 0.0008. The 95% credible intervals and standard errors for the Bayesian model included b0 = 37.787 to 38.117, se = 0.084; b1 =-0.013 to-0.009, se = 0.0009; and = 0.230 to 0.368, se = 0.035.

CONCLUSIONS

Results of the two models are consistent with each other. However, results from the Bayesian construct allow for a simple and effective way to analyze small sample sizes while providing probabilistic statements that can be directly interpreted. The direct interpretation of the Bayesian approach also circumvents the dichotomous decision that accompanies the frequentist p-value, thus increasing the transparency of the models results. Furthermore, the heightened conservativeness of the Bayesian model, evident by the uncertainty of the Bayesian estimates, helps to limit false positive outcomes.

OPERATIONAL RELEVANCE

Using a Bayesian inferential statistical model can be a beneficial alternative method to overcome common shortfalls that accompany research in the military field setting (i.e., small sample sizes, non-normal distributions, and small effects). Further, results from the Bayesian approach allow for directly interpretable and theoretically justified probabilistic outcomes compared with the hypothetical outcomes that accompany the frequentist approach. This key difference allows for easier dissemination of results to leadership and operators alike.

AUTHORS

Jake Bernards (1)
Jason Jameson (1)
Andrew Jensen (1)
Laura Arrington (1)
Karen Kelly (1)

(1) Naval Health Research Center (San Deigo, United States)

QUANTITATIVE MODEL OF BODY WEIGHT LOSS FOLLOWING RAPID ASCENT AND ACCLIMATIZATION TO VARIOUS ALTITUDES

PURPOSE

Reductions in body weight (BW) are commonly observed following rapid ascent to altitude. The purpose of this study was to develop a quantitative model of BW loss at altitude using a relational Mountain Medicine Data Repository containing individual demographic descriptors and repeated-measures of BW from 20 altitude studies.

METHODS

BW was measured in 459 healthy lowlanders (350 men and 109 women; mean±SD; 23±5 yr, 76±12 kg, 48±8 ml/kg/min) that spent between 1 to 20 days at altitudes ranging from 1.9 to 4.5 km with food available ad libitum. BW was measured 2-14 times per individual (1743 measures) using a calibrated digital scale. The BW loss going from sea level (SL) to altitude (ALT) was modelled using a general linear mixed model that accounted for correlations between repeated measurements. The independent variables included in the model were ALT (km), elapsed time at ALT (ET, days), sex, age, baseline BW at SL (basewt, kg), height, maximal oxygen uptake (VO2max), smoking status, and interactions.

RESULTS

The individual decrement in BW ranged from +1.2 kg to-6.5 kg. Individual predictors of this decrement included ALT (P=0.0001), ET (P=0.02), ALT x ET (P=0.001) and basewt x ET (P=0.02) interactions. The following model best predicted BW loss:

BW loss (kg) =0.158 – 0.064 (ALT) + 0.521 (ET) – 0.002 (basewt) – 0.073 (ET) (ALT)-0.006 (basewt) (ET)

When evaluated after 7 days of ALT exposure, BW loss increased by 0.65 kg for every 1 km increase in ALT regardless of basewt. For every 10 kg increase in basewt, BW loss increased by 0.50 kg regardless of ALT. BW loss in the average individual (e.g., 76 kg) increased by 0.02 to 0.44 kg/day depending on the ALT once individuals were above 1.5 km. The model explained 50% of the variability in BW loss at ALT.

CONCLUSIONS

BW loss is dependent on altitude, with minimal BW loss below 1.5 km. At altitudes above 1.5 km, the magnitude of BW loss can be predicted from initial body weight, the length of exposure, and severity of altitude.,

OPERATIONAL RELEVANCE

This predictive equation provides a tool for assessing when excessive altitude-induced BW loss is occurring and potentially contributing to compromised physical performance.

AUTHORS

Upendra Bhattarai (1)

Beth Beidleman (1)

(1) US Army Research Institute of Environmental Medicine (Natick, United States)

CHARACTERIZATION OF METABOLIC DEMAND ON A SKILL-FREE FIREFIGHTING CIRCUIT USING A NEWLY AVAILABLE PORTABLE METABOLIC SYSTEM

PURPOSE

Personal firefighting equipment training is required every four years for deploying members of the Canadian Armed Forces. The purpose of this study was to characterize the metabolic demand (VO2) using a newly developed portable metabolic system and heart rate reserve (HRR) on a simulated skill-free firefighting circuit drawn from Canadian Armed Forces essential tasks.

METHODS

The sample consisted of 21 Canadian Armed Forces members (13 males; 8 females) with 13.6 (11.5) years of service. Participants age was 33.4 (10.1) years old, body weight was 85.4 (22.1) kg, height was 174.5 (10.5) cm, estimated body fat was 25.8 (9.5) percent, and estimated relative VO2 max was 41.6 (8.1) ml*kg-1*min-1. Participants completed a simple skill-free firefighting circuit consisting of two 15m 20lb fire extinguisher carry, a 30m 38mm charged-hose drag and 175 meters of walking under the supervision of military subject matter experts. Heart rate and VO2 were measured continuously during the circuit via Zephyr metabolic system and VO2 master pro respectively. VO2 were calculated using an average of 10 breaths. HRR was calculated using the following equation:% HRR =100*((HR-HRrest) / (HRmax-HRrest)) where HRrest and HRmax were measured. Intraclass correlation (ICC) was calculated between%V O2max and HRR using SPSS 24.

RESULTS

Completion time on the circuit was 227 (19) seconds and rate of perceive exertion was 11 (2) on a 6-20 Borg scale. Drag resistance increased linearly during the hose drag to reach a maximal value of 32.3 (4.0) kgF. Average VO2 to complete the circuit was 22.1 (4.4) ml*kg-1*min-1 (52.5% VO2 max) while peak VO2 occurred during the hose drag and was 31.0 (6.7) ml*kg-1*min-1 (75.6% V O2 max). Average HRR to complete the circuit was 46.3 (9.2)% while peak HRR was 61.4 (13.1)%. Peak%V O2max and HRR consistency ICC was 0.63 ($p<0.05$) while #ABSolute ICC was 0.45 ($p<0.05$). Average%VO2max and HRR consistency ICC correlation was 0.71 ($p<0.01$) while #ABSolute ICC was 0.59 ($p<0.01$).

CONCLUSION

The skill-free firefighting task elicited a mean metabolic demand of 22.1 (4.4) ml*kg-1*min-1 or 46.3 (9.2)% HRR. The ICC between average and peak% VO2 max and HRR was between 0.45 and 0.71. There is a moderate to strong ICC observed between% VO2 max and HRR on this skill-free firefighting circuit.

OPERATIONAL RELEVANCE

The VO2master Pro portable metabolic system offers an alternative to the usage of HRR for metabolic demand quantification on military occupational tasks in the field.

AUTHORS

Etienne Chass (1)
Daniel Théoret (1)

(1) Human Performance Research and Development, Directorate of Fitness, Personnel Support Programs, Canadian Forces Morale and Welfare Services, Government of Canada, Ottawa, Canada. (Ottawa, Canada)

THE RELATIONSHIP OF PHYSICAL FITNESS AND COMBAT-RELATED JOB EXPERIENCE TO FOOT MARCHING PACING STRATEGIES

PURPOSE

Endurance athletes, like Soldiers when foot marching, adopt different pacing strategies (e.g., even pacing, positive splitting or negative splitting) to optimize their performance. Physical fitness, body dimensions or military experience may impact pacing strategy. The analyses examined the relationship of metrics of physical fitness, anthropometry and military experience with the Soldiers pacing trajectory when completing two loaded foot marches.

METHODS

25 male and 23 female active-duty, fully-trained Soldiers performed two, 4 mile foot marches with 7 days of rest in between. They carried a load of (mean ± SD) 45 ± 6.4 kg. Electronic timing gave split times every 0.8 km. Stature and body mass were recorded and a questionnaire recorded their most recent Army Physical Fitness Test (APFT) scores (time to run 3.22 km and pushups and sit-ups completed in 2 min) and their military occupational specialty (MOS). VO2 max was estimated from their 3.22km run times. Group based trajectories for the 0.8 km splits were estimated using a discrete mixed model for clustering of longitudinal data series. Identified trajectories are used to depict group-based road marching strategies over a 4 mile march. Within the analyses, each individual was assigned to a specific march trajectory group. Potential predictors of group assignment were univariately analyzed using one-way ANOVAs coupled with Tukey's post-hoc tests for continuous variables; Fisher exact tests were used for all group comparisons coupled with a Bonferroni adjustment accounting for multiple comparisons for the categorical and binary variables.

RESULTS

Trajectory analysis found 3 pacing strategies (even pacing, slight positive splitting and more extreme positive splitting with a faster finish) for both marches. 1st march finish times (minutes) were (mean ± SD) 65.06±2.7, 74.84±2.8, 86.48±5.71, ($p<0.0001$) for those pacing groups, respectively. APFT scores were 278.4±20.1, 265.4±28.4, 248.1±27.5, $p=0.0199$. VO2max (ml/kg/min) were 54.1±4.6, 50.6±5.1, 46.4±3.4, $p=0.0023$. 2nd march finish times (minutes) were (mean ± SD) 68.36±3.84, 77.97±5.81, 87.21±13.07, ($p<0.0001$) and membership in a combat arms MOS was 71.4%, 38.1% and 20.0% ($p=0.0319$) for those pacing groups, respectively.

CONCLUSIONS

Trajectory analysis identified 3 pacing trajectories. APFT, VO2 max and combat MOS were strongly related to pacing trajectory.

OPERATIONAL RELEVANCE

Understanding fitness levels and prior experience may help leaders coach naïve subjects to perform optimal pacing strategies. Providing pacing training may improve both individual and group performances.

AUTHORS

Peter Frykman (1)
Kathryn Taylor (1)
Stephen Foulis (1)
Jan Redmond (1)
Marilyn Sharp (1)

(1) Military Performance Division, US Army Research Institute of Environmental Medicine (Natick, United States)

ARE THE CURRENT THE BRAZILIAN AIR FORCE PHYSICAL FITNESS TEST CUT-POINTS OUTDATED? AN UPDATE OF THE SCORE REQUIREMENTS

PURPOSE

The Brazilian Air Force (BAF) physical fitness test (PFT) was developed three decades ago and the cut points were established by percentile categorization. These cut points seem to be outdated and less demanding in comparison to other Air Forces. In fact, the results from the last PFT have shown that only 5.0% has failed the test. The aim of the present study was to update the PFT cut points and adjust age groups according to health risk paradigm.

METHODS

The PFT results from all BAF military units collected during the last 8 years were selected to compose the analyses (n = 300.000). They were separated by sex and age (29, 30-39, 40-49, 50-59, 60 y/o) and were adjusted by percentiles (0-5, 6-29, 30-80, 81-95 and 96-100) according to the current BAF PFT standards. The first analyses consisted in determining the best age clusters. They were selected using a regression analysis and the clusters were separated when the slope of the relationship age vs. performance was significantly different from zero (student t-test, $p<0.05$).

RESULTS

The slope analysis considered the following new age groups: 20,21-30,31-34,35-38,39-41,42-43,44-49,50-52,53 for male push-up; 29,30-40,41-44,45 for female push-up and 27,28-30,31-33,34-35,36-38,39-41,42-44,45-50,50 for male sit-up;23,24-25,26-28,29-30,31-34,35-38,39-41,42-45,46-49,50 for female sit-up. The analysis of the data distribution and percentiles demonstrated that current cut-points of the push-up and sit-up tests were underestimated. The new adjustment increased the performance requirements in 50-100% for push-up (eg. 18 vs. 32 repetitions for 29y/o men) and sit-up (eg. 15 vs. 30 repetitions for 50y/o men) tests in both sex categories.

CONCLUSION

The results of this study showed that the current cut-points of the BAF PFT are outdated and presents poor relation with health risk meaning. The methodological approach applied in the present study corrected the distortion and resemble them to other Air Forces PFT standards. In addition, the alteration of the age clusters, in both genders, attenuated the impact of age on performance. Practical implications: The report of this study was submitted to the BAF General Staff Command as a basis to update the PFT regulations. The new standards may induce the enhancement in the physical fitness performance in the BAF militaries personnel, since higher requirements are considered as part of the annual military evaluation and, somehow, contribute on promotion and command position selection.

AUTHORS

Daniele Gabriel-Costa (1)
André Brand Bezerra Coutinho (1)
Marcelo Ribeiro Baldanza (1)
Pedro Celso Gagliardi Palermo (1)
(1) Brazilian Air Force (Rio de Janeiro, Brazil)

OPTIMIZING PULL-UP PERFORMANCE THROUGH SUBMAXIMAL PERFORMANCE PREDICTION TRAINING

PURPOSE

To develop a prediction of body weight pull-up (bwPU) performance from a submaximal kneeling lat pull-down (kLP) performance to better optimize training periodization and progression.

METHODS

A total of 991 cadets (males: n = 760, 81.1 ± 29.2 kg; females: n = 231, 64.7 ± 8.0 kg) from the United States Military Academy volunteered to participate in this study. Using a counterbalanced approach, each participant performed as many consecutive body weight pull-ups and lat pull-downs from the kneeling position (with hips extended) as possible. The weight was set at 80% of the participants self-reported body weight for the kLP exercise. Hands were positioned just outside of the shoulders in a pronated grip (palms facing away) for both exercises. The maximum number of repetitions performed for each exercise were recorded for analysis. Approximately 5 minutes of rest were taken between exercises.

RESULTS

A linear regression was used to develop a prediction of bwPU performance from kLP performance. For females, the prediction equation resulted in 86% shared variance ($p<0.001$), while males resulted in 95% ($p<0.001$).

CONCLUSIONS

Body weight pull-up performance can be predicted with reasonable certainty from a kLP performance set to 80% of body weight. While additional factors (e.g. body composition measures, limb lengths, fatigue) will likely affect the actual performance prediction on an individual level, it appears that these additional variables may only account for 15% of the variance. While further research in this area is needed, this initial prediction metric offers a reasonable estimate of maximal performance from a submaximal bout.

OPERATIONAL RELEVANCE

The bwPU is a challenging exercise and assessment of muscular strength/muscular endurance. As such, it is often used as an indicator of physical fitness in the US military (US Army Rangers, US Navy SEALs, US Marine Corps, US Air Force, etc.). This predictive scale can be used to develop a training program that progresses the individual appropriately based off their submaximal performance in a similar, modified exercise.

AUTHORS

Jennifer Hewit (1)
Daniel Jaffe (1)
Todd Crowder (1)
(1) US Military Academy (West Point, United States)

PERCEIVED TRAINING LOAD AND JUMPING RESPONSES FOLLOWING SIX WEEKS OF TRAINING IN BRAZILIAN NAVY COMBAT DIVERS SPECIAL OPERATIONS COURSE

PURPOSE

The purpose of the current study was to describe and examine the variations of session rating of perceived exertion (sRPE), total quality of recovery (TQR) and the countermovement jump (CMJ) height during six weeks of a Brazilian Navy special operations training program.

METHODS

Eight male military personnel participated in the study (28.7±3.8 years, 175±5 cm, 79.0±7.5 kg, 46.0±6.7 mL.kg-1.min-1). Participants performed two sessions a day, five days a week of physical training (consisted by strength training, swimming and running) during six weeks. The sRPE was assessed in each training session, while the CMJ height and TQR were assessed in each training day. One-way repeated measures analysis of variance (ANOVA) was used to verify the differences in variation of sRPE, CMJ height and TQR along the six weeks of training. Pearson product-moment coefficient of correlation was used to analyze the relationships between sRPE, CMJ height and TQR. In addition, we estimated the 95% confidence intervals (CI95%). Analyses were conducted using the SPSS statistical software package (version 21.0; SPSS, Inc., Chicago, IL, USA) at a significance level of $P<0.05$.

RESULTS

Considering each of the six weeks, respectively, the results were: sRPE in arbitrary units (A.U.) – 471.8±225.7, 823.1±258, 598.7±290.8, 1088.2±357.9, 521.3±289.5 and 799.8±674.7; CMJ height (cm) – 28.5±0.3, 28.1±1.5, 28.0±2.0, 26.4±1.2, 25.3±2.1 and 26.8±0.6; TQR (A.U.) – 15.4±1.0, 14.0±1.8, 14.6±1.3, 13.3±1.3, 11.4±2.3 and 13.2±0.6. ANOVA showed that there were no changes ($P>0.05$) for any of the assessed variables throughout the six weeks investigated. Additionally, there were no correlations between sRPE and CMJ height ($r=-0.21$; CI95%-0.87 to 0.73; $P>0.05$). However, there was a nearly perfect correlation between CMJ height and TQR ($r=0.96$; CI95% 0.64 to 1.0; $P<0.05$).

CONCLUSIONS

Although jump height and quality of recovery seems not to vary according to the internal training load (sRPE), our findings showed that an improved recovery of training session may increase the jump height.

OPERATIONAL RELEVANCE

Considering that TQR scale is a very practical and low cost tool for monitoring neuromuscular fatigue, its use might be recommended for analyzing the recovery of military personnel during intensive training programs.

AUTHORS

Allan Inoue (1)
Daniel Alves (2)
Maria Miranda (3)
Thiago Lopes (2)
Priscila Bunn (4)

(1) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science, Rio de Janeiro, Brazil; Exercise Psychophysiology Group, School of Arts, Sciences and Humanities, University of São Paulo, São Paulo, Brazil; Exercise and Sport Sciences Postgraduate Program, Rio de Janeiro State University, Rio de Janeiro, Brazil; Operational Human Performance Postgraduate Program, Air Force University, Rio de Janeiro, Brazil (Brazil); (2) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science, Rio de Janeiro, Brazil; Operational Human Performance Postgraduate Program, Air Force University, Rio de Janeiro, Brazil (Rio de Janeiro, Brazil); (3) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science, Rio de Janeiro, Brazil; Exercise and Sport Sciences Postgraduate Program, Rio de Janeiro State University, Rio de Janeiro, Brazil (Rio de Janeiro, Brazil); (4) Brazilian Navy, CEFAN, Research Laboratory of Exercise Science, Rio de Janeiro, Brazil; Exercise and Sport Sciences Postgraduate Program, Rio de Janeiro State University, Rio de Janeiro, Brazil; Operational Human Performance Postgraduate Program, Air Force University, Rio de Janeiro, Brazil (Rio de Janeiro, Brazil)

INCREASING CONFIDENCE IN A WARFIGHTING EXPERIMENT

BACKGROUND

One of the frictions that exists in performing a warfighting experiment is that between scientific rigour and the need for the experiment to be in a warfighting context. Often the experimental design is based on when soldiers or training estates are available and an estimated cost for the experiment. An experiment is then designed to fit around these variables, regardless of the statistical impact this will have on the results. However, there is an ever-increasing demand to minimise costs whilst also maximising results and finding a trade-off between the two. An optimal experiment format may not be simply the cheapest experiment, neither the one with the largest confidence in the results.

PURPOSE

Create a tool that can be used by any experiment planner, during the planning stage, which considers the format of the experiment and the effect this has on statistical power and the total cost. This tool is aimed to be used by a non-technical experiment planner to ensure they achieve a largest statistical power for the minimal cost. In particular the aspiration is that it is a key part of the toolset for staff working in force headquarters and trials & development units within the military as part of their planning.

METHODS

Review of existing mathematical literature surrounding statistical power and effect sizes regarding sample sizes of experiments. Review of optimisation methods and optimality conditions for feasible solutions.

RESULTS

A tool was built using Visual Basics for Applications in Excel that allows an experiment planner to enter the experiment parameters such as budget, time available and relevant costs. The tool uses Cohens d as an effect size, and a relevant experiment power calculation, along with optimising the feasible solutions using Generalised Reduced Gradient Non-Linear optimisation to find feasible solutions and determining the most optimal solutions using a Pareto Frontier in respect to maximising power and minimising budget.

CONCLUSIONS

The tool can be used throughout the planning process for an experiment, allowing for iterative refinement of the costs, duration and number of participants required for the experiment based on a satisfactory confidence level with statistical rigour.

OPERATIONAL RELEVANCE

There is a need for warfighting experiments to be cost effective but also of sufficient statistical significance to be worthwhile performing. The tool outputs a range of optimal scenarios, in respect of both statistical power and total cost, allowing the experiment planner to decide the best plan of action regarding unquantifiable constraints.

AUTHORS

Edward Knight (1)

Christopher Rolfs (2)

(1) DSTL (Ashford, United Kingdom); (2) Cervus Defence and Security (Westbury, United Kingdom)

THE BRAZILIAN ARMY PULL-UP TEST DESCRIBED BY PRINCIPAL COMPONENT ANALYSIS

PURPOSE

To compare the force curves patterns during the pull-up exercise using the principal components analysis.

METHODS

Forty-one male soldiers (26.0 ± 1.78 years; 76.2 ± 8.13 kg; 177 ± 7 cm) participated in this study. The experimental protocol was performed in two stages (stage 1 anthropometry and stage 2 pull-up performance), where a maximum repetition (RMax) test was performed as predicted by the Brazilian Army Physical Fitness Test. For the interpretation of the curve data, the signal was separated in five moments, with R1 being the second repetition, the percentages of 25% RMax (R25), 50% RMax (R50), 75% RMax (R75) and next-to-last repetition (R100). An ANOVA was performed for repeated measures for each phase of the movement and force values at each angle; no normality test was performed for the data according to the assumption of the central limit theorem.

RESULTS

More than 90% of the variance of the signals were contained in the first three main components (PC), around 63% CP1, 20% CP2 and 10% CP3. Principal Component Analysis (PCA) of the signals showed a standard curve for the tension force measured by the charge cell to the half of the Nr RMáx of pull-up and that a pattern representing all of the R100 signals was not found. The force values found in the studied angles presented differences between almost all the repetitions and between the Cct and Ecc phases, except for the angle 120 in the ECC phase. It was not possible to identify an association between the difference in performance and PCA scores in the forces measured at the angles studied.

CONCLUSION

These observations demonstrate that there is a standard curve for the traction force and that this pattern is maintained up to half the number of maximal repetitions. Similar behavior was obtained during the angle-force relationship and repetitions, mainly in the concentric phase. It was not possible to identify an association between performance and principal component analysis scores.

OPERATIONAL RELEVANCE

As discussed in this report, is plausible to use the principal components analysis (PCA) to identify and create a pull-up repetition pattern, using only the traction force on the bar, removing the error of interpretation of the referee. In this context, it is recommended that the pull-up training be performed with a focus on the initial angles of the concentric and final phases of the eccentric, where the highest values of the forces applied during the movement were measured.

AUTHORS

Joao Guilherme Nascimento (1)
Carlos Gomes (2)
Runer Marson (1)

(1) Brazilian Army Research Institute of Physical Fitness (Rio de Janeiro, Brazil); (2) Federal University of Rio de Janeiro (Rio de Janeiro, Brazil)

THE RELATIONSHIP OF PEAK MUSCLE POWER AND MUSCULAR MASS IN BRAZILIANS JUNGLE WARRIOR

PURPOSE

The vertical jump test is widely used to assess lower body power in sport and correlates well to strength, speed performance, and military tasks. The purpose of this study was to determine the relationship between peak power and the anthropometric body composition in students of Brazilian Army Jungle Warfare Instruction Center.

METHODS

Ninety-eight male soldiers in the BRA Army were volunteers of investigation. The subjects were characterized by age (27.2±3.9 years), total body mass (75.8±7.8 kg), height (177.9±6.5 cm), and fat mass (14.0±3.5%). The total body mass, fat mass, and lower limbs fat-free mass (LLFFM) were determined by bioelectrical impedance analysis (InBody 270, Biospace Ltd, Seoul, South Korea). The lower limbs peak muscle power (LLPP) was calculated using the Sayers equation. For the utilization of this equation, the subjects performed the countermovement jump (CMJ) on electronic contact mat (Axon Jump 4.01). The Shapiro-Wilk test was used for assessing normality. These parameters were analyzed using descriptive statistics and Pearsons correlation coefficients (r). According to the non-normality related to data of age and percentage of fat, these were used as a control in the partial Pearsons correlation coefficients (r). All statistical analyses were performed using IBM SPSS 24. This study was approved by the Research and Ethics Committee (CAEE: 55948016.1.0000.5289).

RESULTS

Specific outcomes demonstrate that correlating LLFFM (20.00±2.2 kg) with LLPP (3463.7±426.1 Watts) the Pearsons correlation coefficients was 0.78. Using the partial Pearsons correlation coefficients, controlling by age and fat mass, the results showed similar coefficients r =0.75 and r =0.78, respectively.

CONCLUSION

These observations demonstrate the importance to evaluate the low limbs peak muscle power and its association with anthropometric body composition for the performance of functions inherent to military tasks, as well as the high age-independent correlation.

OPERATIONAL RELEVANCE

As discussed in this report, the lower limbs fat-free mass was an important predictor of vertical jump performance. Therefore, the likelihood of add the countermovement jump test may contribute to the improvement of the selection military process with the appropriate physical profile for the specific physical requirements, age-neutral, of the Brazilian Army Jungle Warfare Instruction Center, considering that operational military tasks require a combination of strength, power, and aerobic capacity.

AUTHORS

Adriano Pereira (1)
Marcus dos Santos (2)
Brayner Verde (2)
Marcos Fortes (1)
Runer Marson (1)

(1) Brazilian Army Research Institute of Physical Fitness (Brazil); (2) Brazilian Army Jungle Warfare Instruction Center (Manaus, Brazil)

EFFECTS OF HYDRATION STATUS IN HOT ENVIRONMENT ON COGNITION, REACTION TIME, ANAEROBIC POWER AND SPEED IN MALE TEAM SPORT ATHLETES

PURPOSE

To determine the effects of hydration status and high-intensity physical activity in the heat on physical and cognitive performance parameters prior to and 24 hours following exercise.

METHODS

Thirteen male athletes completed maximal vertical jump (in), repeated sprints (complete rotations performed on non-motorized treadmill), reaction time (s) (Quickboard LLC; Memphis, TN), and cognition tests (Trailmaking; versions A and B [TrailA, TrailB]) (mean ± SD; body mass, 70.2±9.0kg; height, 174±9cm; VO2max, 53.5±7.1 ml/kg/min). These tests were completed at 3 time-points: 1) baseline (BASE) in thermoneutral environment (euhydrated state [USG <1.020]); 2) prior to exercise in hot environment (40 deg C ambient temperature, 35% relative humidity) while euhydrated (Pre-euh) and dehydrated state (22 hours fluid restriction [Pre-deh]); and 3) 24 hours following exercise in thermoneutral environment for the respective hydratation states (Post-euh, Post-deh). Exercise consisted of intermittent treadmill protocol of various speeds individualized by participants fitness levels, ranging from 0-25 kph for 75 minutes. Post measures were collected the day following testing in euhydrated state and thermoneutral environment. Repeated measures ANOVA (2x5) was used to identify time point significant differences ($p<0.05$) with Bonferonni post-hoc analysis (alpha set at 0.05).

RESULTS

An improvement was found for TrailA, BASE to Post-euh ($p=0.014$; MD± SE, 4.3 ± 1.0); TrailB, BASE to Post-euh ($p=0.031$; 18.6 ± 4.0) and Pre-euh to Post-euh ($p=0.036$; 6.6 ± 1.4); reaction time, BASE to Pre-euh ($p=0.05$;-11.1 ± 2.7). A decline was found for sprints, BASE to Pre-euh ($p=0.022$;-5.7 ± 1.2), and BASE to Pre-deh ($p=0.032$;-9.0 ± 2.0). No differences were found with vertical jump at any timepoint.

CONCLUSION

Our findings indicate that improvements occurred 24 hours after exercising in the heat for simple and complex cognitive tasks when in euhydrated state, whereas these improvements were not noted in dehydrated state. In addition, improvements were found in reaction time in euhydrated state only while in the heat. Finally, sprinting was negatively affected during the trial for both euhydrated and dehydrated groups, although the difference was greater in dehydrated state. Of note, vertical jump was not affected by hydration status or hot environment.

OPERATIONAL RELEVANCE

Being hydrated while operating in a hot environment can positively affect simple and complex cognitive tasks as well as reaction time. The ability to sprint is dampened in the heat regardless of hydration status, although it is negatively affected greater while dehydrated.

AUTHORS

Cody Butler (1)
Courteney Benjamin (1)
Yasuki Sekiguchi (1)
Margaret Morrissey (1)
Erica Filep (1)
Rebecca Stearns (1)
Douglas Casa (1)

(1) University of Connecticut (United States)

WHAT COOLING TEMPERATURE AND WHICH BODY PART ARE THE MOST EFFECTIVE FOR ALLEVIATING HEAT STRAIN WHILE WALKING IN WARM AND HUMID ENVIRONMENTS?

Wearable cooling technologies for military uniforms have been suggested, but a whole body cooling system is neither feasible nor practical for soldiers who wear heavy military gear. Determining the most effective body region and cooling temperature for smart military uniforms may be an alternative. The purpose of the present study was to explore the combination of the most effective body region and cooling temperature in a warm and humid environment. Four body regional liquid perfused garments were developed: a hood (90 cm in tubing length and 517 ml·min-1 in water flow rate), a vest (230 cm, 363 ml·min-1), gloves with sleeves (80 cm, 1,323 ml·min-1) and knee socks (150 cm, 1,374 ml·min-1). Water temperatures were set at 10, 15, 20, and 25oC. A male subject participated in a total of 16 trials (4 types of garments × 4 water temperatures). Each trial was composed of a 10-min rest followed by a 30-min walk (5, 6 and 7 km·hr-1 for 10 min each) and a 20-min recovery at an air temperature of 33oC with 70% relative humidity. The increase in rectal temperature (Tre) did not follow any linear tendency for any of the four cooling temperatures, while the cooling effects per tubing length was greater for the gloves and socks than for the vest and hood (Tre were 0.55, 0.45, 0.48, and 0.51oC for the hood, vest, gloves and socks). The four garment conditions showed the lowest mean skin temperature (Tsk) at 10oC cooling than the other three cooling temperatures and mean Tsk was the lowest for the vest with 10oC among the 16 conditions. Heart rate (HR) showed the lowest value for the vest condition (124 bpm averaged for the 4 cooling temperatures) and 132, 133 and 131 bpm for the hood, gloves, and socks condition, respectively. Total sweat rate was the smallest for the glove with 10oC (309 g·hr-1) among the 16 conditions. There was not any linear tendency in metabolic rate according to the four cooling temperatures, but the metabolic rate was greater for the vest (519 kcal·hr-1 at the end of exercise) and hood (533 kcal·hr-1) than for the gloves (490 kcal·hr-1) and socks condition (512 kcal·hr-1), which was pertinent for pinching around the head or increasing pressure on the treadmill. We concluded that the vest with 10oC cooling was the most effective and the gloves with 10oC were the most efficient for alleviating heat strain.

AUTHORS

Jae-Yeon Jung (1)
Juho Kang (1)
Yelin Ko (1)
Seon-Hong Seol (1)
Joo-Young Lee (1)

(1) Seoul National University (South Korea)

USE OF A PLATEAUING CORE TEMPERATURE AS A SECONDARY PASSING CRITERIA FOR A HEAT TOLERANCE TEST FOR U.S. NAVY AND MARINE CORPS WARFIGHTERS

PURPOSE

The Naval Health Research Center (NHRC) uses a heat tolerance test (HTT) more strenuous than other agencies (5.3 km/h; 4.0% grade vs. 5.0 km/h; 2.0% grade), such as the Israeli Defense Force, because U.S. Navy and Marine Corps Special Operations warfighters operate at high metabolic workloads. The current HTT core temperature (TC) pass criterion is 38.6°C. Since a TC increase of <0.45°C during the final 60 min indicates a plateau in TC (TCP), NHRC has explored the feasibility of an alternative criterion of a final TC between 38.6°C and 38.8°C and a TCP during the final 60 min, indicating stable thermoregulation. The purpose of this work was to evaluate TCP during minutes 60120 (TCP of a heat trial along with an additional 30 min [60150 min]).

METHODS

Sixty-seven warfighters (age: 24 ± 4 yr, ht: 178.5 ± 7.2 cm, wt: 84.2 ± 9.0 kg) completed 150 min of continuous walking (5.3 km/h; 4.0% grade) in 40°C and 40% relative humidity. Heat trials with a TC <38.6°C within 120 min were considered heat tolerant (HT). TCP was evaluated for trials where TC = 38.6°C to 38.8°C between 60 and 120 minutes (TCP120). Lastly, TCP was also evaluated during an additional 30 min of testing (60150 min, TCP150). Comparisons between TCP120 and TCP150 and HT and heat intolerance were analyzed using independent samples t tests ($p < 0.05$).

RESULTS

Sixty-one warfighters had a final TC 38.6°C with no difference between TCP120 and TCP150 (0.13 ± 0.05 vs. 0.19 ± 0.07°C; $p = 0.15$). Similarly, five warfighters had a final TC 38.8°C with no difference between TCP120 and TCP150 (0.31 ± 0.13 vs. 0.46 ± 0.19°C; $p = 0.17$). By demonstrating a TCP120, bolstered by a TCP150 during the additional 30 min of the heat trial, 66 of 67 warfighters could be classified as HT.

CONCLUSIONS

These findings suggest that this innovative TC pass/fail criterion may be helpful in evaluating HT in Special Operations warfighters. A case could be made that demonstrating a 60-min TCP, even within a TC range of 38.6°C to 38.8°C, provides strong evidence of a stable thermoregulatory capacity. Further work on the utility of TCP as a secondary HTT pass/fail criterion is warranted.

OPERATIONAL RELEVANCE

Warfighters who exceed traditional HTT pass/fail criteria may still be retained if they are able to demonstrate HT through TCP. These findings may improve military force operational readiness through increased warfighter retention.

AUTHORS

Andrew Ordille (1)
Douglas Jones (1)
Katherine Wilson (1)
Jay Heaney (1)

(1) Naval Health Research Center (San Diego, United States)

GENETIC POLYMORPHISMS INFLUENCE ON SUSTAINED ATTENTION AND SLEEPINESS BEFORE AND DURING TOTAL SLEEP DEPRIVATION IN HEALTHY SUBJECTS

INTRODUCTION

Sustained vigilant attention impairment due to sleep deprivation is objectively evaluated with the psychomotor vigilance task (PVT). However, many studies have shown interindividual differences in cognitive responses to sleep deprivation thus highlighting that some individuals are more vulnerable to the effects of sleep loss. This is partially explained by the influence of genetic polymorphisms. After a review of literature, we identified 14 common single nucleotide polymorphisms (SNPs) associated with vulnerability to sleep loss in healthy subjects. The aim of this work was to evaluate and compare influence of 14 SNPs on the degradation of performance on PVT and sleepiness in healthy sleep deprived subjects. The challenge is to determine the most pertinent SNP to understand and prevent sleep loss high vulnerability in soldiers and the general population.

METHODS

A total of 45 healthy subjects (aged 38.2 ± 2.1) performed a 10-min PVT and reported subjective sleepiness on Karolinska sleepiness scale (KSS) every six hours during a total deprivation (TSD) (38 hours of continuous awakening) sleep protocol. Genetic polymorphisms (14 SNPs) were determined from a salivary sample. Effect of genetic polymorphisms on sustained attention and sleepiness has been evaluated using a 2-way repeated measures ANOVA (polymorphism x time since awakening) and effect size.

RESULTS

Our results showed that several SNPs are highly interconnected. Many of them are associated with sustained attention and sleepiness before (baseline) and during total sleep deprivation, particularly polymorphisms for TNF-, the pro-inflammatory cytokine, and ADORA2A, the adenosine A2A receptor gene. Several SNPs for ADORA2A, inflammatory cytokines (TNF-, IL-1, IL-6), the circadian clock gene PER3, and COMT largely influenced the PVT relative speed and lapses during TSD. Genetic mutations on TNF-(rs1800629), ADORA2A (rs5751876), COMT (rs4680), and ADA (Rs73598374) are associated (significant effect sizes) with subjective sleepiness.

CONCLUSION

Our findings provided evidence that it is not only one gene that influences the sensitivity to sleep deprivation but an association of several of them. Analysis of ADORA2A (5751876), TNF-, (rs1800629), COMT (rs4680), PER3 (rs228697), and ADA (rs73598374) polymorphisms seems pertinent to determine individual vulnerability profile on sustained attention and sleepiness during sleep loss in the soldiers particularly, and to individualize sleep hygiene advices and countermeasures.

AUTHORS

Mégane Erblang (1)
Catherine Drogou (2)
Danielle Gomez-Merino (2)
Arnaud Rabat (2)
Mathias Guillard (2)
Fabien Sauvet (2)
Claire Thomas (3)
Mounir Chennaoui (2)

(1) French Armed Biomedical Research Institute (France); (2) French armed biomedical research institute – EA7330 VIFASOM (Brétigny sur orge, France); (3) UMR LBEPS, Paris Saclay – Evry University (Evry, France)

SPECIAL FORCES OPERATORS' SLEEP AND FATIGUE MANAGEMENT: HOW ONE SIZE DOES NOT FIT ALL

Currently in life science, especially in extreme environments or niche populations, where a cohort studies approach is not feasible due to a lack of subjects, there is a large growing interest to treat interindividual differences as a signal instead of noise or unexplained errors (e.g., Cain, 2007; Grassmann, 2017; Mairesse et al., 2018; Van Puyvelde et al., 2018) to better understand underlying mechanisms. The current project was a plea to respond to the wake-up call of Petit et al. (2019) and to put a window on idiosyncratic sleep traits that take into account individual chronotypes as a starting base for further examination into well-tailored individual countermeasures that count for both quantity and quality aspects of sleep.

This approach is especially relevant when dealing with operational sleep and fatigue management in special forces operators. From a population sample point of view, operators cannot readily be assimilated to a general population, both because of selection and training. From an operational relevance point of view, besides scientific considerations, the main validity criterion is whether a given countermeasure is effective and well tolerated for a given operator.

In this contribution, we will review the current evidence base for individualized sleep and fatigue management regimes, both published and from our most recent experiments in extreme environments. We will illustrate how we apply these most recent results in interindividual differences related to sleep and chronobiology in an evidence based approach, yet tailored to the individual. Individual variabilities taken into account include chronotype-according to the most recent classification from Putilov et al., 2019-, sleep duration, caffeine metabolism, modafinil tolerance and exogenous melatonin response.

AUTHORS

Nathalie Pattyn (1)
Emilie Dessy (1)
Martine Van Puyvelde (1)
Aisha Cortoos (1)
Xavier Neyt (1)
Olivier Mairesse (1)

(1) Royal Military Academy (Belgium)

INDIVIDUALIZED INTERVENTIONS TO OPTIMIZE AND ENHANCE WARFIGHTER ALERTNESS

PURPOSE

Optimizing caffeine consumption can substantially improve its effectiveness in mitigating alertness impairment during sleep deprivation. However, there are no tools that individuals can use to determine how much caffeine they should consume and when for safely maximizing alertness, depending on their sleep/work schedules and susceptibility to sleep deprivation.

METHODS

To address the need for such a tool, we combined our previously developed computational tools: 1) a validated unified model of performance (UMP), which predicts psychomotor vigilance task (PVT) performance across a wide range of sleep/wake and caffeine schedules, 2) an artificial intelligence algorithm that uses PVT measurements to customize the UMP parameters to an individuals response to sleep deprivation, and 3) an optimization algorithm to obtain caffeine recommendations that enhance alertness at the desired time, for any sleep/work schedule. We used the resulting tool to calculate personalized caffeine recommendations for reducing the alertness impairment of 21 subjects, during an 8-h period after they had been awake for 43 h, to an alertness level no greater than that caused by a blood alcohol concentration (BAC) of 0.08%. To place the advantages of personalizing the recommendations in perspective, we compared them to recommendations obtained using the UMP for group-average predictions.

RESULTS

Based on the individualized model predictions, during the 8-h peak-alertness period, 14 subjects had an alertness impairment [mean 368 ms, standard deviation (SD) 65 ms] greater than that caused by a BAC of 0.08%. We obtained a wide range of personalized recommendations: whereas the seven subjects most vulnerable to sleep deprivation required between 500 and 1000 mg of caffeine, the seven most resilient subjects required none. For the former subjects, following the group-average recommendation instead would have worsened their alertness impairment (mean 46 ms, SD 39 ms) compared to the personalized recommendations. In contrast, for the seven most resilient subjects, following the same recommendation would have led them to consume 300 mg of caffeine not needed to maintain their desired alertness levels.

CONCLUSIONS

We present the first caffeine optimization tool that, during any sleep-deprivation condition, provides personalized guidance for safe and effective caffeine dosing to maximize alertness at the most needed times.

OPERATIONAL RELEVANCE

Impaired alertness increases Warfighter accident risk. Our computational tool will help to mitigate this risk by providing optimal caffeine recommendations that take into account the individual Warfighters response to sleep deprivation.

AUTHORS

Francisco Vital-Lopez (1)
Jacques Reifman (2)
Sridhar Ramkrishnan (1)
Tracy Doty (3)
Thomas Balkin (3)
Kamal Kumar (1)
Jaques Reifman (2)

(1) Department of Defense Biotechnology High Performance Computing Software Applications Institute, Telemedicine and Advanced Technology Research Center, United States Army Medical Research and Development Command; The Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc. (Fort Detrick, United States); (2) Department of Defense Biotechnology High Performance Computing Software Applications Institute, Telemedicine and Advanced Technology Research Center, United States Army Medical Research and Development Command (Fort Detrick, United States); (3) Behavioral Biology Branch, Walter Reed Army Institute of Research (Silver Spring, United States)

THE IMPACT OF GENETIC VARIATIONS IN ADORA2A IN THE ASSOCIATION BETWEEN CAFFEINE CONSUMPTION AND SLEEP

ADORA2A was shown to be responsible for the wakefulness-promoting effect of caffeine and 1083T>C genotype was found to contribute to individual sensitivity to caffeine effects on sleep. We investigated the association between six single nucleotide polymorphisms (SNP) from ADORA2A and self-reported sleep characteristics and caffeine consumption in 1,023 active workers of European ancestry aged 18-60 years. Three groups of caffeine consumers were delineated, low, moderate and high (0-50, 51-300, and >300 mg/day respectively. We found that at caffeine levels higher than 300 mg/day, total sleep time decreased whatever ADORA2A polymorphism (F=13.9, p<0.1%). However, in low caffeine consumers (equivalent to less than one expresso per day), lower TST is observed in the T allele compared to homozygote C carriers of rs5751876, rs2298383 and rs3761422. Conversely, higher TST is observed in G allele compared to the homozygote C carriers of rs4822492 (p<0.05), the four SNPs are being in strong linkage. In addition, the rs5751876 and rs2298383 mutations are associated with a higher risk of sleep disorders (after adjustment for age, tobacco and sexe) in low, moderate and all consumers (p<0.05 for all). Our results identified genetic polymorphisms (including rs5751876) for the G protein-coupled A2A receptor associated with sleep duration when individuals did not consumed caffeine or less than 50mg per day. In addition, the risk of sleep disorders is related to rs5751876 and rs2298383. This open perspective on diagnosis and pharmacology of sleep disorders.

AUTHORS

Fabien Sauvet (1)
Mégane Erblang (2)
Cartherine Drogou (2)
Danielle Gomez-Merino (2)
Arnaud Metlaine (3)
Anne Bolland (4)
Jean François Deleuze (4)
Damien Leger (5)
Mounir Chennaoui (2)

(1) IRBA (French Armed forces Biomedical Research Institute) (Brétigny sur Orge, France); (2) IRBA; EA 7330 VIFASOM, Université Paris Descartes (Brétigny sur Orge, France); (3) Sleep center, Hotel Dieu, EA 7330 VIFASOM, Université Paris Descartes (Paris, France); (4) Centre National de Recherche en Génomique Humaine (CNRGH), Institut de Biologie François Jacob, Évry, France (Evry, France); (5) Sleep center, Hotel Dieu APHP,, EA 7330 VIFASOM, Université Paris Descartes (Paris, France)

TS8.
ENVIRONMENTAL EXTREMES: PUSHING THE LIMITS OF HUMAN TOLERANCE

#ABS408

FEBRUARY 13, 2020

ALTITUDE: PERFORMING ON THE EDGE IN SICKNESS AND IN HEALTH

PURPOSE

Physical performance tasks requiring sustained effort take longer to complete at altitude (ALT) compared to sea level (SL). The purpose of this study was to develop a quantitative model of time-trial (TT) performance during acclimatization to various altitudes using a relational Mountain Medicine Data Repository containing individual demographic descriptors and repeated-measures of TT performance from 12 altitude studies.

METHODS

TT performance was measured on 385 healthy lowlanders (322 men and 63 women; mean±SD; 23±4 yr, 76±12 kg, 49±7 ml/kg/min) that completed a given amount of work as fast as possible at both SL and during various time points at ALT on either a treadmill (loaded and non-loaded) or cycle ergometer. Volunteers spent between 0.2 to 8.2 days at various altitudes ranging from 2.0 to 4.3 km. AMS incidence was measured using the Environmental Symptoms Questionnaire AMS-Cerebral (AMS-C) factor score. AMS-C 0.7 was considered sick. The percent increase in TT duration from SL to ALT was modelled using a general linear mixed model that accounted for correlations between repeated measurements. Predictors included in the model were altitude (ALT), elapsed time at altitude (ET), AMS incidence (AMSi), sex, body mass index (BMI), SL VO2max, race, smoking status, and interactions.

RESULTS

The% increase in TT performance in individuals ranged from-9.2% to 356%. Individual predictors of this decrement included ALT (P=0.0001), ET (P=0.0001), ALT x ET (P=0.0001) and AMSi (P=0.0001). The following model best predicted the% increase in TT performance:

TT duration (%) = 0.0 + 8.89 (ALT)-40.43 (ET) + 11.89 (ET) (ALT) +16.17 (AMSi)

When evaluated after 1 day of altitude exposure, the TT duration (%) increased by 18.7±2.6% for every 1 km increase in ALT regardless of sickness. TT duration (%) also increased 16.2±2.5% in sick compared to non-sick individuals regardless of ALT. The model explained 40% of the variation of increase in TT duration at ALT.

CONCLUSIONS

This model predicts that TT performance is affected not only by ALT and elapsed time at ALT but that individuals sick with AMS demonstrate a 12% greater increase in physical task duration at ALT than those not sick with AMS.

OPERATIONAL RELEVANCE

Preventing AMS following rapid ascent to ALT is critical for preventing decrements in physical performance.

AUTHORS

Beth Beidleman (1)

Upendra Bhattarai (1)

(1) Biophysics and Biomedical Modeling Division, US Army Research Institute of Environmental Medicine (Natick, United States)

Disclaimer: Authors views; not official U. S. Army or DoD policy.

OUTPERFORMING THE HEAT IN THE JUNGLE: DEVELOPMENT OF AN INDIVIDUAL AND GROUP HEAT ACCLIMATIZATION TRAINING TOOL

PURPOSE

At the 4th International Congress on Soldiers Physical Performance in 2017 a novel, individual heat acclimatisation dosimeter concept was presented. This concept was a field-based, individual approach to heat acclimatisation where real-time feedback to the individual directed exercise intensity. This training tool followed the constant strain, controlled hyperthermia model of acclimatisation to provide the most appropriate forcing function for core temperature. Since this initial oral presentation, the concept has been further developed at an individual and a group level and incorporated into military heat acclimation in the UK prior to deployment and heat acclimatisation when deployed.

METHODS

During the individual heat acclimatisation training tool (iHATT) development, volunteers wore an Android smart watch that was connected to a Polar heart rate monitor and heart rate was used to inform the US Army estimated core temperature (ECTemp) algorithm which guided volunteers to run, walk or jog depending on their individual estimated core temperature response. Pacing data from a global positioning system (GPS) from the iHATT, were used to develop a group acclimatization training protocol for the fairly homogenous environment of Brunei that is Physical Training Instructor led. This protocol provides a progressive, constant strain model of acclimatization where speeds of 11, 9 and 5 km.h-1 were used for running, jogging and walking respectively. Over a duration of 8 days, total time, total work done and clothing (sports clothing to military fatigues) were increased to promote the constant strain approach. To ensure safety, the U.S. Army Open Body Area Network (OBAN) monitoring system was used to monitor all students undertaking the group acclimatization task. This group acclimatization model has been completed by over 200 students.

RESULTS

This group acclimatization protocol has been used across different training courses throughout 2018/19. When students have moved into the jungle phase of their training, reports indicate better performance and there has a reduced incidence of EHI. The introduction of this new approach to heat acclimatization in the UK and when deployed has resulted in an anecdotal decrease in EHI heat exhaustion cases and a decrease in #ABSolute heat illness.

CONCLUSIONS

This simple, yet safe approach appears promising as a tool to improve the acclimatization response of military personnel preparing to exercise in hot environments and to reduce the incidence of heat illness.

OPERATIONAL RELEVANCE

An efficient method of undertaking heat acclimatization will reduce risk of illness, increase training days and improve training experience.

AUTHORS

Mark Buller (1)

Simon Delves (2)

(1) USARIEM (United States); (2) Institute of Naval Medicine (Gosport, United Kingdom)

SKELETAL RESPONSES TO EXTENDED DURATION SPACE FLIGHT

PURPOSE

Astronauts experience a rapid and substantial loss in bone mass following prolonged spaceflight (>30 d) caused by near weightlessness of microgravity. The risk for fracture on return to earth, and premature osteoporosis in later life, is a concern for astronaut safety. This review will provide an overview of skeletal responses to spaceflight and simulated microgravity, explore the efficacy of exercise countermeasures for bone loss, address the risks for fracture risk with future planetary exploration, and highlight our current knowledge gaps and limitations of space studies.

METHODS

Published literature on space flight and bed rest analog studies was retrieved from PubMed and Google Scholar databases, and 'grey' literature was obtained from NASA and ESA sources.

RESULTS

Astronauts lose ~ 0.5% to 1.5% of areal bone mineral density (aBMD) from the hip and spine per month with 4 to 6-months space sojourns, but the inter-individual variability is large. The loss in aBMD is associated with a ~50% increase in bone resorption and increased urinary calcium excretion on landing; estimated daily bone calcium losses are ~250 mg. HR-pQCT data confirm decreased cortical (-1.5%) and trabecular (-2%) volumetric BMD (vBMD), decreased cortical thickness (-4%), and increased cortical porosity (15%) at the ultradistal tibia on return to earth. Cortical vBMD and thickness recover 12 months post flight, but deficits in cortical porosity and trabecular bone persist and impair estimated mechanical strength. Bone indices at the non-weight bearing radius are preserved following microgravity exposure, but progressively decline post flight. Planned extended space missions of >12 months are estimated to result in ~50% decrements in bone mass.

CONCLUSIONS

Prolonged space missions result in site-and bone-compartment specific losses that are attenuated, but not prevented by in-flight load bearing exercise; the forces required to maintain skeletal integrity remain lower than those experienced at 1g. The rate of bone loss in space exceeds that typically observed in older individuals with systemic bone disease, supporting the need for pharmacological intervention. Most studies report DXA-derived BMD, routinely used to monitor astronaut's bone health, but HR-pQCT and novel techniques for measuring in vivo bone material properties will provide a better understanding for fracture risk with current and future space missions.

OPERATIONAL RELEVANCE

Fracture risk occurs on a continuum from high load-low trauma, to no load-high trauma. The extreme, prolonged exposure of astronauts to microgravity will help us understand the pathogenesis of skeletal injuries that jeopardise operational readiness of military personnel.

AUTHORS

Julie Greeves (1)

(1) UK Army (Andover, United Kingdom)

TS8.
ENVIRONMENTAL EXTREMES: PUSHING THE LIMITS OF HUMAN TOLERANCE

#ABS019

FEBRUARY 13, 2020

THERMOREGULATION DURING A MOCK ARCTIC TRAINING SCENARIO WEARING A CLOSED CELL WETSUIT

PURPOSE

To measure changes in skin (Tsk) and core (Tc) temperatures, as well as cognitive function, during a mock Arctic training scenario using a novel closed cell wetsuit.

METHODS

Fourteen (n=14) U.S. Navy SEALs who were tasked with cold-water training participated in this study. To mimic cold weather operations, a training pool and a refrigerated truck were chilled to approximately 2C and 6.7 to 0.5C, respectively. Operators began with a 2-hour shallow dive (infiltration) in the cold pool, followed by 4 hours in the freezer truck to simulate land operations in a cold environment, and concluded with a 3-hour dive (mock exfiltration) submerged underwater in the cold pool. Operators were provided a Tc pill and Tsk patches were affixed to the right side of the participant at four locations: arm (lateral deltoid), chest, thigh, and calf. Tc and Tsk readings were collected throughout the 9-hour training evolution. Cognitive function was assessed at three time points: baseline, 4 hours, and 9 hours. Mean skin temperature (MnTsk) was calculated using the Ramanathan (1964) equation: Tsk = 0.3(Tchest+Tarm) + 0.2(Tthigh+Tcalf). Operators wore a novel closed cell wetsuit to test thermal effectiveness.

RESULTS

There were no differences between pre-and post-evolution Tc (pre: 37.3±0.6 vs. post: 36.8±0.3°C; $P > 0.05$); however, two individuals experienced significant decreases (34.2 and 32.7) in Tc at 3.5 and 4 hours into the study (and one again at 6 hours). MnTsk significantly decreased for all participants over the 9-hour training evolution, (pre: 33.9±0.9 vs. post: 28.5±1.6°C; $P < 0.01$). All other skin temperature locations (face, arm, chest, thigh, calf, hand, foot) also experienced significant temperature loss ($P < 0.05$) over the course of the training evolution, regardless of position. All participants were able to maintain cognitive function with no statistical differences between pre-and post-evolution time points ($P > 0.05$). Additionally, both participants who experienced significant decreases in Tc displayed no cognitive deficits during their bout of mild hypothermia ($P > 0.05$).

CONCLUSIONS

These findings demonstrate no change in cognitive performance or thermoregulation during a long-duration cold training using a novel closed cell wetsuit.

OPERATIONAL RELEVANCE

These data demonstrate that missions and operations in Arctic-like conditions are sustainable without compromising cognitive performance or operational readiness. More work is needed to determine the effects on tactical and fine motor performance.

AUTHORS

Karen Kelly (1)
Jake Bernards (2)
Andrew Jensen (2)
Laura Arrington (2)

(1) Naval Health Research Center (United States); (2) Naval Health Research Center-Leidos (San Diego, United States)

REFERENCE

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THERMAL, AUTONOMIC AND PERCEPTUAL RESPONSES DURING REPEATED COLD-WATER IMMERSIONS IN SUSTAINED HYPOXIA

PURPOSE

The study examined whether, and to what extent, sustained hypoxia would modulate thermoregulatory effector responses during repeated innocuous cold stimuli encountered in a single day.

METHODS

Eleven male lowlanders completed, in a single-blinded manner, two 10-h experimental sessions, while breathing either a normoxic [fraction of O2 (FO2): 0.21, partial pressure of inspired O2 (PO2): ~21 kPa] or a hypoxic (FO2: 0.12, PO2: ~12 kPa; simulated altitude of ~4,300 m) gas. During each session, and at the same time of the day, subjects underwent sequentially three 120-min immersions in 20°C water (cold-water immersion; CWI), interspersed by 120-min rewarming periods. Thermal [rectal temperature (Trec), skin temperature (Tsk)], autonomic [oxygen uptake (VO2), mean arterial pressure (MAP), forearm cutaneous vascular conductance (CVC)] and perceptual [thermal sensation (TS) and comfort (TC)] responses were monitored throughout. Physiological responses were evaluated with a repeated measures ANOVA, followed by Tukey HSD test; whereas perceptual responses were analyzed with a Friedman, followed by a Wilcoxon test.

RESULTS

In normoxia, the drop in Trec was greater in the third (~1.2°C) than in the first and second (~0.9°C) CWIs (P 0.05). The first hypoxic CWI augmented the Trec fall (~1.2°C; P = 0.002), but Trec did not vary between the three hypoxic CWIs. VO2 was similar in the three normoxic CWIs. In hypoxia, by contrast, the cold-induced increase in VO2 was augmented by ~15% in the second (P = 0.45), and by ~25% in the third (P 0.01) CWI. Tsk and forearm CVC were similar in the six CWIs. Regardless of breathing condition, the cold-induced elevation in MAP was blunted in the second and third CWI (P 0.05). In both conditions, subjects felt colder and thermally more uncomfortable at the initial part of the second and third CWI ($P < 0.05$). Hypoxia aggravated the sensation of coldness ($P = 0.05$) and thermal discomfort ($P = 0.04$) at the end of the third CWI.

CONCLUSIONS

Present findings demonstrate that in normoxia, repeated cold provocations during a 10-h period, increases the susceptibility to develop hypothermia; an effect that appears prevented by hypoxia, via a gradual upregulation of the endogenous heat production. Whole-body thermal perception seems to remain intact in hypoxia.

OPERATIONAL RELEVANCE

Military personnel may be at high risk of developing accidental hypothermia, while operating in cold, mountainous regions. Yet information on the interactive effects of sustained hypoxia and prolonged cold stress on thermoregulatory function in non-acclimatized individuals has been lacking.

AUTHORS

Michail Keramidas (1)
Roger Kölegård (2)
Ola Eiken (2)

(1) Division of Environmental Physiology,KTH Royal Institute of Technology (Stockholm, Sweden); (2) Division of Environmental Physiology, KTH Royal Institute of Technology, (Stockholm, Sweden)

EXPEDITION ICE MAIDEN: ENDOCRINE, REPRODUCTIVE AND SKELETAL RESPONSES TO THE FIRST ALL-FEMALE UNASSISTED ANTARCTIC EXPEDITION

Arduous military training in energy deficit disturbs reproductive, adrenal, thyroid and somatotropic hormones, and uncouples bone turnover in men. There are no comparative studies in women, yet women are more prone to bone stress injuries than men, and possibly more susceptible to metabolic perturbations associated with energy deficit.

PURPOSE

To examine the effect of an unassisted Antarctic crossing on endocrine, reproductive and skeletal health in women.

METHODS

Six women (mean ± SD, age 32 ± 3 years, height 1.72 ± 0.07 m, body mass 72.1 ± 3.8 kg) each hauled an 80 kg sledge over 1700 km in 61 days coast-to-coast across the Antarctic. Basal circulating endocrine and bone turnover markers, and dynamic reproductive and adrenal function, were measured 39 days before, and 4 and 15 days after the expedition. Whole-body fat mass, lean mass and areal bone mineral density (aBMD), and tibial volumetric BMD (vBMD), geometry, microarchitecture and mechanical properties were assessed 39 days before and 15 days after the expedition. Data were analysed with one-way repeated measures ANOVAs and paired-samples t-tests.

RESULTS

Participants lost 13 ± 3% body mass ($P < 0.001$). Leptin decreased from pre-expedition to 4 days post-expedition (10.8 ± 4.8 vs 2.7 ± 1.6 ngml-1, $P = 0.005$), but no other significant changes in basal reproductive, adrenal, thyroid and metabolic markers were observed. Luteinizing hormone, follicle-stimulating hormone and cortisol reactivity were unchanged. There were reductions in trunk (2.6%), ribs (5.0%) and spine (3.4%) aBMD from pre-to post-expedition (all P 0.046); arms, legs, pelvis and total body aBMD were not different (all P 0.075). Tibial vBMD, geometry, microarchitecture and mechanical properties at the distal metaphysis (4% site) and diaphysis (30% site) were not different between pre-and post-expedition (all P 0.082). Bone-specific alkaline phosphatase was higher 15 days post-than 4 days post-expedition (18.0 vs 16.3 gl-1, respectively, $P = 0.028$). Sclerostin, procollagen 1 N-terminal propeptide, C-telopeptide cross-links of type 1 collagen and adjusted calcium were unchanged (all P 0.154).

CONCLUSION:

We found no evidence of disturbed endocrine and reproductive function in the first women to complete an unassisted Antarctic traverse. The deleterious effect of the expedition on aBMD may be due to indirect and direct effects of prolonged energy deficit on bone turnover.

OPERATIONAL RELEVANCE

Mechanical loading appears protective of the appendicular skeleton during periods of unavoidable energy deficit, but further strategies to protect the axial skeleton are required.

AUTHORS

Thomas O'Leary (1)
Robert Gifford (2)
Rebecca Double (1)
Sophie Wardle (1)
Julie Greeves (1)

(1) British Army (Andover, United Kingdom); (2) University of Edinburgh (Edinburgh, United Kingdom)

EFFECT OF HEAT ACCLIMATION ON MUSCLE METABOLIC ADAPTATIONS INDUCED BY ENDURANCE TRAINING: AN ANIMAL MODEL

PURPOSE

Heat acclimatization (HA) leads to improve endurance skills in hot environment. More conversely, heat adaptation could also improve aerobic capacities in temperate environment. In particular, meanwhile cardiovascular responses, skeletal muscle oxidative features, per se, may change through alteration of mitochondrial function and dynamic induced by HA [1]. This study addresses the issue of the effects of HA combined to endurance training on metabolic adaptations in skeletal muscle and their consequences to endurance abilities.

METHODS

32 rats were divided in 4 groups: control (C), trained (T), heat-acclimatized (H) and trained and heat-acclimatizated (HT) for 6 weeks. Soleus muscle metabolism was studied by in situ measurement of mitochondrial respiration at 35°C, in presence of pyruvate (Pyr) or palmitoyl-coenzyme A (PCoA), in phosphorylating conditions (V max) or not (V 0). Two-way ANOVA were performed to assess the effect of HA and training. Interaction between both conditioning was assessed by Newman-Keuls test.

RESULTS

Aerobic performance (measured by maximal velocity) increased and retroperitoneal fat mass decreased with training, independently of heat exposure ($p<0.001$ and $p<0.001$ respectively). Citrate synthase and hydroxyl-acyl-dehydrogenase increased with endurance training ($p<0.001$ and $p<0.01$ respectively) without any effect of HA. Training induced the increase of V 0 and V max for PCoA ($p<0.001$ and $p<0.01$ respectively) without any effect of heat exposure. For pyruvate oxidation, the training-induced increase of V 0 ($p<0.01$) was limited when combined to heat acclimation (-23%, $p<0.01$). Training and heat acclimation independently increased V max for pyruvate (+ 60% $p<0.001$ and + 50% $p=0.01$ respectively) without additive effect of the combination. Heat acclimation doubled training effect on muscle glycogen storage ($p<0.001$).

CONCLUSION

Heat acclimatization could specifically impair training-induced increase of pyruvate oxidation endurance training but enhance glycolytic pathway. This metabolic phenotype was previously described after hypoxic exposure. This heat and training combined effect on glycogen storage and the preservation of training-induced increase of fatty acids oxidation despite heat exposure need to be further investigate.

OPERATIONAL RELEVANCE

If heat exposure during endurance training doesnt seem to improve mitochondrial oxidative capacities, benefits on heat adaptation and tolerance must be kept in mind. Furthermore, the increase in glycogen storage observed after combined exposition to heat and endurance training may provide upper ability to delay the onset of fatigue during high intensity exercise, typically, in final close-combat phase. Fatty acids/carbohydrates intake balance should fit to specific needs induced by climate.

AUTHORS

Pierre-Emmanuel Tardo-Dino (1)
Pierre-Emmanuel Tardo-Dino (1)
Cindy Taverny (1)
Julien Siracusa (1)
Stéphanie Bourdon (1)
Stéphane Baugé (1)
Nathalie Koulmann (1)
Alexandra Malgoyre (2)

(1) French Armed Forces Biomedical Research Institute (Brétigny sur Orge, France); (2) French Armed Forces Biomedical Research Institute (Brétigny sur Orge, France)

COLD-INDUCED THERMOGENESIS IN LEAN AND OBESE YOUNG MEN

PURPOSE

It has been appreciated for over two centuries that cold increases energy expenditure in endothermic animals. There are large capacities for cold-induced thermogenesis in some animals, but this component is believed to be small in adult humans. It is important to understand the mechanisms by which human thermogenesis is regulated, especially in people who work and live in cold temperature environments.

METHODS

In a controlled inpatient setting (13 days), we measured energy expenditure at multiple ambient temperatures between 16-31 under light clothing and fasted resting condition in a whole-room indirect calorimeter in each of the 12 lean and 9 obese young healthy study participants (25±6 years old). Skin and core body temperature, muscle shivering activity, heart rate/heart rate variability, and hormone variations were simultaneously measured as well as subjective scales of thermal comfort and hunger. We also quantified brown fat activity, volume, and distribution by FDG-PET/CT.

RESULTS

Lean and obese subjects showed a temperature range where resting energy expenditure was at a minimal and did not vary with ambient temperature, which is the basal metabolic rate (BMR). The temperature threshold when cold-induced thermogenesis starts (the lower critical temperature) was lower in the obese vs. lean men (21.1±1.7 vs. 22.9±1.2, p=0.03) but both groups reached similar lowest tolerable temperatures (20.3±1.6 vs. 21.2±1.5, p=0.2). The capacity of cold-induced thermogenesis was lower in the obese vs. lean men (125±146 kcal/day or 6±7% of the BMR vs. 300±218 kcal/day or 17±11%, p=0.01). The core and weighted-mean skin temperatures were highly comparable but regional skin temperature patterns showed subtle differences between two groups. Brown fat volume was lower in the obese vs. lean men (130±121 vs 334±162 ml, p=0.03), but did not correlate with the individual capacity of cold-induced thermogenesis.

CONCLUSIONS

A capacity of tolerable cold-induced thermogenesis of 17% above the BMR in lean young men is a substantial amount. The interesting finding of a lower capacity in obese young men (6%) at a similar tolerable temperature challenges the notions that higher fat insulation would permit additional cold tolerance and larger body mass will generate higher cold-induced thermogenesis.

OPERATIONAL RELEVANCE

Understanding thermal physiology of different body size and types will help evaluate energy demands, stress, and physical functions in solders training and operating in cold climates.

AUTHORS

Kong Chen (1)

Robert Brychta (1)

(1) National Institutes of Health (Bethesda, United States)

AN ARCTIC SOLDIERS PERSPECTIVE ON SUCCESS IN THE COLD

PURPOSE

Military operational performance in the austere and extremely cold Canadian Arctic is a highly specialized function that requires advance planning and considerable training. The Arctic is an unforgiving environment where seemingly small problems can rapidly evolve into disaster and mission failure. This presentation summarizes key training points used by the Canadian Voltigeurs in preparing soldiers for an arctic mission that differs from typical military field training.

METHODS

The lessons learned from two experienced female Arctic soldiers are summarized to assist the military community in understanding the steps to success in the extreme cold and to assist researchers in areas of continuing issues.

RESULTS

It is vital to master dressing for Arctic conditions; being too cold or too hot can lead to the same Results freezing, frostbite and hypothermia. Since the temperature is unforgiving, every section member must be well trained to understand and execute their assigned tasks, working well as a team, fast and logically to avoid being exposed to the cold for too long. Most of the movements are done with snowmobiles or planes; there must be a plan to survive in the cold if someone is injured, lost, or a storm arises. Leaders need to be experienced and effective decision makers in terms of mission, movement and camp, ensuring smooth operation of the team and minimizing time exposed to the cold. The Inuit rangers are an irreplaceable part of the team, with deep knowledge about weather, terrain, and survival (e.g., they can anticipate a blizzard and properly advise the chain of command on courses of action). A key to Arctic survival is to avoid separation of the team; and communication systems are vital to be able to summon help or resources without delay (e.g., injuries, fuel supplies, replacement essentials such as a stove, etc.).

CONCLUSIONS

There is a big difference between occasionally conducting training in the cold and actually having a trained and experienced force that knows how to perform in the Arctic environment with confidence. There is a need for rapid response Arctic-trained units that have prepared continuously for this mission and have refined their Arctic tactics, techniques and procedures (TTPs).

OPERATIONAL RELEVANCE

With global warming opening up strategic shipping lanes and exposing natural resources in the Arctic, there will be more national competition for these resources and an increasing need for Arctic specialized military units.

AUTHORS

Émilie Gauthier-Wong (1)

Caroline Roy (1)

(1) Canadian Armed Forces (Trois-Rivières, Canada)

OPERATING IN COLD CLIMATES: NOT ONE SIZE FITS ALL

Maintaining performance and operational capabilities in cold environments is an ongoing challenge for many military units around the world. Humans are particularly well-adapted for dissipating heat in warm, dry climates but are particularly bad at retaining heat in cold environments. In this context, much effort from an engineering standpoint has focused on developing protective clothing and shelters as well as other technologies to reduce excessive heat loss and ultimately, improve cold tolerance. While better equipment and adapted training have clearly improved access to more extreme cold climates for occupational and recreational activities, they have also greatly increased the risks for accidental cold-weather injuries and/or hypothermia. This review provides current knowledge on human cold research from mechanisms to performance and highlights the important interindividual differences for cold tolerance. In the last 20 y, metabolic, physiological, psychological and imaging methodologies have been combined to improve our understanding of the metabolic parthways involved in sustaining heat production in the cold. This research has clearly demonstrated that cold response in humans is characterized by a wide array of thermogenic processes, energy demands, shivering responses and thermal comfort even in women and men of similar morphology and body composition. These individual variations in thermogenic and thermal processes have important consequences on the capacity to work and perform in cold temperatures. To address this issue, some research has focused on establishing strategies to improve cold tolerance using cold acclimation and nutrition to increase heat production and thermal comfort as well as to reduce heat loss and shivering. For example, cold acclimation protocols have been shown to improve thermal comfort and reduces shivering intensity by as much as 40% within a week. Similarly, some nutritional supplements can stimulate heat production and reduce shivering in the cold. Clearly, the increase access to Arctic regions and the development of northern navigation channels is of great importance. However, it requires a better understanding of the factors that influence individual cold tolerance in order to optimize military operational capabilities aimed at maintaining national security and retaining northern sovereignty.

AUTHORS

François Haman (1)

François Haman (2)

(1) University of Ottawa (Ottawa, Canada); (2) University of Ottawa, Ottawa CANADA (Ottawa, Canada)

WET EQUIVALENT AIR TEMPERATURE: AN INDEX FOR WET CLOTHING DURATION LIMIT OF EXPOSURE IN COLD AND WET ENVIRONMENTS

PURPOSE

Here we propose a thermal model to predict the Wet Equivalent air Temperature (WET). WET is the effective air temperature for dry clothing which results in equal heat loss to exposure to the actual air temperature for wet clothing. Existing guideline IREQ-ISO-11079 provides insight on required insulation and safe exposure duration (DLE) based on the weather condition and activity level, but assume the clothing is dry. The WET is used in IREQ-ISO-11079 to estimate the wet DLE.

METHODS

WET is calculated by adapting the heat balance model described in Parsons (2006). Clothing wetness (wcl) is introduced analogous to skin wetness wsk, where dry wcl =0 and wet wcl=1. Based on an empirical study wet clothing insulation was estimated as 40% of the dry insulation value. Evaporation of wet clothing is formulated analogous to evaporation of sweat from the skin, using wcl instead of wsk. Wet clothing itself blocks evaporation from skin tissues, therefore we assumed that no evaporative heat transfer occurs from the skin through the clothing when the clothing is fully wet.

RESULTS

Two examples of simulation results are presented: 1) soldier on guard, Tair=18°C, windspeed=1ms-1, metabolic rate=110Wm-2, dry insulation=0.8clo. Dry DLE following IREQ ISO11079 is >8h. For wet clothing WET=7.6°C and consequently DLE decreases to 1h18m. 2) supine sniper waiting for target, Tair=20°C, windspeed=0.5ms-1, metabolic rate=60Wm-2, dry insulation=1.4clo. Dry duration limit of exposure following IREQ ISO11079 (DLE) is 2h30m. For wet clothing WET=11.6°C and consequently DLE decreases to 1h30m. For all situations mean radiant temperature was assumed equal to air temperature.

CONCLUSION

The Wet Equivalent temperature can be used to estimate the DLE in cold and wet environments. The dry and wet duration limits provide a bandwidth of safe operation time.

OPERATIONAL RELEVANCE

Military people can be exposed to cold and wet environments. Working in cold environments poses possible health and performance risks, which are exacerbated by wet clothing. Clothing can get wet because of various reasons, e.g. external factors such as heavy rainfall, walking or swimming through water, or internal factors such as sweating. Therefore, the actual safe exposure duration may be significantly shorter for wet clothing. With the WET index a safe duration limit can be estimated for cold and wet conditions.

AUTHORS

Boris Kingma (1)

Jan Ubbo van Baardewijk (1)

(1) The Netherlands Organisation for Applied Scientific Research, Unit Defense, Safety and Security, Soesterberg, The Netherlands (Netherlands)

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REVIEW OF CANADIAN ARMED FORCES PERSONAL PROTECTIVE EQUIPMENT DURING CANADIAN ARCTIC OPERATIONS

PURPOSE

Data collected on cold weather injuries during the past 4 years suggests deficiencies in personal protective kit worn during extreme cold in Arctic operations and/or training in how to properly use and manage protective kit. One question being investigated is the association between cold injuries and the use of specific clothing items, face protection, boots, and gloves and the sources of that equipment.

METHODS

Information about personal protective kit was collected surveys administered to military personnel on Operations NUNALIVUT 2018, EXERCISE NOREX 2018, EXERCISE GUERRIER-NORDIQUE and Operation NANOOK-NUNALIVUT 2019. Participants indicated which protective cold weather clothing they planned to wear during the Operation or Exercise and indicated if it was standard issued or commercial equipment.

RESULTS

A total of 511 military personnel participated in the survey. High proportions of participants reported using non-issued liner gloves (72%), mittens (56%), hat (47%), socks (42%), thermal underwear (40%), and goggles (42%) either alone or in combination with issued kit. These are also items that cover the body areas which have the highest prevalence of cold weather injuries. During the most recent training exercise, nearly one half (46%) of the soldiers experienced a cold weather injury of some kind, either self-reported or identified by a medical officer during medical checks.

CONCLUSION

Many deployed CAF members augmented their personal protective kit with commercial kit. The reasons varied from personal preference, size requirements, perceived deficiencies with the issued kit, and shortages in the supply of issued kit. While certain pieces of commercial kit may provide the same or more protection against extreme cold, this has not been validatedsome pieces of commercial kit that are being purchased and worn may not be as protective as issued kit, leading to an increase in cold weather injuries.

Our current work is focused on understanding the efficacy of issued and commercial kit, so that soldiers decisions to augment their equipment with commercial goods can be made on the basis of data collected in the field, instead of on manufacturers claims.

OPERATIONAL RELEVANCE

Wearing proper personal protective equipment in extreme cold environments not only protects soldiers from cold weather injuries, but is also a critical enabler for humans operating and performing their duties optimally in the Arctic. Soldiers have historically augmented their issued kit with commercial products and will continue to do so. It is therefore critical that they do so with goods that offer the increased protection.

AUTHORS

Wendy Sullivan-Kwantes (1)
Katy Moes (1)
(1) DRDC (Toronto, Canada)

PULK CONTRA BACKPACKS. EXAMINATION ON THE EFFICIENCY OF PULK VERSUS BACKPACKS DURING A MILITARY SKI MARCH IN NORTH NORWAY

PURPOSE

In military operations mobility is very important and in the Artic this is particularly challenging and the environment requires special training and equipment. In Norway the dismounted soldiers in the squad usually use backpacks for the gear that they need to transport and sometimes also a pulk which the soldiers switch to pull behind them. In a flat landscape it is obviously an advantage to have pulk compare to a backpacks. However, in more hilly terrain this is not so obvious. Therefore, it is of importance to understand how the soldiers in a squad manage to move through more hilly terrain with a pulk each and with no backpacks.

METHODS

Two squads (n=4, n=5) were tested on separate days, skiing with pulk or skiing with backpacks on a track in hilly terrain. Distance, average speed, weight of pulk/backpacks, vertical movement, heart rate, core temperature, and skin temperature (chest) were measured. Soldiers were also surveyed about their preference.

RESULTS

Average speed for the two squads was 1.7 and 1.0 km/hour (pulk) and 2.3 and 1.4 km/hour (backpacks). Average heart rates combined for both squads (n=8) were 117 + 9 (pulk) and 107 + 5 (backpacks). Average core temperature combined for both squads were 37.7 + 0.2 (n=6, pulk) and 37.6 + 0.2 (n=7, backpacks). The mean vertical movement for the two squads with pulk were 410 m uphill (ascent) and 340 m downhill (descent) and the corresponding results for backpacks were 435 m and 375 m respectively. Chest skin temperature was ~3 °C lower for pulk compare to backpacks. The result from the survey (questionnaire) showed that 67% of the soldiers preferred the pulk, 33% preferred a combination of pulk and backpacks, and nobody wanted a solution only based on backpacks.

CONCLUSIONS

Based on the monitoring in the field in this study the soldiers with the pulk could take about 50% more weight with them compared to backpacks; however, speed decreases by ~25-30%. Based on heart rate responses, physical load increased by ~10%. Chest skin temperature decreased by ~3 °C probably due to increased ventilation in the clothing (it was easier to open up the lining of the upper body when walking with a pulk compared to a backpacks). Most soldiers prefer the pulk.

AUTHORS

Svein Martini (1)

(1) FFI – Norwegian Defence Research Establisment (Kjeller, Norway)

RANGE OF MOTION ASSESSMENT OF MOBILITY RESTRICTIONS FROM BODY ARMOR AND RIFLEMAN KIT FOR FEMALES

Research characterizing fully encumbered Soldiers movement is limited, especially when focused specifically on female personnel. The few studies characterizing movement of female personnel are generally limited to minimally clad individuals, and do not take into account specific issues of fit/sizing disaccommodation that many female Soldiers experience. Investigating this research gap is important because poor fit/sizing of clothing and individual equipment can negatively impact user comfort, mobility, system functionality, safety and system integration.

This study investigated the role of two different unisex body armor systems (A (vest) and B (plate carrier)), both worn with a rifleman kit, on mobility performance for females compared to each other and to a baseline condition (duty uniform only). Sixteen female active duty Soldiers took part in this study (age: 24.6 ± 6.53 years; time in service: 4.6 ± 6.29 years). Seven (43.8%) participants wore size extra small body armor, six (37.5%) wore small, and three (18.8%) wore medium. Participants completed twelve different body movements consisting of neck (cervical rotation, ventral-dorsal cervical flexion), shoulder/reaches (forward extended reach, overhead extended reach, shoulder abduction, cross body reach), hip (knee lift), lower back (spine lateral flexion, spine rotation, trunk flexion sitting and standing) and dynamic/whole body (figure 8 duck movement). All movements are components of mission movements likely to be affected by individual worn equipment.

Configurations A and B showed similar effects for the shoulder/reaches, hip, lower back and dynamic/whole body movements relative to the baseline configuration, where range of motion or movement performance was significantly degraded from the baseline ($p < .001$). Analysis showed no degradation in performance when A and B were compared for these movements. However, performance for cervical rotation in A was degraded (approaching significance, $p = .07$) compared to the baseline, while there was no degradation in performance with B. For the ventral dorsal cervical flexion movement, performance was degraded in B (approaching significance, $p = .08$) compared to baseline, and there was no degradation in performance for A.

Previous research with males have shown differences in performance between plate carriers and full vests in the rifleman configuration (Mitchell, Choi and Garlie, 2017). The current study indicates that regardless of the body armor design and style, the addition of the body armor and/or the rifleman kit degrades the performance of female Soldiers. Further analysis is needed to determine if females anatomy, strength, or the design of the equipment are the cause of this difference.

AUTHORS

K. Blake Mitchell (1)
Todd N Garlie (1)
Hyeg Joo Choi (1)
Jose D Villa (1)
Linda L DeSimone (1)

(1) CCDC Soldier Center (Natick, United States)

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CURRENT AND FUTURE OPPORTUNITIES FOR WEARABLE ASSISTIVE TECHNOLOGIES ACROSS DEFENCE
#ABS151

FEBRUARY 13, 2020

REDISTRIBUTING THE LOAD CARRIED FROM THE SHOULDERS TO THE HIPS: AN INTERDISCIPLINARY EVALUATION OF THE VIRTUS DYNAMIC WEIGHT DISTRIBUTION SYSTEM

PURPOSE

To identify the benefits and potential trade-offs of redistributing load from the shoulders to the hips, using the UK in-service VIRTUS Dynamic Weight Distribution (DWD) system.

METHOD

Nine participants completed a laboratory test on two occasions wearing a 25kg backpack with and without the DWD engaged. The laboratory test involved measurements of force / pressure on the shoulders, pulmonary function, cardiopulmonary parameters, discomfort, working memory (2-back task), lower limb joint kinematics, electromyography (EMG), and ground reaction forces. Measurements were taken at rest or whilst marching on a treadmill. Participants marched for 40 minutes, with speed and incline increased every ten minutes (four stages in total); exercise intensity ranged from 28% (Stage 1) to 78% (Stage 4) of maximal oxygen uptake. Data were analysed using a two-way repeated measures ANOVA or paired t-test.

RESULTS

Force on the shoulders was reduced by 70% ($p<0.0001$) and shoulder pressure by 66% ($p<0.0001$) when the DWD was engaged. Gait biomechanics were also affected when the DWD was engaged: the loading rate of the vertical ground reaction force reduced by 3.7% ($p=0.028$), the peak EMG of gastrocnemius medialis reduced by 15% ($p=0.018$), and hip extension reduced by 18% ($p=0.031$). The severity of shoulder discomfort decreased when the DWD was engaged, but frequency of reported hip discomfort increased. Response accuracy during the 2-back task was 13% greater with the DWD engaged during Stage 4 of the exercise test ($p=0.028$). Minimal differences in other physiological parameters were identified.

CONCLUSIONS

Guidelines for recommended maximum forces that should be borne on the shoulders (145N, [1]) were only exceeded without the DWD (> 200N) whilst with DWD these forces were significantly less (< 65N). The DWD provided some biomechanical benefits to users as indicated by the reduced gait compensations to walking with a backpack load. When the DWD was engaged, discomfort was transferred from the shoulders to the hips which are more tolerant to increases in pressure. Data indicate that the reduction in discomfort observed with the DWD was the main contributory factor that led to improvements in accuracy during the 2-backs.

OPERATIONAL RELEVANCE

This work has identified benefits and trade-offs associated with using the DWD, which will inform policy and training regarding use of the DWD.

AUTHORS

Nicola Armstrong (1)
Joon-Hyuk Park (2)
Andrew Twedell (3)
Angela Boynton (3)

(1) Defence Science Technology Laboratory (United Kingdom); (2) Army Reserach Laboratory (MD, United States); (3) Army Research Laboratory (MD, United States)

[1] Stevenson JM, Bossi LL, Bryant JT, Reid SA, Pelot RP, Morin EL (2004) A suite of objective biomechanical measurement tools for personal load carriage system assessment. Ergonomics 47:1160-1179 doi:10.1080/00140130410001699119.

REDUCED EFFECTIVENESS OF A PASSIVE LOWER LIMB EXOSKELETON DURING A PROLONGED LOADED MARCH

PURPOSE

The Operational Exoskeleton (OX) is a passive lower limb exoskeleton designed to support soldiers carrying heavy packs by transferring a proportion of the pack-mass to the ground during the stance phase of loaded marching. The aim of this study was to investigate how the use of the OX impacted biomechanical, physiological and psychophysiological responses during prolonged loaded walking.

METHODS

Ten healthy, male, soldiers (32 ± 10 years old, 1.80 ± 0.05 m in height, 84 ± 7 kg in mass) completed a familiarisation period, functional movements, and two 1-hour prolonged load carriage trials (with and without the OX). Each load carriage trial was completed on a flat treadmill at 5 km/h with a 30 kg backpack and carrying a replica weapon (4.5 kg). Energy consumption (K4b2, Cosmed), in-shoe forces (Pedar, Novel) and ratings of perceived exertion (15-point Borg scale) were collected when wearing and not wearing the OX during the prolonged trials. Additionally, a 5-point Likert scale (1 totally acceptable; 3 neutral; 5 totally unacceptable) was used to subjectively rate functional movements and a semi-guided questionnaire that were completed at the end of the protocol. A repeated-measure ANOVA with two factors (condition and time) was performed to compare dependant variables during the prolonged trials (SPSS).

RESULTS

When wearing the OX there was a significant reduction in load supported by the user during the first 40 minutes of the prolonged trial ($p < 0.05$) [as observed via in-shoe forces], but no differences at the 50 minute time period onwards ($p > 0.05$). Energy cost was significantly higher at all time points during the OX trial ($p < 0.05$), and there was a trending increase in the difference in energy cost between the OX and the control condition as the trial progressed. Subjectively, soldiers rated the assistance provided by the OX as totally acceptable acceptable, and the OX to be overall acceptable neutral.

CONCLUSIONS

The OX successfully demonstrated the capability to partially transfer pack-mass during a 1 hour march. However, there was an increased metabolic demand, and the load transfer benefit was variable across users and reduced as the trial progressed. The OX was perceived positively by the soldiers, however, on balance the OX still requires further development work before it can realise the desired capability benefit.

OPERATIONAL RELEVANCE

Continued collaboration between Defence scientists, industry and academia will ensure exoskeleton development aligns with military needs and realises the desired capability benefit.

AUTHORS

Kurt Mudie (1)
Daniel Billing (2)
Greg Carstairs (1)
Logan Hard (2)
Richard Molloy (1)
Rezaul Begg (2)
Daniel Billing (1)

(1) DST Group (Australia); (2) Victoria University (Melbourne, Australia)

WALKING WITH A SEMI-ANTHROPOMORPHIC QUASI-PASSIVE EXOSKELETON DOES NOT INCREASE ENERGY EXPENDITURE AND REDUCES BIOMECHANICAL LOADING OF SOLDIERS WHILE WALKING WITH A HEAVY LOAD

PURPOSE

Soldiers have to carry heavy loads up to 60 kg during marches. The high loads cause discomfort which impairs the fighting abilities of soldiers. Carrying a heavy backpack furthermore increases biomechanical load on the joints, increasing the risk on injuries and reducing deployability. A possible solution for these problems is the use of an exoskeleton during long marches. Exobuddy, a semi-anthropomorphic quasi-passive exoskeleton, was specifically developed for long marches and transfers the weight of the heavy load to the ground, thereby supporting soldiers.

AIM

This study aims to assess the effect of Exobuddy on biomechanical loading, energy expenditure and physical and cognitive residual operational capacity during and after marching with a heavy load.

METHODS

A cross-over trail was performed with 6 military male subject (22.5 ± 1.9 years). Subjects walked 90 minutes on a treadmill (5.5 km/h) while wearing a 40kg backpack or the Exobuddy combined with a 40kg backpack. Subjects could regulate the magnitude of the support. During walking biomechanical loading, oxygen uptake, rate of perceived exertion (RPE) and heart rate were measured. Before and after walking several test were performed to measure upper body strength, marksmanship and agility. During walking the go/no go test was performed to assess cognitive functioning.

RESULTS

The self-selected support of Exobuddy was 35% ± 12% (19 ± 4 kg) during walking. Support was relatively stable throughout the stance phase with the highest level of support at the beginning of the stance phase. Walking with the Exobuddy resulted in a similar oxygen uptake and heart rate compared to walking with only the backpack (24 ± 2 versus 22 ± 3 ml/kg/min with $p = 0.139$ for oxygen uptake; 136 ± 16 versus 127 ± 10 bpm with $p = 0.136$ for heart rate). RPE and discomfort were similar when walking with Exobuddy or backpack, with discomfort increasing significantly over time for both conditions ($p = 0.008$). The upper body strength test, marksmanship test, agility test and go/no go test did not result in a significant difference between conditions.

CONCLUSIONS

Exobuddy reduces the biomechanical costs of walking with a heavy load. More importantly, Exobuddy reduces biomechanical loading with no significant changes in metabolic costs.

OPERATIONAL RELEVANCE

This study shows that Exobuddy is an excellent option to decrease loading of soldiers, hereby decreasing the risk of injuries without extra metabolic costs that usual come with passive exoskeletons.

AUTHORS

Milene Catoire (1)
Aijse de Vries (1)
Leanne van der Hout (1)
Coen Greidanus (2)
Lotte Linssen (1)
Trebsijg van de Wijdeven (2)
Reinier Könemann (1)
Rogier Barents (2)

(1) TNO Human Factors (Soesterberg, Netherlands); (2) Intespring (Delft, Netherlands)

CHARACTERIZING HUMAN MOTOR ADAPTATION TO AN ANKLE EXOSKELETON SYSTEM

PURPOSE

Human augmentation systems, such as exoskeletons, claim to offload effort while improving operator performance. However, previous studies often report initial increased muscle or metabolic activity with exoskeleton use and individual operator adaptation periods appear variable. Currently, there is no scientific explanation for individual adaptation variability highlighting a critical gap in the field of military exoskeleton research to address. Presented here are initial results from an ongoing study designed to determine which baseline operator characteristics (e.g., gait, cognition, anthropometry, and proprioception) are related to short-and long-term adaptation to an ankle-based exoskeleton. Results included examining gait as characterized by normalized stride length (NSL) during exoskeleton walking.

METHODS

In preparation for a larger study of US Army Soldiers, pilot data from 10 subjects were collected (N=8 presented). Responses were measured for baseline tests including motor, cognitive, and combination cognitive-motor tasks. Subjects also completed exoskeleton walking tasks at treadmill speeds varying from 0.5m/s to 1.5m/s. Walking speed was 1.3 m/s for the results presented. Gait with was characterized through NSL across two exposures. Three time regions were considered: baseline (B, middle 30 seconds of 1-minute steady-state walking with the exoskeleton unpowered); exo-active (EA, last 2 minutes of a 10-minute powered walking period), and exo-off (EO, last 2 minutes of a 5-minute walking period with the exoskeleton unpowered).

RESULTS

A repeated measures ANOVA support significant ($p<0.05$) effects of subject, region, and the subject-region interaction on NSL. All three walking regions were significantly different when subjects were pooled. However, the subject-condition interaction highlighted different emergent behaviors. Three subjects showed no significant differences in NSL across regions. Another set of three subjects showed significantly longer NSL during EA than EO, but no significant difference from B. One individual had significant differences across all three regions, with NSL increasing from B to EA to EO. One individual showed significantly lower NSL during EA than B and EO

CONCLUSIONS

Preliminary evidence indicates significant differences in adaptation strategy across exoskeleton operators during short-term adaptation. Future analyses will consider how these strategies and gait characteristics may change across subsequent exoskeleton exposures. Further military exoskeleton research is critical to determine the relative contributions of gait, cognition, anthropometry, or proprioception on adaptation.

OPERATIONAL RELEVANCE

Successful implementation of military exoskeletons has the potential to increase the performance of the operator. However, a better understanding of the exoskeleton-operator interaction is needed, including what characterizes adept users and aids in reduced adaptation timelines.

AUTHORS

Meghan O'Donovan (1)
Aditi Gupta (2)
Kari Loverro (3)
Karen Gregorczyk (1)
Aaron Rodriguez (2)
Harvey Edwards (2)
Ryan McKindles (2)
Leia Stirling (2)

(1) CCDC – Soldier Center (Natick, United States); (2) Massachusetts Institute of Technology (Cambridge, United States); (3) CCDC-SC (Natick, United States)

DEVELOPMENT OF A TARGETED FAMILIARIZATION PROTOCOL FOR OPTIMIZING ADAPTATION FOR LEARNING TO WALK WITH A PASSIVE LOAD-BEARING EXOSKELETON

PURPOSE

Learners can adopt adaptive (reduce energy expenditure and musculoskeletal stress) or maladaptive strategies (movement changes associated with discomfort or fear of injury) when familiarizing with new devices. Repeated use of maladaptive strategies limits effectiveness of device use and acceptance and increases risk of injury. The aim of this study is to promote adaptive strategies for using a passive load-bearing exoskeleton (EXO) through optimal familiarization.

METHODS

Two-phase iterative design (Canadian soldiers who were naïve to the EXO). Phase1. Controlled experimental design. Three soldiers completed two 6-minute walk tests (6MWT) with EXO and reported discomfort. Location of discomfort and optimal movement strategies were integrated into a 3-hour familiarization period (warm-up, walking, obstacles). After familiarization, participants completed 2 6MWT, 3 usability questionnaires (technology acceptance; LEAP rating; device satisfaction) and an interview. Summary scores and descriptive analysis informed development of a 9-day familiarization period. Phase2. In a single-subject research design, three soldiers completed 3 6MWT tests with EXO and reported location of discomfort. Soldiers then completed 9x3h of familiarization (task-oriented activities that progressed from non-loaded skills/agility circuit to a loaded circuit). Two 6MWT with EXO, 3 usability questionnaires and a focus group were then administered. Summary scores and descriptive analysis were performed.

RESULTS

Phase1. Soldiers perceived discomfort in feet, anterior tibia and hip. Muscle activations of the core, hips, and legs were included in familiarization. Upon completion, users felt less discomfort when using the EXO, but were still not at complete acceptance. Soldiers confirmed that targeted familiarization assisted in their learning but suggested that >3 hours was needed. Phase2. Soldiers perceived discomfort in back, anterior tibia and hip. Balancing, agility and obstacle/circuit tasks were perceived as most useful during familiarization. Again, users felt less discomfort when, but were still not at complete EXO acceptance. Soldiers confirmed that familiarization helped, but suggested more walking tasks, circuit variations, additional obstacles and more rest.

CONCLUSIONS

It is critical to understand user experiences to improve uptake and satisfaction with device use to optimize usage. Obtaining user feedback through subjective approaches can inform development of familiarization protocols, thus improving the likelihood of positive adaptation and reducing the risk of maladaptive compensation strategies during familiarization.

OPERATIONAL RELEVANCE

Optimal familiarization can facilitate adaptive strategies among soldiers when learning to use a passive exoskeleton prior to operations to prevent injuries, promote device acceptance, and to optimize tactical advantages. Integration of movement strategies relevant to tactical operations are recommended.

AUTHORS

Elyann Périard-Fournier (1)
Jenna Crocker (2)
Gabriel Diamond-Ouellette (3)
Sophie Bourasaa (3)
Thomas Karakolis (4)
Etienne Lamoureux (5)
Laurent J Bouyer (3)
Krista L Best (3)

(1) Center for Interdisciplinary Research in Rehabilitation and Social Integration (CIRRIS), Department of Rehabilitation, Université Laval, Quebec City, QC, Canada; 3Defense Research and Development Canada (Quebec, Canada); (2) Center for Interdisciplinary Research in Rehabilitation and Social Integration (CIRRIS), (Quebec City, Canada); (3) Center for Interdisciplinary Research in Rehabilitation and Social Integration (CIRRIS), Department of Rehabilitation, Université Laval, Quebec City, QC, Canada (Quebec City, Canada); (4) Defense Research and Development Canada (Quebec City, Canada); (5) Mawashi Science and Technology. (Montreal, Canada)

PHYSICAL AUGMENTATION OPPORTUNITIES WITHIN CLOSE COMBAT OPERATIONS

PURPOSE

To identify potential opportunities for wearable assistive technologies to provide the greatest benefit to the Warfighter.

METHOD

Physical demands were evaluated for the most common and mission critical dismounted Warfighter tasks associated with close combat operations as determined through a review of Army Techniques Publications, Soldier Training Publications, Field Manuals and input gathered from subject matter experts. Selected Warfighter tasks (e.g., movement under direct fire) were decomposed from job tasks (e.g., conduct movement to position) into component tasks and functional activities (e.g., bounding rush) and the task demands associated with each functional activity were mapped to categories within an established taxonomy of human performance. Further, a systematic review of open literature publications was completed to investigate non-combat musculoskeletal injury incidence in military personnel. Data on the regions on the body injured, types of injuries, and/or activities associated with injuries were extracted. Identified activities were further evaluated against the task demands results to identify relationships between the non-combat injuries and operational tasks.

RESULTS

Warfighter tasks identified for further analysis included engagement of targets with a rifle or carbine, movement under direct fire, and movement over, through and around obstacles. Common component tasks and functional activities comprising these Warfighter tasks included individual movement techniques and Warfighter skills requiring a variety of physical attributes associated with agility, dexterity, coordination, movement speed, strength, flexibility and endurance. The most commonly injured regions on the body were the ankle, knee, shoulders and lower back. The majority of musculoskeletal injuries were strains and sprains, and most often associated with running, load carriage, sports, and tactical training.

CONCLUSIONS

Based on these preliminary analyses, recommendations have been made for close combat tasks expected to benefit most from physical augmentation. In addition, the lower limbs and lower back were identified as critical areas to target support from physical assistive technologies. However, further research and analysis is required to fully understand the specific biomechanical and physiological requirements of the identified tasks to develop more detailed design guidance (e.g., timing of assistance within task).

OPERATIONAL RELEVANCE

While exoskeleton technologies show promise as enablers for Warfighter mobility, lethality and survivability, there remains a lack of information linking the design and development of exoskeletons to the specific needs of military users. The outcomes from these analyses will focus and accelerate the development of physical augmentation technologies targeted to enhance performance and mitigate injury risk specific for the dismounted Warfighter.

AUTHORS

Angela Boynton (1)
Andrew Tweedell (1)
Kurt Mudie (2)
Andrew Tweedell (1)

(1) Army Research Laboratory (Aberdeen Proving Ground, United States); (2) Defence Science and Technology Group (Melbourne, Australia)

CLASSIFICATION OF WARFIGHTER MOVEMENTS USING DATA FROM A SINGLE INERTIAL MEASUREMENT UNIT

PURPOSE

Accurately quantifying Warfighter movement patterns in operational and training environments has the potential to improve decision making, training outcomes and overall mission safety and success. The aim of this study was to develop a machine-learning classification model to label inertial measurement unit (IMU) data into a set of six important categories of movement performed by dismounted combatants.

METHODS

Ten male and ten female civilians (27±5 years old, 1.72±0.08m in height; 71.5±8.7kg in mass) volunteered to participate in this study. Five IMeasureU BlueThunder IMUs (500 Hz 9 Axis) were attached to the right and left shank, upper posterior and anterior torso, and left humerus of each participant. The testing protocol involved 2 minutes of walking, 4 minutes of running, 2 minutes of walking, 4 minutes of standing, 2 minutes of crawling, 4 minutes of lying supine, 4 minutes of lying prone, 2 minutes of crawling and 10 minutes of a random set of these activities, 15-30 seconds at a time. A 10 K-fold cross-validation was applied across the data, whereby 90% of the data was used to train the model and the other 10% was used to test it.

RESULTS

Average task classification accuracy across individual sensor locations was greatest for the front torso (99.96%), followed by the left humerus (99.95%), upper torso (99.92%), left shank (99.91%) then right shank (99.71%). Specific to each completed movement, the posterior upper torso location demonstrated a high average sensitivity for classifying crawling (99.4%), lying prone (97.8%), lying supine (100%), running (99.8%), standing (99.6%) and walking (99.2%).

CONCLUSIONS

A single non-obtrusive IMU was able to successful classify six military specific movements at an accuracy >97%. Further, all 38 transitions from walking to running and vice versa were successfully detected within 5 seconds of when they occurred. The posterior upper torso location was preferred due to the high accuracy, in addition to the ease of integration into the current soldier combat ensemble.

OPERATIONAL RELEVANCE

The ability to accurately record and reconstruct high resolution movements in an operational and field environment can provide important information to guide real-time and post event decision making. Further, battlefield threats continue to evolve and the ability to accurately reconstruct events provides vital insights necessary to further improve the survivability and sustainability of the Warfighter.

AUTHORS

Kurt Mudie (1)
Daniel Billing (2)
Rhys Williams (3)
Nicholas Beagley (1)
Mark Finch (3)
Daniel Billing (1)

(1) DST Group (Australia); (2) Victoria University (Melbourne, Australia); (3) IMeasureU (Auckland, New Zealand)

A COMPARISON OF MULTIPLE MACHINE LEARNING ALGORITHMS ON THE PREDICTION OF GAIT EVENTS DURING LOAD CARRIAGE

PURPOSE

Evidence suggests that exoskeletons must be capable of adapting to the user to maximize their augmentation potential. The aim of this research was to compare the performance of multiple Machine Learning (ML) algorithms for the prediction of gait events (heel strike, peak load, foot flat, peak propulsion and toe off) using kinematic data of the shanks and thighs. The implemented algorithms included Artificial Neural Networks (ANN), Support Vector Machines (SVM), Gaussian Naive Bayes (NB), Classification and Regression Trees (CART), K-Nearest Neighbours (KNN) and Linear Discriminant Analysis (LDA).

METHODS

Six young and able-bodied soldiers (22±2 years-old, 1.77±0.02m, 82±4kg) walked for 10-minutes at 5km/h on a 0% treadmill grade carrying a 20kg backpack. A 3D motion capture system and a force plate integrated treadmill recorded kinematic and kinetic data, respectively. Each of the X, Y and Z vector values for the angular velocity as well as linear acceleration of the left and right thighs and shanks were computed using the motion capture system to resemble the output of a wearable Inertial Measurement Unit (IMU). The angular velocity and linear acceleration data of 1,068 strides were each labelled with the respective gait event and used to train and test the ML algorithms. The algorithms performance was evaluated using leave-one-out cross validation.

RESULTS

Mean classification accuracies for each algorithm were 98.5% for CART, 98.4% for SVM, 96.9% for ANN, 96.7% for KNN, 96.2% for LDA and 87.6% for Gaussian NB across all foot events. Mean classification accuracies for each foot event ranged from 95.6-98.7% for heel strike, 85.6-96% for peak loading, 55.6-99.6% for foot flat, 98.8-97.7% for peak propulsion and 99.2-100% for toe off across all algorithms.

CONCLUSIONS

CART and SVM demonstrated acceptable overall sensitivity accuracies for detecting gait events using only kinematic data during loaded walking. The findings suggest classical machine learning algorithms may be sufficient to develop high quality predictive models for prediction of gait events to improve exoskeleton adaptability. However, future research is needed to determine the accuracy of the developed classifier model for predicting gait events using only kinematic data collected by wearable IMUs in the field.

OPERATIONAL RELEVANCE

Results suggested considerable potential for using ML techniques to predict gait events from IMUs in a field environment. The ability to accurately detect and predict gait events can improve the performance of current exoskeleton systems by making them more flexible and adaptable to changes in task demands during loaded marching.

AUTHORS

Kurt Mudie (1)
Daniel Billing (2)
Abdelrahman Zaroug (2)
Daniel Lai (2)
Daniel Billing (2)
Rezaul Begg (2)

(1) DST Group (Australia); (2) Victoria University (Melbourne, Australia)

VALIDATION OF WEARABLE SENSORS TO IDENTIFY MILITARY RELEVANT ACTIVITIES IN THE FIELD

Wearable sensors allow researchers to track Soldier movements in training and operational environments. However, in order to translate these data into useful information for researchers or commanders, determination of activity type is necessary to process those sensor data using relevant algorithms.

PURPOSE

Develop and validate algorithms that identify physical activity types from inertial measurement units (IMUs) sensor data.

METHODS

Twenty Soldiers (19 male) completed 10 different physical activities, within a 3-hour data collection: walking (with and without an external load), running, standing, sitting, transitioning from standing to prone, prone, jumping jacks, sit ups and pushups. Soldiers were instrumented with seven IMUs (500 Hz), one on each wrist, lower leg and foot plus one on the torso. The a priori algorithm design required no more than three sensors and did not require Soldier-performed calibration activities (e.g., toe-touches) for the classifier. For validation purposes, the activity classifier was developed independently (n=10) and then tested on a blind data set (n=10). Following examination of classifier errors, a second classifier was developed based upon all participant data, which added an unknown activity category, and then was tested across all participants. An external company completed classifier development.

RESULTS

Two sensors, right wrist and left foot were used to create both classifiers. Classifier accuracy on the blind data set, across all activities was 85 ± 15%, with the highest accuracy with sit-ups, 98%, and lowest accuracy with the standing to prone movement, 43%. Walking, running, standing, sitting and push-ups were also >90% accurate with only one participant having more than 60 seconds of false positives during any activity. The second classifier accuracy from the entire data set, across all activities was 98±2%, with 100% accuracy for walking, running, sitting, sit-ups and lift and carry and lowest accuracy in standing to prone, 92%.

CONCLUSIONS

Common military activities were classified from two wearable sensors without any required Soldier-performed calibration activities.

OPERATIONAL RELEVANCE

Classification of common military activities with only two non-invasive sensors enables more detailed assessments of stresses and work-rest cycles experienced in training, where many injuries occur, or operational environments. Assessing performance and potential for injury risk through biomechanical analyses for each activity type is possible without an observer tracking the activities completed.

AUTHORS

Rebecca Fellin (1)
Joseph Seay (1)
Nathaniel Smith (1)
Alvin Korus (1)
Victoria Bode (1)
Peter Frykman (1)
Mark Buller (1)

(1) United States Army Research Institute of Environmental Medicine (Natick, United States)

CONSIDERATIONS WHEN COLLECTING WHOLE-BODY TACTICAL MOVEMENTS UNDER LOAD USING WEARABLE IMU SENSORS

PURPOSE

To validate an inertial measurement unit (IMUs) suit against a gold standard optical motion capture (OPT) system for military-based movements, and to discuss considerations and limitations when designing IMU-based research protocols for military applications.

METHODS

Twenty participants performed eight military-based movements: walking, running, prone-to-run, kneel-to-run, prone-to-kneel, kneel-to-prone, run-to-kneel (RTK), and run-to-prone (RTP). Full body kinematics were collected simultaneously from an IMU suit (MVN BIOMECH, Xsens, Netherlands) and a cluster-based OPT marker set (Vicon, UK).

Time-series marker positional data from both systems were imported into Matlab (2018b, The Mathworks); markers that were similar between systems (N = 30) were retained for further processing. Data were synchronized with a handclap event, were cropped based on gait and visual events, and time normalized to 101 samples. Data from both systems were stacked into a single matrix and analyzed using principal component analysis (PCA). Using a trace criterion of >90% of variance explained, six (91%) and five PCs (91%) were retained for the RTK and RTP tasks, respectively. Pearson correlations assessed the level of agreement in PC scores between the IMU and OPT systems.

This #ABStract presents only the RTK and RTP tasks; however, all data will be presented at the conference using the PCA approach as well as traditional comparisons such as peak angles and angular velocities.

RESULTS

Pearson correlations revealed that the PC scores between the IMU and OPT systems were significantly correlated at $p < 0.004$ and had r-values ranging from 0.577 0.984 (i.e. moderate to very high) across both the RTK and RTP tasks.

CONCLUSION

The results indicate that the Xsens IMU and Vicon OPT systems capture similar whole-body kinematics for the RTK and RTP tasks when analyzed using PCA. Nevertheless, there are important limitations and considerations that biomechanists should be aware of when designing IMU-based research protocols for military applications, which will be the main focus of the talk.

OPERATIONAL RELEVANCE

IMUs are desirable for field-based research because of their portability, large capture volumes, and does not require line of sight. However, before IMUs can be widely adopted by the military research community, biomechanists should be aware of their limitations and considerations when developing an IMU based research protocol (e.g. calibration, hardware placement, drift).

Educating researchers on the IMU motion capture approach creates the potential to greatly advance our understanding of movement alterations caused by both extrinsic (e.g. body-borne loads, environment) and intrinsic variables (e.g. sex, stress).

AUTHORS

Matthew Mavor (1)
Gwyneth Ross (1)
Cerys McGuinness (2)
Thomas Karakolis (2)
Ryan Graham (1)

(1) University of Ottawa (Ottawa, Canada); (2) Defence Research and Development Canada (Toronto, Canada)

USING ACTIVITY MONITORS TO OBJECTIVELY MEASURE SKELETAL LOADING IN MILITARY PERSONNEL: PERFORMANCE TO INJURY APPLICATIONS

PURPOSE

Assessing operational performance in the field using validated wearable sensors provides scientific rigor to performance outcomes. Previous studies established a method for estimating ground reaction forces (GRFs) during load carriage [1] but this method has not been validated during prolonged ruck march. The purpose of this study was to determine if the current method to estimate peak GRFs is valid for prolonged load carriage.

METHODS

Twelve male Soldiers completed a 10.2 km course while wearing 2 different loads (26.1 and 48.5 kg). At the start (0 km), middle (4.3 and 6.0 km), and end (10.2 km), GRFs were collected using in ground force plates. Triaxial accelerations were collected using an Actigraph GT3X+ activity monitor positioned over the lateral aspect of the left hip. Peak vertical GRF was identified for each left foot contact on the force plate. Peak vertical acceleration was averaged over the 5 seconds before and after contact with the force plate. GRFs were predicted at each time point using a previously published equation [1]. Average percent error between actual and predicted GRF was calculated along with root mean square error (RMSE) and Bland-Altman analysis. Percent errors less than 7% were considered to validate use of the previous equation.

RESULTS

Average #ABSolute percent error was 3.4±7.2% for all time points (2.0-5.9% depending on time point). RMSE was 100.2 N for all time points (90.0-124.8 N depending on time point). Bland-Altman analysis resulted in upper and lower limits of agreements of 233.9 and-151.2 N, respectively.

CONCLUSIONS

The previous equation to predict peak vertical GRF from acceleration is valid for use over a 10.2 km ruck march. Since the vertical GRF is the predominant component of GRFs during walking, this is the component of primary interest for overall forces sustained by the body. This method can be used to quantify these forces outside of a laboratory.

OPERATIONAL RELEVANCE

Understanding the forces sustained by warfighters can be used for several applications. Recent work utilized similar methods to objectively quantify activity and forces during rehabilitation of tibial stress fractures. Once predicted, the GRFs can be equated with changes in bone density. Additionally, differences in musculoskeletal loading due to different equipment can be quantified using this method. These results provide insights into the effects of new or novel equipment used by warfighters.

AUTHORS

Jennifer Neugebauer (1)

(1) US Army Futures Command (United States)

ACCURACY OF ENERGY EXPENDITURE ESTIMATION WITH OR WITHOUT HEAT FLUX INFORMATION

PURPOSE

Different military work tasks or long-term sport performances challenge evaluation of energy expenditure (EE) rate. Wearable monitoring technologies with heart rate (HR) data may give useful EE-information during moderate or high intensive actions, but several tasks include low intensive periods e.g. at rest or readiness state. Shcherbina et al. (2017) showed poor accuracy of EE-estimations from commercial wearable products, e.g. the smallest median of estimation error was 27.4%. Rather than indirect EE-estimation, direct measurement of heat production would increase the accuracy of EE-estimation, especially during low metabolically demanding periods. Therefore, a heat flux (HF) sensor was combined with HR and motion sensors.

METHODS

Twenty-eight healthy subjects participated in the study. HR variability (V800, Polar) and HF (gSKIN®) were measured from the wrist. The effectiveness of additional HF-sensor for EE-estimation was validated against indirect calorimetry (Oxycon Pro, MasterScreen CPX) during rest (sitting and standing) and physical activities (walking, cycling and arm crank exercises) with different intensities (20, 30 and 40%VO2max) in randomized order. After data collection, a machine-learning algorithm combined HF and HR responses with subjects background information (age, height, weight, and physical activity level) to improve EE-estimation from indirect calorimetry data. The algorithm was trained and tested using cross-validation (n-1 subject model), where data from each subject was used to test the trained algorithm derived from all other subjects data.

RESULTS

Estimation error for the cross-validated algorithm, which combines HR, HF and background information, was 8.3% (median value) in the range from-16.9% to 56.5%. Half of the estimation error values differed less than 25% from reference values. Estimation error range without HF was larger (-26.0% to 61.2%), however median error value is slightly closer to reference (7.2%) compared to the algorithm with HF. Alternatively, the median estimation error value was very small from HF alone to reference (-0.05%), but estimation error range was larger (-39.1% to 76.3%).

CONCLUSION

Data from HF-sensor improves the accuracy of EE-estimation compared to HR and background information alone. However, EE-estimation would be even more accurate due to larger training data for algorithm.

OPERATIONAL RELEVANCE

Wearable EE-monitors with HF-sensors could indicate more accurate metabolic stress level of soldiers and assist optimizing their work capacities. However, sweating is complex for the HF-sensor, which measures removed heat energy due to evaporation from the skin. Hence, the algorithm should also take this into account.

AUTHORS

Heikki Peltonen (1)
Mika Silvennoinen (1)
Mari Sulonen (1)
Heikki Kyröläinen (1)

(1) University of Jyväskylä (Jyväskylä, Finland)

REFERENCE

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ACCURACY OF ACTIVITY ZONE CLASSIFICATION BETWEEN HEART RATE RESERVE AND ACCELEROMETRY IN MILITARY FIELD EXERCISE

PURPOSE

Advances in wearable technology have improved objective measurement of physical activity (PA) in free-living environments. In the military, accelerometry and heart rate (HR) are used to measure activity intensity, but it is unclear whether pre-defined thresholds of PA intensity agree between these methods. This study compared classification of activity intensity between individualised HR measurement and accelerometry in military personnel.

METHODS

During 5 days of a defensive field exercise comprising trench-digging and defending/assaulting tactical positions, nineteen (10 male, 9 female) British Army Officer Cadets (mean ± SD: age 24 ± 3 years, height 1.75 ± 0.08 m, body mass 76.4 ± 10.3 kg) concurrently wore chest-mounted HR monitors (Polar, Finland) and research-grade wrist accelerometers (GENEActiv, UK). Heart Rate Reserve (HRR) was calculated for each participant by subtracting resting HR (lowest measured in training) from maximum HR (highest measured in best-effort 2.4 km run). Time spent in PA intensity categories was calculated using established thresholds of cardiovascular strain: Sedentary (<20%HRR), Light (20-39.9%HRR), Moderate (40-59.9%HRR) and Vigorous (60%HRR). Raw acceleration data were divided into the same PA categories using previously-validated thresholds for sum of vector magnitudes. For every 15-minute epoch of activity, the accelerometers ability to correctly classify PA intensity was assessed using sensitivity (true-positive rate) and specificity (true-negative rate).

RESULTS

Accelerometer-derived estimated energy expenditure was 4984 ± 757 kcal.day-1. On average, the monitoring methods (HRR vs accelerometry) identified 1129 vs 1975 min of Sedentary behaviour, and 2768 vs 667 min of Light, 841 vs 2153 min of Moderate and 49 vs 23 min of Vigorous PA. The accelerometer performed better at identifying Sedentary (sens/spec (95% CI): 0.72(0.68-0.744)/0.68(0.67-0.70) and Moderate (sens/spec: 0.69(0.65-0.73)/0.61(0.59-0.62)) than Light (sens/spec: 0.16(0.15-0.18)/0.89(0.88-0.91)) intensity activity, but classification accuracy was variable between individuals. There was insufficient Vigorous activity for inclusion in analysis.

CONCLUSIONS

Activity intensity levels from accelerometry did not directly align with individualised HRR thresholds. Fixed activity thresholds derived from normative data cannot adjust for inter-individual variation and may vary in accuracy between individuals and measurement devices. These data suggest that military-specific activity thresholds determined both at the population-and soldier-level may be beneficial, particularly for quantifying cumulative low-level activity.

OPERATIONAL RELEVANCE

Improving accuracy of monitoring changes in PA and training load is important for informing training and recovery strategies. This study supports the need for military-personnel-specific PA thresholds for wearable accelerometers that closer align with cardiovascular demand to more accurately understand soldier training load.

AUTHORS

Andy Siddall (1)
Sarah Needham-Beck (1)
Steven Powell (1)
Victoria Edwards (1)
Sam Blacker (1)
Sarah Jackson (2)
Julie Greeves (2)
Stephen Myers (1)

(1) University of Chichester (Chichester, United Kingdom); (2) Department of Army Health and Physical Performance Research (Andover, United Kingdom)

VALIDATION OF WEARABLE SENSORS FOR THE DETECTION OF SPATIO-TEMPORAL GAIT EVENTS DURING RUNNING AND WALKING

PURPOSE

The purpose of this investigation was to validate the accuracy of a wearable sensor for the detection of spatio-temporal gait events in military-relevant environments. Specifically, this study investigated the validity of the MilestonePod [now Zwift Pod; Zwift Inc.; Long Beach, CA] in walking and running in both combat boots and running shoes. Sensor accuracy was tested in both treadmill and overground conditions.

METHODS

Data from the MilestonePod (MSP) was compared to a relevant gold standard for each surface condition: instrumented treadmill (TM) [Bertec; Columbus, OH] and an Optogait photogate system (OPT) [Microgait; Mahopac, NY]. Nine subjects participated in the treadmill study (boots only, walking vs running), and 12 subjects participated in the overground study (boots vs running shoes, and walking vs running). The surface of the overground study was a hardwood basketball gym floor. The four variables of interest were cadence (steps / min), pace (meters / sec), ground contact time (sec), and stride length (meters). Repeated measures ANOVAs were conducted to assess the differences between gait and footwear with alpha set at 0.05.

RESULTS

In the TM comparisons, the MSPs underestimated all variables in the boot/walking trials (9.9% to 25.4% difference). MSPs were reasonably accurate in the boot/running trials for pace, ground contact time, and stride length (< 8.5% difference). Cadence was less accurate (17.8% difference). In the OPT comparisons, the MSPs were very accurate for cadence (< 1% difference) and reasonably accurate for ground contact time (<5% difference) across all conditions. Conversely, the MSP significantly underestimated pace and stride length in all conditions other than running in running shoes, with differences exceeding 20%.

CONCLUSIONS

Treadmill and overground trials indicate that the MSPs are reasonably accurate for subjects running while wearing running shoes. However, when conditions are changed, either by walking, or by changing footwear, the accuracy of the MSPs decreases, especially for pace and stride length.

OPERATIONAL RELEVANCE

Wearable, wireless sensors may be useful tools during training and operational environments for the measurement of movement patterns. Previous work has suggested that changes in movement patterns may be indicative of fatigue and injury status. It is important to ensure sensors are sufficiently accurate, such that they can be used to identify soldier readiness before, during, and after operational missions. Further, these sensors must be capable of providing accurate data in conditions beyond simply running at a steady state in running shoes.

AUTHORS

Truman Gabriel (1)
Rebecca Zifchock (1)
Rebecca Zifchock (1)
Donald Goss (1)
Erin Miller (1)
Amy Weart (1)
Clifford Hancock (2)
Michael Lafiandra (1)
Gregory Freisinger (1)

(1) United States Military Academy (West Point, United States); (2) U.S. Army CCDC Soldier Center (Nadick, United States)

EMOTION RECOGNITION AND VIGILANCE IS COMPROMISED DURING MILITARY OPERATIONAL STRESS

PURPOSE

Military operational stress can be comprised of physical exertion, cognitive overload, sleep and caloric restriction. Cognitive readiness and resilience are warranted to optimize operational performance. This study aimed to identify cognitive domains most susceptible to military operational stress.

METHODS

Nineteen male Soldiers (255 years, 1776cm, 8113 kg, 187 BF%) completed a 5-day/night protocol simulating military operational stress. Subjects were given 50% of baseline caloric demands on Days 3 and 4. Subjects completed physical and cognitive evaluations from 0900 to 2230. Nights 3 and 4 included restricted sleep from 0100-0300 and 0500-0700, with subjects completing psychomotor evaluations between 0300-0500. Cognition was completed each morning at 0900. Cognition is a cognitive test battery developed by NASA that covers a range of cognitive domains including sensorimotor speed (MP), spatial learning and memory (VOLT), working memory (NBACK), concept formation (AM), spatial orientation (LOT), emotion recognition (ERT), #ABStract reasoning (MRT), complex scanning and visual tracking (DSST), risk decision making (BART) and vigilant attention (PVT). Performance scores are based on accuracy and response time correlated to a percentile position within a normative distribution, with a maximum score of 1,000. ANOVA or Friedman test with a Bonferroni correction for multiple comparisons were used appropriately ($p<0.05$, $p<0.008$, respectively). Day 1 scores were excluded from the analysis to account for learning effect.

RESULTS

ERT performance declined after one night of sleep restriction (2(3) =11.1, p=.011, Day 2: 417.8 295.3 vs. Day 3: 268.7 251.5, p=.007) and recovered by Day 5 (549.1 285.7, p=.002). PVT performance declined after two nights of sleep restriction compared to baseline (F(3,54)=12.1, p<.001, Day 4: 271.1 259.0 vs. Day 5: 432.5 242.7, p=.027), but rebounded with full recovery sleep on Day 5 (514.7 218.0, p=.001). Recovery sleep also improved VOLT performance compared to two nights of sleep restriction (F(3,54)=9.4, p<.001, Day 4: 647.1 100.6 vs. Day 5: 713.4 88.9, p=.004). No significant differences were observed in the other cognitive domains across the stress scenario.

CONCLUSIONS

Morning time emotion recognition and psychomotor vigilance were affected by simulated military operational stress. Other cognitive domains such as concept formation, spatial orientation, and #ABStract reasoning may be less affected by military operational stress.

OPERATIONAL RELEVANCE

Social cognition and vigilant attention may be more susceptible to military operational stress compared to other cognitive domains. Sufficient recovery sleep is warranted to restore performance in these cognitive domains.

AUTHORS

Meaghan Beckner (1)
Shawn Eagle (1)
Aaron Sinnott (1)
Alice LaGoy (1)
Shawn Flanagan (1)
Anne Germain (2)
Peter Roma (3)
Christopher Connaboy (1)
Bradley Nindl (1)

(1) Neuromuscular Research Laboratory/Warrior Human Performance Research Center, Department of Sports Medicine and Nutrition, School of Health and Rehabilitation Sciences, University of Pittsburgh (Pittsburgh, United States); (2) Military Sleep Tactics and Resilience Research Team, Department of Psychiatry, School of Medicine, University of Pittsburgh (Pittsburgh, United States); (3) Behavioral Health & Performance Laboratory, Biomedical Research and Environmental Sciences Division, KBR/NASA Johnson Space Center, Houston, TX (Houston, United States)

TS20.
COGNITIVE PERFORMANCE IN MILITARY PERSONNEL EXPOSED TO HARSH ENVIRONMENTS
#ABS363

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COLD NOISE: EX-GAUSSIAN ANALYSIS REVEALS SHIFTS, STRETCHING, AND INDIVIDUAL DIFFERENCES IN RESPONSE TIME DISTRIBUTIONS DUE TO COLD STRESS

PURPOSE

Cold water immersion (CWI) has the known mean effect of slowing response times (RTs). However, mean effects only show generic patterns and fail to account for variations across individuals. Understanding individual differences in RTs allows for better performance prediction. This requires more refined analysis. Therefore, ex-Gaussian and cluster analyses were used to dissociate subcomponents of RT distributions following CWI.

METHODS

Thirty-six military members completed a simple response task (SRT) pre-and post-cold water immersion (1°C). The SRT consisted of a stimulus presented in the center of the screen for 40 trials per condition. Participants were instructed to respond to the stimulus as quickly as possible. All stimuli timed out after 1000ms without a response. Response omission errors (~1% of all trials) were excluded. Ex-Gaussian and hierarchical clustering analyses were conducted in R using the retimes and cluster packages respectively. Ex-Gaussian analysis generates three parameters of interest: mu (), sigma (), and tau (). Mu and sigma approximate the mode and standard deviation of the Gaussian distribution, whereas tau represents the frequency of outliers.

RESULTS

Overall, ex-Gaussian analysis demonstrated pre-to-post increases in, $p < .001$;, $p < .001$; and, $p = .002$. Thus, the distribution of post-immersion RTs shifted, stretched, and contained more frequent extreme responses compared to the pre-immersion distribution. Next, clustering by ex-Gaussian parameters produced three distinct distributions (groups). The first distribution ($n = 8$) showed increases in each parameter (,,) (all ps $< .02$). The largest effect occurred in, followed by, then (i.e., RTs slowed while also increasing in variability and extremity). The second distribution ($n = 14$) similarly increased in all parameters, all ps$< .02$. In contrast, the largest effect was in, followed by then. The third distribution ($n = 14$) showed an increase in, $p < .001$, but no variation in, $p > .1$. Interestingly, this group showed a decrease in, $p = .02$, suggesting an overall decrease in distribution noise.

CONCLUSIONS

Our individual difference analysis of RTs provides a better view of performance patterns during CWI. These analyses can be developed to predict individual warfighters vulnerability to CWI.

OPERATIONAL RELEVANCE

Warfighters operating in austere settings risk degraded cognitive performance. Importantly however, cognitive degradation varies across contexts and individuals. Understanding the variety of performance outcomes in extreme cold environments is critical to the effective planning and execution of current and future operations.

AUTHORS

Timothy Dunn (1)
Dale Hirsch (1)
Dale Hirsch (1)
Weimin Zheng (1)
Andrew Ordille (1
Douglas Jones (1)
Stephan Eggan (1)
Nicholas Roberts (2)
Jay Heaney (1)

(1) Navy (United States); (2) Marine Corps (Bridgeport, United States)

IMPAIRMENT AND RECOVERY OF PSYCHOMOTOR TASKS DURING A MILITARY COLD WATER IMMERSION AND REWARMING EXERCISE

PURPOSE

Environmental insults, such as cold water immersion, can deteriorate aspects of performance that are essential to warfighter readiness. Operationally relevant processes such as cognitive throughput (speed and accuracy of information processing) and reaction time are degraded by cold sensation (distraction) and cold extremities (loss of dexterity), respectively. However, the sensitivity of cognitive throughput and reaction time to cold is not well-defined in operational settings. The purpose of this work, therefore, was to investigate the degree of impairment and recovery of cognitive throughput and reaction time during a military cold water immersion and rewarming exercise.

METHODS

Thirty-six military personnel (age: 28 ± 6 yr, ht: 176.5 ± 7.3 cm, wt: 79.8 ± 10.4 kg) participated in psychomotor testing during a cold (1°C) water immersion and rewarming exercise. Psychomotor testing consisted of tablet-based simple reaction time (SRT) and match-to-sample choice reaction time (CRT) tests, which were administered pre-and post-immersion, and following 60 min of passive rewarming (in a sleeping bag). Prior to each psychomotor assessment temperature perception, shivering sensation, mean skin temperature ($\bar{T}$sk), and core temperature (Tc) were obtained. Cognitive throughput (number of correct responses/test duration), CRT, and SRT were determined and analyzed using repeated measures analysis of variance (significance: $p < .05$). Data are presented as percent change from pre-immersion.

RESULTS

Cognitive throughput, CRT, and SRT performance were impaired following cold water immersion by-10% ($p < .03$),-20% ($p < .001$), and-42% ($p < .01$), respectively. Following 60 min of rewarming, however, only cognitive throughput performance recovered to pre-immersion levels (-1%, $p = 1.00$), whereas CRT (-8%, $p < .009$) and SRT (-16%, $p < .001$) performance remained impaired. Physiological and perceptual data indicate that temperature perception was reduced (-151%, $p < .001$), shivering sensation increased (256%, $p < .03$), and $\bar{T}$sk (-29%, $p < .001$) and Tc (-4%, $p < .001$) decreased as a result of cold water immersion. With the exception of Tc, all returned to pre-immersion levels following rewarming.

CONCLUSIONS

Findings suggest cognitive throughput is less sensitive to cold and recovers quicker compared with CRT and SRT, both of which require an element of dexterity. When exposed to cold in operational settings, warfighters should anticipate greater impairments in reaction time and dexterity-related tasks compared with tasks requiring more cognitive-related processes.

OPERATIONAL RELEVANCE

Warfighters that are able to anticipate performance impairments in operational settings can be better prepared and improve their readiness in cold environments.

AUTHORS

Douglas Jones (1)
Andrew Ordille (1)
Rebecca Weller (1)
Katherine Wilson (1)
Eric Duckworth (1)
Valerie Costantini (1)
Dale Hirsch (1)
Nicholas Roberts (2)
Jay Heaney (1)

(1) Naval Health Research Center (San Diego, United States); (2) Marine Corps Mountain Warfare Training Center (Bridgeport, United States)

THE IMPACT OF ENVIRONMENTAL STRESS ON COGNITIVE PERFORMANCE: COMMONALITIES AND POINTS OF DIFFERENCE

PURPOSE

Military personnel can be deployed in regions markedly different from their own, experiencing hot days, cold nights, and trips both above and below sea level. Despite these stressors, high-level cognitive and operational performance must be maintained. Understanding the impact of these stressors on cognitive and military task performance is important. Greater understanding allows performance decrements to be predicted and accounted for, and any potential strategies to overcome the negative effect(s) to be identified.

METHODS

A systematic review of Medline (PubMed), EMBASE (Scopus), PsycINFO, and Web of Science was conducted from inception to September 2018. Eligibility criteria included a healthy human cohort, an outcome of cognition or military task performance, and assessment of an environmental condition.

RESULTS

The search returned 113,850 records, of which 124 met the inclusion criteria. Thirty-one studies investigated the effect of heat on cognitive and military task performance. Performance in the heat appears to be influenced by the severity of heat stress, the duration of exposure, and the complexity of the task to be performed. Judgement is also impacted by heat with adverse changes to impulsivity and confidence in performance.

Twenty studies examined cold stress. More complex, military simulation tasks tended to be the activities in which performance was impaired. Whereas, like heat stress, tasks that were well-learned and practiced, and often simpler, were less affected.

Fifty-nine studies investigated altitude. Unlike cognitive performance under heat or cold stress, the severity and duration of time at altitude, rather than task complexity, appeared to have the greatest impact on cognition. Although performance tended to become more impaired with increasing altitude, the variation reported between the studies may arise from interindividual differences, with some individuals impaired at much lower altitudes than others.

Eighteen studies examined being below sea-level. Impairment in these studies is thought to be a consequence of the narcotic action of the inert gases, rather than simply increased pressure. In combination with the direct effects of gas narcosis, cognitive impairment may also arise from an emotional reaction to the dive. Greater impairments are observed during open water dives and in more anxious divers.

CONCLUSIONS

Several factors combine to determine the influence of environmental stress on cognitive and military task performance.

OPERATIONAL RELEVANCE

Extreme environmental conditions are often unavoidable. This review gives us a greater understanding of scenarios in which environmental stressors are likely to impair performance and we suggest strategies to minimize this effect.

AUTHORS

Kristy Martin (1)
Emily McLeod (1)
Julien Périard (1)
Ben Rattray (1)
Richard Keegan (1)
David Pyne (1)

(1) University of Canberra Research Institute for Sport and Exercise (Australia)

THE IMPORTANCE OF THE PERCEPTUAL COMPONENT OF THERMAL STRESS IN PHYSICAL AND COGNITIVE PERFORMANCE

PURPOSE

In addition to physiological strain, performing endurance exercise in the heat is associated with significant subjective thermal strain [1]. This strain is indicated by ratings of heat sensation, thermal discomfort and higher perceived exertion. Its possible role in the impairment of endurance performance in the heat is however often ignored. The aim of this study was to dissociate subjective thermal strain from the physiological strain normally experienced during endurance exercise in the heat, and test the hypothesis that subjective thermal strain, by itself, impairs endurance performance in a temperate environment.

METHODS

In 20 °C and 44% relative humidity, 12 endurance-trained athletes (1F 11M; mean ± SD; age: 27 ± 6 y; VO2max: 61 ± 6 ml/kg/min) performed a time to exhaustion (TTE) test in two different experimental conditions: with an electric heat pad applied to the subjects' upper back (HP) and control (CON: without heat pad). In both conditions, subjects cycled to volitional exhaustion at 70% of their VO2max. Cardiorespiratory, metabolic, thermoregulatory and perceptual responses were measured throughout the TTE test and compared at 0%, 50% and 100% isotime and at exhaustion.

RESULTS

TTE was reduced by 9% in HP (2092 ± 305 s) compared to CON (2292 ± 344 s; p=.023). The main effect of condition on thermal discomfort at isotime (p=.002), the effect of condition on thermal sensation at 0% isotime (p=.004) and the condition by isotime interaction on rating of perceived exertion (p=.036) indicated higher subjective thermal strain in HP compared to CON. None of the measured cardiorespiratory, metabolic and thermoregulatory variables differed significantly between conditions.

CONCLUSIONS

Our novel experimental manipulation (HP) was able to induce significant subjective thermal strain and reduce endurance performance in a temperate environment without inducing the general physiological strain normally associated with impaired endurance performance in the heat. These results suggest that subjective thermal strain is an important and independent mediator of the heat-induced impairment in endurance performance.

OPERATIONAL RELEVANCE

Perceptual responses to the heat play an important, independent role in the negative effects of heat on performance. Therefore, besides focusing on the physiological effects of heat to counteract the heat-associated performance impairments, a focus on the perceptual effects is also warranted (e.g. acute interventions like menthol spray or a more chronic intervention like perceptual heat-acclimatization protocols).

AUTHORS

Jeroen Van Cutsem (1)
Bart Roelands (2)
Kevin De Pauw (2)
Romain Meeusen (2)
Samuele Marcora (3)

(1) Vrije Universiteit Brussel, Belgium / VIPER Research Unit, Royal Military Academy, Brussels, Belgium (Belgium); (2) Vrije Universiteit Brussel, Belgium (Brussels, Belgium); (3) University of Kent at Medway, Chatham, UK (Chatham, United Kingdom)

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Contact: jeroenvancutsem@hotmail.be

TEMPORAL DYNAMICS OF COGNITIVE OPERATIONS DURING A MILITARY COLD WATER IMMERSION AND REWARMING EXERCISE

PURPOSE

Warfighters performance often slows in harsh environments as traditionally measured with response time (RT). While reflecting the cumulative duration of subprocesses, RT measurements are insufficient in providing insights into mechanisms underlying performance deterioration. Thus, understanding the degree to which each subprocess is affected is critical to develop strategies to improve performance. This study examined the effects of cold water immersion (CWI) on the timing of subcomponents of cognitive operations with electroencephalogram (EEG). Partitioning RTs by the timing of the neural correlates of evolving cognitive subprocesses reveals dynamics of cognitive operations in the brain and provides scientific bases for mitigating performance declines in harsh environments.

METHODS

Twelve military personnel (age: 29 ± 6 yr) participated in psychomotor testing during a 1°C CWI and rewarming exercise. Testing consisted of simple reaction time (SRT) and match-to-sample memory (MTS) tasks performed in seven environmental conditions: baseline (indoors), pre-immersion, CWI, post-immersion, and at 0, 15, and 60 min of rewarming. EEG was recorded during each condition. Stimulus-locked and response-locked lateralized readiness potential (LRP) latencies were analyzed to assess the effects of cold exposures on cognitive operations. Repeated measures analysis of variance was used to examine differences in LRP latencies.

RESULTS

Mean ± SD SRT response-locked LRP latencies increased ($p < .005$) during immersion (144 ± 36 ms), post-immersion (141 ± 31ms), and 0 min rewarming (150 ± 20 ms) compared with baseline (134 ± 29 ms); stimulus-locked LRP latencies increased ($p < .005$) only during immersion (351 ± 97 ms) compared with baseline (284 ± 54 ms). In the MTS task, response-locked LRP latencies during immersion were longer than baseline, but not statistically significant; stimulus-locked LRP latencies during immersion (351 ± 97 ms) were significantly longer ($p < .005$) than baseline (301 ± 49 ms) and post-immersion (265 ± 37 ms).

CONCLUSIONS

Stimulus-locked LRP latency indicates time lapse between stimulus perception and motor response selection. Increased latencies during immersion suggests that cognitive processes of stimulus perception and motor response selection were prolonged. Response-locked LRP latency represents time lapse between motor programming, preparation, and execution. Latency increase during immersion strongly implies that cold exposure slowed brain cognitive processes in the final stages of motor responses. These prolonged subcognitive processes could thus contribute to the observed slowdown of warfighters performance in harsh environments.

OPERATIONAL RELEVANCE

Warfighters who are able to anticipate performance impairments can be better prepared for military operations in cold environments.

AUTHORS

Weimin Zheng (1)
Andrew Ordille (1)
Douglas Jones (1)
Timothy Dunn (1)
Trevor Viboch (1)
Paula Poh (1)
Stephen Eggan (2)
Nicholas Roberts (3)
Jay Heaney (2)

(1) Naval Health Research Center and Leidos (San Diego, United States); (2) Naval Health Research Center (Bridgeport, United States); (3) Marine Corps Mountain Warfare Training Center (San Diego, United States)

THE ROLE OF VITAMIN D IN MUSCULOSKELETAL INJURY RISK

PURPOSE

Musculoskeletal injuries (MSkI) are the leading cause of lost training days and medical discharge in military personnel. Musculoskeletal injuries are a significant financial and manpower burden for defence forces worldwide and can compromise operational readiness. The risk factors commonly reported in military recruits include younger and older age, female sex, and a history of low physical activity levels, smoking and injury. Emerging, modifiable risk factors such as vitamin D status are less well studied, but restoring hypovitaminosis D may benefit most, if not all, personnel, at some point during a military career. This paper will discuss the prevalence of vitamin D deficiency, the contribution of vitamin D status to MSkI risk, and effects of supplementation on injury prevalence in military populations.

METHODS

Published literature on vitamin D and military training and operations was retrieved from PubMEd and Google Scholar databases. Grey literature was obtained from unpublished academic and military sources.

RESULTS

Vitamin D status demonstrates a seasonal trend, with highest total 25(OH)D in the summer and lowest in the winter. Vitamin D deficiency, 25(OH)D 50 nmol·L-l [20 ng·mL-l], was associated with stress fracture risk during arduous military training (OR 1.6 (95% CI 1.0, 2.6)). In a meta-analysis of 2634 military personnel, the mean difference in serum 25(OH)D was lower in 761 stress fracture cases compared with controls (2.44 ng·mL-l (-4.05,-0.84)). A recent, unpublished study in military recruits observed increased bone stress injury risk (OR 3.7 (1.46, 9.47)) in recruits with 25(OH)D 50 nmol·L-l and an increased ratio (>100 vs <100) of 1,25(OH)2D to 24,25(OH)2D. A daily oral vitamin D (1000 IU) and Ca (2000 mg) supplement vs placebo reduced stress fracture risk by 20%, and improved bone health indices, during 8-weeks of initial military training.

CONCLUSIONS

Vitamin D deficiency may play an important role in stress fracture, but not overall MSkI, risk, supporting prevailing classical effects on bone health. There is emerging evidence that bone stress injury risk in vitamin D deficient groups is influenced by the relative proportion of the biologically active 1,25(OH)2D to the catabolic metabolite 24,25(OH)2D, but further work is required to confirm this association. Daily vitamin D supplements (1000 IU) with calcium (2000 mg) restore 25(OH) D concentrations, decrease stress fracture risk and improve bone health indices in some populations.

OPERATIONAL RELEVANCE

Militaries should consider vitamin D supplementation during arduous training, particularly in winter or for those based at higher latitudes.

AUTHORS
Julie Greeves (1)
(1) UK MOD (United Kingdom)

PREVALENCE OF MUSCULOSKELETAL INJURY AND RELATIONSHIP TO ANNUAL FITNESS SCORES IN MARINE CORPS RECRUITS

PURPOSE

The purpose of this effort was to examine the relationships between scores on annual USMC required fitness tests with injury frequency and type.

METHODS

Archival data from 2011-2016 was reviewed and included 43,004 observations from 28,829 unique individuals. Prevention program data and injury data within the Marine Corps Training Information Management System was searched to determine the prevalence of reported MSKI among male Infantry Marines recruits at the Marine Corps Recruit Depot (MCRD). The data were stratified by injury type, such as stress fracture, fractures and soft-tissue injuries (sprains and strains). Injuries were also classified as traumatic, new overuse or a pre-existing overuse injury. The injury data were studied in the context of each physical fitness test conducted at MCRD.

RESULTS

The most common injuries were described as sprain, strain and stress fractures with 17%, 13% and 11% prevalence rates, respectively. Further specification determined these injuries to be related to new overuse (36-61%) or traumatic in nature (28-40%). Conditioning hikes were highlighted as being the primary causes of injuries with 31% of the injuries related to the hike. Running claimed 12% of reported injuries. No statistically significant differences were observed between injured and uninjured Marines on tasks that primarily depended on upper body strength (pull-ups and ammunition can lift) and core endurance (crunches). However, running events exhibited statistically significant differences ($p < 0.05$) between injured and uninjured Marines.

CONCLUSIONS

Most injuries sustained by Marines during basic training comprised sprains and strains. Moreover, across the three fitness tests conducted at MCRD, Marines who remain uninjured during basic training typically outperformed Marines who reported at least one injury, which included higher overall composite scores for each fitness test and faster run times. Follow-up analyses will examine (1) whether specific MCRD training events/subevents resulted in higher injury rates; (2) whether injury rates can be predicted from performance on specific fitness test components; and (3) whether the specific period during training when an injury occurs (e.g., early or later in training) adds value to the developing predictive model of injury risk.

OPERATIONAL RELEVANCE

This data demonstrates that injuries are most likely due to aerobic conditioning and extended duration tasks, such as running and conditioning hikes, rather than more static, strength-based events.

AUTHORS

Karen Kelly (1)
Andrew Jensen (2)
Brenda Niederberger (2)
Melissa Laird (1)
Jason Jameson (2)

(1) Naval Health Research Center (United States); (2) Naval Health Research Center-Leidos (San Diego, United States)

INFLUENCE OF TRAINING LOAD ON INJURY RISK DURING BRITISH ARMY OFFICER CADET INITIAL MILITARY TRAINING

PURPOSE

The influence of training load on injury risk has been investigated in high performance sport, providing practitioners with prescription guidelines to attenuate injury incidence. To date, this has not been investigated during military training. The aim of this study was to examine training load and injury risk during British Army Officer Cadet (OC) initial training.

METHODS

Sixty-three (43 male, 20 female; 24 ± 2 y; 1.76 ± 0.09 m; 79.1 ± 10.8 kg) OCs undergoing 44 weeks of training at the Royal Military Academy Sandhurst (RMAS) volunteered to participate. Weekly training load (cumulative 7-day) was monitored using a wrist-worn accelerometer (GENEActiv, UK). Moderate-vigorous physical activity (MVPA) and the ratio between MVPA and sedentary-light PA (SLPA [MVPA:SLPA]) were used to investigate the influence of training load on injury risk. Self-report injury data were combined with musculoskeletal injuries recorded at the RMAS medical centre. Training loads were split into quartiles with the low load group used as the reference to enable the comparison of injury risk between training load levels using Odds Ratios (OR) and 95% confidence intervals (95% CI).

RESULTS

Ratios of MVPA to SLPA quartiles were low (<0.41), low-moderate (0.41-0.46), moderate-high (0.47-0.52) and high (>0.52). Compared to low load, likelihood of injury (OR; 95% CI) was not significantly greater in the low-moderate quartile (1.14; 0.66-3.02, p>0.05). Likelihood of injury significantly increased with exposure to high-moderate (2.05; 1.01-4.16, p=0.031) and high loads (2.39; 1.20-4.78, p<0.001). These results were reflected in #ABSolute training load minutes alone, with high-moderate (1242-1454 mins; 2.29; 1.14-4.58) and high (>1454 mins; 2.09; 1.04-4.22) weekly MVPA exposure significantly increasing odds of injury above low load (<996 mins; p<0.05). Injury likelihood was not significantly greater in the low-moderate quartile (996-1241 mins; 1.30; 0.62-2.76, p>0.05).

CONCLUSION

Exposure to high-moderate or high MVPA:SLPA increased odds of injury by 2-4.5 fold, suggesting that the ratio of workload to recovery is important for mitigating injury occurrence. Similarly, exposure to high-moderate or high weekly MVPA approximately doubled the odds of injury. Limiting weekly MVPA to ~1240 minutes, accompanied by 2750 minutes of SLPA, ensuring MVPA:SLPA is 0.45, may be an appropriate target for reducing the likelihood of injury during OC initial military training.

OPERATIONAL RELEVANCE

This research provides guidelines for training load prescription in initial military training which may attenuate injury risk.

AUTHORS

Steven Powell (1)
Stephen Myers (1)
Andy Siddall (1)
Sarah Needham-Beck (1)
Victoria Edwards (1)
Sarah Jackson (2)
Julie Greeves (2)
Sam Blacker (1)
Steve Myers (1)

(1) Occupational Performance Research Group, University of Chichester (Chichester, United Kingdom); (2) Department of Army Health and Physical Performance Research, Army HQ (Andover, United Kingdom)

MEASURING OVERTRAINING MARKERS TO PREDICT INJURY IN MILITARY PERSONNEL

PURPOSE

To determine the efficacy of measuring functional assessments and pro-inflammatory cytokines as tools to identify the risk of musculoskeletal injuries (MSKI) in U.S. Service Members (SMs).

METHODS

SMs (goal: N = 50) who are engaged in an exercise program (of varying exercise intensities to encompass a wide range of responses), either with their unit or individually, at least 3 times a week per Department of Defense policy, will be enrolled for 4 weeks. Functional movement screen (FMS), Y-balance test lower quarter (YBLQ), ankle dorsiflexion range of motion (AD-ROM), and urine samples are conducted pre-and post-study enrollment. SMs are also instructed to collect at-home urine specimens each week (one 1-2h post-exercise, and one 22-24h post-exercise) for a total of 8 samples. SMs will complete weekly logs that track sleep, training disposition, and new onset of MSKI (as is routine of reporting MSKI). Pro-inflammatory cytokines and cytokine by-products (neopterin, serotonin, cortisol, tryptophan, kynurenine, melatonin) will be measured from urine samples to examine changes between subsequent days and weeks.

RESULTS

The primary outcome is new onset MSKI, and will be described by injury type and severity. Adjusted analyses will include Cox proportional hazard regression and include cumulative injury incidence defined as the proportion of participants who reported MSKI. The injury incidence rate will be the proportion of participants with 1 MSKI divided by the cumulative time in training for all participants. A chi-square statistic will be used to investigate differences in injury risk by FMS total score and established cut-off values associated with risk of MSKI1,2. Based on published data from military cohorts1 and normative values from healthy non-injured populations2, it is expected that individuals who report an MSKI during enrollment will have FMS score 14. Overtraining will be assessed using separate logistic regression analyses to investigate the association between injury, sleep, exercise and healthy history, and functional assessments by cytokine levels. Urinary cytokine levels are expected to increase in those reporting MSKI during enrollment.

CONCLUSIONS

Results of this study will help determine proof of concept and lend support for establishing recommendations to reduce injury risk during training or exercise of SMs.

OPERATIONAL RELEVANCE

Signs of overtraining via biomarkers or other health assessment may assist U.S. SMs in modifying field activity training programs to reduce the risk of musculoskeletal injuries.

AUTHORS

Paula Poh (1)

Pinata Sessoms (2)

Daniel Trone (2)

(1) Leidos, Inc., Naval Health Research Center (San Diego, United States); (2) Naval Health Research Center (San Diego, United States)

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PREVALENCE OF MUSCULOSKELETAL INJURY RATES: FACTORS TO CONSIDER WHEN MAKING COMPARISONS ACROSS NATIONS

PURPOSE

The first step in developing and initiating strategies for the reduction and prevention of musculoskeletal injuries (MSKIs) is to understand what the current prevalence and incidence rates are to establish a baseline to assess success of these strategies. One of the first steps in the NATO Research Task Group (RTG) 283 effort is to identify if there were similarities or differences in rates of MSKI across the NATO nations, to use as indicators for possible strategies guidance.

METHODS

NATO RTG 283 nation members (from Belgium, Canada, Germany, Latvia, Netherlands, Slovenia, United Kingdom, and United States) provided details on the rates of MSKI for their nation, following their respective countrys protocol for determining rates. These data were then compared and contrasted to identify patterns.

RESULTS

In comparing the MSKI rates across the NATO nations, there were some similarities, in that the most common MSKIs tended to be those of the lower extremities, and the MSKI rates, at least for some injury locations, tended to significantly differ between males and females. However, overall, it was not possible to combine information and present a summary of the differences. Reasons were that i) not all nations have military medical record systems that allow for complete capture of injuries (either acute and/or overuse), ii) there is no consistent injury coding system applied among all nations, and iii) some nations have only data from self-reported rates of MSKIs among military subgroups and thus not necessarily comparable to medical encounter MSKI rates.

CONCLUSIONS

Several recommendations to permit injury data and rate metrics comparisons across nations include: identification of key common data elements or metrics such as a decision to adopt common diagnosis coding (such as ICD10) and common definitions for terms (such as for acute and overuse injuries) and determination of effective ways to account and include MSKIs that may not be reported to medical providers. In the #ABSence of common metrics across NATO countries, it is recommended that research designs evaluating MSKI reduction intervention or strategies determine nation-specific baseline MSKI rates or include control/comparison group in order to accurately assess whether interventions work and to improve the applicability of the information learned to other nations.

OPERATIONAL RELEVANCE

MSKIs, occurring during training or preparation for operations, are the primary reason why NATO military personnel are unable to deploy on operations. The identification of common approaches across nations are key to cross-sharing of successful MKSI prevention strategies.

AUTHORS

Susan Proctor (1)

(1) US Army Research Institute of Environmental Medicine (Natick, United States)

MUSCULOSKELETAL MODELING AND SIMULATION OF MILITARY LOAD CARRIAGE

PURPOSE

Musculoskeletal injury to the lumbar spine is one of the most prevalent medical issues among military service members. Heavy pack loads regularly carried on the back of warfighters are associated with higher rates of overuse injuries. Trunk muscle activity may be affected by the placement and attachment of the external load (e.g., implementation of a hip belt vs. only shoulder straps). Muscle and joint contact forces are important metrics in understanding overuse injury, but they cannot be measured directly. Therefore, we developed and evaluated a musculoskeletal model as a tool to investigate the effects of backpack design on these internal forces.

METHODS

A musculoskeletal model with detail of the lumbar spine was developed in OpenSim software v3.3. Backpack attachments to the torso and pelvis were modeled as passive linear spring and damper pairs. We created simulations of loaded walking (~18 kg) using previously collected motion capture data of six active duty U.S. Marines to estimate muscle and joint contact forces. We performed a sensitivity study of the model using Monte Carlo sampling from probability distributions of stiffness (normal ~5060±978 Nm^-1) and damping (log-normal ~320±125 Nsm^-1) of backpack attachments. Each attachment parameters influence on lumbar force was calculated. Variation in lumbar joint contact forces as a result of overall variations in attachment parameters was quantified using coefficients of variation to provide a measure of model robustness.

RESULTS

The model effectively reproduced the kinematics of loaded walking. Nearly even load distribution between the torso (99.01±11.16 N) and pelvis (92.82±10.92 N) backpack attachments was achieved. Lumbar force coefficients of variation were low (2.85% in anterior force and 1.04% in vertical force). Vertical stiffness parameters for the torso and pelvis backpack attachments had the greatest influence on lumbar forces. Greater torso and pelvis attachment stiffness corresponded to larger and smaller lumbar forces, respectively.

CONCLUSION

We successfully implemented a backpack with load distribution between the pelvis and torso within a musculoskeletal model. The sensitivity study results suggest that outcome measures are robust to uncertainty in model definition, which is important because effective stiffness of backpack attachments can be influenced by the wearer.

OPERATIONAL RELEVANCE

Quantification of internal joint and muscle forces under different loading conditions can help identify causes of musculoskeletal injury and lead to improvements in equipment design. Musculoskeletal modeling and simulation approaches are critical for estimating these internal forces and can be used to evaluate pack design or carry method prior to field testing.

AUTHORS

Jordan Sturdy (1)
Pinata Sessoms (2)
Anne Silverman (1)

(1) Colorado School of Mines (Golden, United States); (2) Naval Health Research Center (San Diego, CA, United States)

THE LONG-TERM IMPACT OF INJURIES ENCOUNTERED DURING BASIC MILITARY TRAINING

INTRODUCTION

Injuries during basic military training (BMT) are highly prevalent due to unaccustomed exercises realized with unaccustomed equipment in an unaccustomed environment for an unaccustomed long period. These injuries are up to three times higher during BMT than injuries experienced further in the military career. Many risk factors are identified but few have been tackled efficiently in BMT. Of all injuries, the most injured anatomic location is the lower extremity, followed by the low back. Incidence varies between 16 and 76%. In 66% of the cases, a first time occurrence of the injury is described during BMT. As one knows that the major risk factor for sports and other injuries is a previous injury, we hypothesized the injuries encountered during BMT could have a major impact on the subsequent military career.

METHODS

a survey was sent out to military personnel who went through BMT between 2007 and 2010. Data were collected on the injuries sustained during BMT and during their subsequent military career.

RESULTS

93 (10 female and 83 male soldiers) questionnaires were analyzed. 45% reported an injury during BMT of which 57% were overuse injuries, 36% traumatic musculoskeletal injuries and 7% other injuries. The soldiers report that in 84% of the cases, it was a first time injury and 60% were put on a temporary profile due to their injuries. 69% of the injured soldiers report to suffer from the sequels of this first injury during the past decade, where the rest indicate the issue was resolved with or without the help of physiotherapy on base.

DISCUSSION

The injuries during BMT receives quite a lot of attention in all military services all over the world. Many studies, both observational and interventional, have been conducted to tackle the issue. This survey confirms what is known in sports medicine about a previous injury being a major risk factor for future injuries. This emphasize the importance of prevention of injuries during BMT as it could compromise future careers and the physical readiness and performance of the armed forces.

AUTHORS

Damien Van Tiggelen (1)
Yente Wittevrongel (1)
Eric Bernard (1)

(1) Belgian Defense, Military Hospital Queen Astrid (Brussels, Belgium)

TREATMENT AND PREVENTION OF EXERCISE RELATED LEG PAIN IN YOUNG SOLDIERS

Exercise related leg pain (ERLP) is a common problem for young soldiers and has a large impact on military training. Despite the identification of many risk factors for ERLP, the incidence of these injuries does not go down significantly. In The Royal Netherlands Armed Forces the three most common diagnoses in the ERLP group are: 1. Medial Tibial Stress Syndrome (MTSS); 2. Chronic exertional compartment syndrome (CECS); and 3. A combination of both MTSS and CECS. From 2011 onward consecutive studies have been launched from the Sports Medicine to improve the conservative treatment results for MTSS and CECS (secondary prevention). The effects of sport-compression-stockings, extra-corporeal shockwave treatment and gait retraining in shoes and military boots will be introduced. In addition to less running and more sleep, gait retraining may be the most promising intervention to prevent ERLP in the military.

AUTHORS

Wes Zimmermann (1)

(1) Royal Netherlands Armed Forces (Amersfoort, Netherlands)

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PHYSICAL ACTIVITY MONITORING TO QUANTIFY TRAINING LOAD AND INFORM INJURY PREVENTION STRATEGIES

PURPOSE

Physical activity monitoring is routinely used for research in military settings to profile training courses, deployments and daily living. Elite sports teams now routinely monitor players physical activity during all training and competition to try to manage training load, improve physical performance and mitigate injury incidence. Method: This paper presents a summary of a review of extant literature to summarise the considerations for quantifying training load using physical activity data in military settings to develop injury prevention strategies.

RESULTS

Inadequate training loads may not result in the required level of physiological strain to promote adaptations to training, whereas excessive training loads may predispose an individual to a greater risk of injury and illness. Broadly, training loads can be defined as internal (measure of the relative biological stressors imposed on the individual, e.g. heart rate) or external (a measure of the #ABSolute amount of work performed by the individual e.g. movement measured by global positioning systems or accelerometry). Data gathered though these methods can be used to quantify the daily demand of training and be expressed relative to previous training loads (e.g. week-to-week change). These data have the potential to be used prospectively, to identify and manage individuals who are potentially at risk of injury, or retrospectively, by identifying thresholds of training loads associated with increased injury risk and, alongside traditional techniques, to identify risk factors for injury. However, training load monitoring is reliant on user compliance (i.e. individuals wearing devices or completing questionnaires) and can be resource-intensive where data capture and management tools need to be implemented and end-users educated in how to interpret and use data. These challenges are apparent in sports settings and are likely to be amplified in the military where physical activity exposure is likely to be more varied, sporadic and in larger cohorts. Nevertheless, the development of new technology to quantify physical activity alongside automated data capture and analysis techniques provide the basis to potentially implement training load monitoring systems in military settings.

CONCLUSIONS

Quantifying training load using physical activity monitors in the military setting could be used to inform prospective and retrospective injury prevention strategies. Although this is potentially resource-intensive, the development of new technology and analysis techniques offer the potential to quantify acute and chronic physical activity exposure and inform strategies to mitigate injury risk which can complement and enhance existing injury prevention strategies.

AUTHORS

Sam Blacker (1)
Steven Powell (1)
Andrew Siddall (1)
Stephen Myers (1)

(1) University of Chichester (Chichester, United Kingdom)

CAUSES OF INJURY AND ASSOCIATED DAYS OF LIMITED DUTY AMONG SOLDIERS IN THE U.S. ARMY

PURPOSE

To identify the causes of injuries among Soldiers and associated amounts of limited duty time.

BACKGROUND

To improve Soldiers health and performance, the U.S. Army Public Health Center (APHC) applies the five step public health process which answers five key questions: 1) Is there a problem? 2) What causes the problem? 3) What works to prevent the problem? 4) Who needs to know and do what? 5) Did the intervention work? This presentation will focus on answers to the first two questions.

METHODS

APHC merged medical surveillance data with self-reported survey data to characterize the magnitude and causes of the Army injury problem. Results include number of medical encounters (visits), number of Soldiers affected, and amounts of associated limited duty days prescribed by health care providers.

RESULTS

Soldiers made over 2 million medical visits for treatment of injuries in 2017, 41% of all visits. The next leading cause, mental health, only accounts for 18%. Data indicates Soldiers annually experience more than 10 million days of restricted/lost duty due to injury. Over 60% of all limited duty for medical conditions is due to musculoskeletal (MSK) injuries. Leading injury causes in the Armys medical surveillance system: running (37%), work-related tasks (17%), falls (12%), parachuting (11%), and road marching (6.3%). Several survey-based field investigations have found similar results. An investigation of male infantry Soldiers found leading injury causes were (% of injuries, mean number of limited duty days): running (32%, 38 days), lifting heavy objects (13%, 34 days), road marching/hiking (11%, 40 days), sports (10%, 42 days), non-running physical training (8%, 35 days). Another investigation of male air assault infantry Soldiers reported leading injury causes and days of limited duty were: running (30%, 42 days), marching with a load (14%, 38 days), weight-training (9%, 45 days), sports (8%, 39 days), and lifting heavy objects (8%, 47 days).

CONCLUSIONS

APHC application of the public health process demonstrates that injuries are the leading cause of Army medical encounters and limited duty. Consistent with the literature, most injuries are MSK-related, and are primarily due to overuse. Multiple studies show that running, lifting and marching are important causes of injuries.

OPERATIONAL SIGNIFICANCE

to improve combat readiness, military public health and research strategies should focus on finding what works to prevent injuries due to these causes.

AUTHORS

Bruce Jones (1)
Michelle Chervak (1)
Michelle Chervak (1)
Keith Hauret (1)
Veronique Hauschild (1)

(1) U.S. Army Public Health Center (Aberdeen Proving Ground, United States)

RELATIONSHIP OF MUSCULOSKELETAL INJURIES, PHYSICAL FITNESS, AND MILITARY PERFORMANCE IN THE U.S. ARMY

PURPOSE

To describe relationships between musculoskeletal injuries (MSKIs), physical fitness, and performance of physically demanding tasks and soldier skills.

METHODS

Summarize findings from integrated medical surveillance databases, surveys, and studies to describe relationship between injuries, physical fitness and military performance.

RESULTS

Soldiers must be operationally ready and physically able to perform essential physically demanding tasks whenever and wherever called upon. Training to achieve and maintain this operational readiness has unintended consequences including injuries. In 2017, 54% men and 66% of women in the U.S. Army had a least one MSKI, resulting in 10 million days of limited duty. Depending on type of unit and training, up to 80% of MSKIs are overuse (e.g., due to cumulative microtrauma) injuries. Leading MSKI-related activities are running (37%), job-specific tasks (17%), marching with a load (e.g., load carriage; 13%), and slips/falls (6.3%).

To reduce the burden of MSKIs, an evidence-based approach to physical training is required. There is strong and consistent evidence that lower levels of aerobic fitness are associated with higher injury risks; however, relationships between muscular strength or power and injury risk are weaker and less consistent. The stronger associations between aerobic fitness and injury risk may reflect the importance of aerobic capacity when performing multiple soldier skills and physically demanding tasks in succession at a moderate-to-high intensity during training or military operations.

Studies show that aerobic fitness in combination with other components of fitness are required to perform common soldier skills and physically demanding tasks in a field/operational setting. A systematic review and meta-analysis highlighted that the strongest relationships between components of physical fitness and performance on military-relevant tasks were with aerobic fitness, followed by muscular strength and muscular endurance. This finding was supported by an Army study that evaluated relationships between Soldiers fitness on 23 physical fitness assessments and performance on a timed-course of physically demanding Soldier tasks. The final model that predicted time to complete the course included 2 assessments of muscular power (sled drag and medicine ball power throw), and an assessment of muscular strength (hexbar deadlift), aerobic fitness (2-mile run), and speed-agility (400 m sprint).

CONCLUSION

Physical training programs to mitigate injury risk and improve soldier performance should include aerobic fitness, muscular power and strength, and speed-agility, but should be balanced to avoid injury.

OPERATIONAL RELEVANCE

Leaders must apply evidence-based principles of physical training to develop a fit and operationally ready military.

AUTHORS

Keith Hauret (1)
Joseph Pierce (2)
Bruce Jones (1)

(1) U.S. Army Public Health Center (Monrovia, United States); (2) U.S. Army Public Health Command (Aberdeen Proving Ground, MD, United States)

DESCRIPTIVE EPIDEMIOLOGY OF MUSCULOSKELETAL INJURIES AMONG NAVAL SPECIAL WARFARE PERSONNEL

PURPOSE

The aim of this analysis was to describe the incidence and common types of musculoskeletal injuries (MSI) among two groups of active-duty Naval Special Warfare (NSW) personnel: Sea, Air, and Land (SEAL) Operators and students, and Special Warfare Combatant-craft Crewman (SWCC) Operators and students.

METHODS

In this descriptive cross-sectional study, MSI recorded in medical charts during a one-year period were described and classified by frequency, anatomic location, cause, type, and activity during MSI. Statistical analysis consisted of calculation of relative frequency of MSI in each category. The total lifetime cost (sum of medical and work loss cost) of these MSI was estimated using the Web-based Injury Statistics Query and Reporting System Cost of Injury Reports (WISQARS, 2019).

RESULTS

MSI data were available for 202 SEAL (age: 25.8±4.4 years, height: 1.8±0.1 meters, weight: 85.4±8.8 kilogram) and 202 SWCC (age: 24.5±4.6 years, height: 1.8±0.1 meters, weight: 83.0±8.6 kilograms) personnel. MSI frequency was 15.8 and 26.7 MSI/100 personnel/year among SEAL and SWCC, respectively. The most common anatomic location was the upper extremity (43.8% of MSI) among SEAL and lower extremity among SWCC (42.6%). The most frequent anatomic sub-locations varied across groups (SEAL: shoulder, 25.0%, SWCC: lumbo-pelvic region of spine, 18.5%). The most frequent recorded cause of MSI was lifting among SEAL (28.1%) and lifting and running (each 20.4%) among SWCC. Most lifting related MSI (85.0%) occurred during weightlifting as a part of physical training. Physical training was the most common activity at the time of MSI (SEAL: 43.8%, SWCC: 33.3%). Pain/spasm/ache without further elucidation of pathology was the most common MSI type in SEAL (28.1%) and SWCC (29.6%). The cost of these MSI that occurred during a one-year period was estimated to be approximately $2.1 million in 2019 U.S. dollars.

CONCLUSIONS

MSI, especially those affecting the shoulder and lumbo-pelvic spine, cause morbidity and financial cost among NSW SEAL and SWCC Operators and students. These MSI are likely a result of the intense physical activity that NSW personnel undertake to be able to meet occupational demands.

OPERATIONAL RELEVANCE

MSI result in financial cost and morbidity among active-duty NSW personnel. There is a potential to test the effectiveness of a customized training program to optimize ergonomics during physical activity and operational tasks, especially during lifting and physical training, to mitigate MSI risk.

AUTHORS

Mita Lovalekar (1)
Caleb Johnson (2)
Karen Keenan (3)
Bradley Nindl (1)
Kim Beals (1)

(1) University of Pittsburgh (Pittsburgh, United States); (2) Harvard Medical School (Cambridge, United States); (3) Fitchburg State University (Fitchburg, United States)

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A MACHINE LEARNING ALGORITHM TO ENHANCE DECISION MAKING IN THE MANAGEMENT OF MEDIAL TIBIAL STRESS SYNDROME

PURPOSE

Medial Tibial Stress Syndrome (MTSS) has been identified as the most costly musculoskeletal injury (MSKI) to the British army. There is no reliable treatment for MTSS and reoccurrence rates are high. Prevention of MTSS is critical to reducing operational burden. Typically injury prediction is complex, multivariate, and has not been capable of discerning individual level risks. This study investigated the accuracy of a machine learning approach that combines best known risk factors into an individual risk profiling tool for a common MSKI.

METHODS

Using a prospective design, this study combined 10 risk factors identified in 2 previous systematic reviews, to determine the predictive accuracy of an ensemble of machine learners. Data was obtained from 123 recruits (28 females and 95 males). Follow-up was conducted at 3 months to determine those in the group that had developed MTSS. Four ensemble learning algorithms-logistic regression (LR), k-nearest neighbours (kNN), Naïve Bayes (NB) and Decision Tree (Tree) were deployed and trained 5 times on random stratified samples of 75% of the dataset. The resultant algorithms were tested on the remaining 25% of the dataset and the models were compared for classification accuracy, precision and recall. Where possible, visualisation tools were created to determine the utility of the resultant algorithms.

RESULTS

Ranked classification accuracy was (Tree= 0.987, NB=0.897, LR=0.800, kNN=0.755).

Models ranked by precision were (LR=1.000, Tree=0.952, NB=0.740, kNN=0.556).

Models ranked by recall were (Tree= 0.987, NB=0.925, kNN=0.250, LR=0.225).

Tree visualisation tool provided cut points to classify likely MTSS sufferers, and identify thresholds for high and low risk profiles. NB visualization tool demonstrated useful capacity to model the effects of risk interventions in MTSS, allowing for a context of modifiable and non-modifiable factors.

CONCLUSIONS

Tree and NB model analyses offer accurate individual level risk predictions as well as the capacity to model the effects of risk modifications for MTSS. These predictive models provide military institutions, clinicians and instructors with a strong and accurate calculator for predicting an individual recruits risk of MTSS. Further research must determine the generalizability of these findings.

OPERATIONAL RELEVANCE

Accurate identification of individuals at risk of MTSS is an important advance in the management of this difficult and costly problem.

The ability to mitigate occupational risk is increasingly a responsibility of commanders and trainers. MSKI is often complex and multifactorial, making prediction and management arduous. Machine learning methodologies can provide decision makers with better tools for MSKI control.

AUTHORS

Phil Newman (1)
Jeremy Witchalls (1)
Cameron Garnock (2)

(1) University of Canberra (Canberra, Australia); (2) Royal Australian Navy (Canberra, Australia)

MUSCULOSKELETAL INJURIES RECEIVING LOST DUTY DAYS IN THE U.S. ARMY FROM 2017-2018

PURPOSE

Musculoskeletal injuries (MSKIs) are the leading cause of Army limited duty days (LDDs). The study purpose was to determine type and mechanisms of injury (MOIs) for MSKIs receiving LDDs in active duty (AD) Soldiers during 2017-2018 to guide future evidence-based strategies to improve performance and readiness.

METHODS

All 2017-18 AD data from the LDD system (eProfile) were combined to determine total LDDs per MSKI type. Descriptive statistics and incident injury rates (IIR) were calculated and comparisons were made to Health of the Force (HOF) Army metrics which use ICD-10 codes medical visits to define MSKI. These data were reported in the HOF (https://phc.amedd.army.mil/topics/campaigns/hof) and resulted in an IRR of 1,399 per 1,000 Soldier-years in 2017 and 1,821 per 1,000 Soldier-years in 2018.

RESULTS

In 2017, 97,872 of 465,295 Soldiers (21%) suffered a MSKI with 10,332,775 LDDs (average of 77 LDDs/MSKI). The IIR was 287 per 1,000 Soldier-years. The highest incident MSKIs involved the knee, 22% (48,515 MSKIs with 2,549,513 LDDs (average of 53 LDDs/MSKI) and the primary MOIs were running, team sports, and fall/trip); next was the ankle/foot, 20% (44,063 MSKIs with 1,926,089 LDDs (average of 44 LDDs/MSKI) and the primary MOIs were running, fall/trip, and team sports); and the lumbar spine, 15% (31,867 MSKIs with 1,919,841 LDDs (average of 60 LDDs/MSKI) and the primary MOIs were running, occupational lifting, and physical training (PT)). While the shoulder was ranked fourth in MSKI frequency, the average LDDs/MSKI was 62.

In 2018, 112,959 of 465,590 Soldiers (24%) suffered a MSKI with 10,322353 LDDs (average of 65 LDDs/MSKI). The IIR was 343 per 1,000 Soldier-years. The pattern of MSKIs in 2018 was similar to 2017, the most injured body regions were the knee, ankle/foot, and lumbar spine with similar MOIs.

CONCLUSIONS

Higher incident rates of MSKIs are produced when examining medical visit versus LDD data systems, as not all MSKI receiving medical visits result in LDDs. Additionally, although MSKIs involving the knee were most frequent, MSKIs involving the shoulder were most severe, i.e. they had the longest average LDDs. Reporting MSKIs with increased LDDs may provide more accurate results related to MSKIs effect on readiness.

OPERATIONAL RELEVANCE

Injury prevention efforts should focus on major LDD producing MSKIs, those to the knee, ankle/foot, lumbar spine and shoulder. Leaders should perform risk analyses on activity types reported to result in MSKIs with LDD, especially PT and running.

AUTHORS

Tanja Roy (1)
Craig McKinnon (1)
Bradley Ritland (1)
Shannon Merkle (1)

(1) U.S. Army Research Institute of Environmental Medicine (Natick, United States)

SEX DIFFERENCES IN BONE ANABOLISM IN U.S. ARMY SOLDIERS IS PARTIALLY EXPLAINED BY BASELINE BONE MICROARCHITECTURE DURING BASIC COMBAT TRAINING

PURPOSE

Female Soldiers tend to have more favorable changes in bone microarchitecture during basic combat training (BCT) compared to male Soldiers. In addition, individuals with lower volumetric bone mineral density (vBMD), prior to BCT, have a more robust adaptive bone response to training. We aim to evaluate whether baseline differences in vBMD and/or bone microarchitecture between males and females explain the sex differences in anabolic bone response to BCT.

METHODS

We measured trabecular vBMD (Tb.vBMD), thickness (Tb.Th) and bone volume fraction (Tb.BV/TV) at the distal tibia in 424 recruits (123 females, 301 males) before and after BCT using high-resolution peripheral quantitative computed tomography. Linear models adjusted for BMI and race were used to evaluate the main effects of sex and the baseline bone parameters, as well as their interaction, on changes in each of the corresponding bone parameters. Mediation analysis was use to quantify the proportion of sex-related differences in the anabolic response to BCT that could be explained by each of the baseline bone parameters.

RESULTS

Both male and female recruits had statistically significant ($p<0.0001$) increases in Tb.vBMD, Tb.Th and Tb.BV/TV (males: 0.32%-1.16%, females: 0.76%-2.23%). Sex significantly modified the relationship between baseline Tb.vBMD, Tb.Th, and Tb.BV/TV, and the corresponding change in each bone parameter, with women having greater inverse relationships than men. The effect of sex was significantly mediated by all baseline bone parameters. Specifically, baseline levels of Tb.vBMD, Tb.Th, and Tb.BV/TV, accounted for 63%, 65%, 70% of the sex effect on changes seen in those parameters, respectively.

CONCLUSIONS

The anabolic response to BCT was highest in women with the lowest bone microarchitecture parameters at baseline. The partial mediation of the effect of sex by each of the baseline bone parameters indicates that the increased bone anabolic response by women is only partially related to the fact that women on average have lower baseline levels of Tb.vBMD, Tb.Th and BV/TV.

OPERATIONAL RELEVANCE

BCT is a time marked by heightened physical activity. Animal studies demonstrate that the anabolic response in bone to physical activity may offer mechanical benefits that can offset risk of injuries such as stress fractures. Stress fractures are a pervasive and costly problem during BCT with females having a higher risk for stress fractures compared to males. Understanding the variability in the anabolic bone response during BCT, may be useful in identifying ways to maximize adaptive bone formation with the goal of reducing risk of stress fracture.

AUTHORS

Kathryn Taylor (1)
Stephen Foulis (2)
Katelyn Guerriere (2)
Kristin Popp (3)
Mary Bouxsein (4)
Julie Hughes (2)

(1) U.S. Army Research Institute of Environmental Medicine (Natick, United States); (2) US Army Research Institute of Environmental Medicine (Natick, MA, United States); (3) US Army Research Institute of Environmental Medicine (Natick, MA, United States); (4) Endocrine Unit, Massachusetts General Hospital, Center for Advanced Orthopedic Studies, Beth Israel Deaconess Medical Center, Department of Orthopaedic Surgery, Harvard Medical School (Boston, MA, United States)

MUSCULOSKELETAL INJURY RATES AMONG NSAID USERS IN THE IDF: A DECADES PERSPECTIVE

Evidence emerging from animal studies connecting non-steroidal anti-inflammatory drug (NSAID) use with increased MSKI risk has raised questions regarding current treatment recommendations. The physicians dilemma in routinely prescribing medications to soldiers for various health states is outlined by the desire to provide definitive treatment without causing harm.

PURPOSE

To examine the rates of MSKI in the Israel Defense Force (IDF) in relation to preceding NSAID use.

METHODS

A retrospective data analysis was performed on the IDF population in active service between the years 2009-2018. Data was subdivided by service type (compulsory or career), position (combat, combat support and non-combat), and sex. NSAID use was filtered based on the diagnosis given during the medical encounter resulting with a prescription, precluding all MSKI related diagnoses. MSKIs were defined as the outcome if a diagnosis occurred at a later encounter.

RESULTS

4.5% of the soldiers treated by NSAIDs between the years 2009-2018 were treated for strictly non-MSKI related indications. 41.2% of patients prescribed non-MSKI related NSAIDs in comparison to 29.4% in the general population, were later diagnosed with an overuse MSKI. Among this group, 42.6% of men and 38.9% of women were prescribed the NSAID medication prior to sustaining the injury.

CONCLUSIONS

This work addresses for the first time the issue of NSAID treatment in relation to overuse MSKI in a military setting. Other medications used concomitantly were not assessed. Further work is currently underway to shed light on possible associations between NSAID use and overuse MSKIs.

OPERATIONAL RELEVANCE

For soldiers, particularly in combat training, maintenance of optimal health and performance is crucial to mission readiness. Exposure to arduous physical conditions on a daily basis holds a risk for a multitude of musculoskeletal injuries (MSKIs). Based on this work we hope to gain the necessary insight to decide whether or not recommendations should be altered based on current knowledge.

AUTHORS

Chen Fleischmann (1)
Ran Yanovich (1)
Vered Kleitman (2)
Ilana Gens (3)
Saar Ashri (4)
Vicky Yoffe (5)
Ameer Shufani (4)
Aharon Finestone (6)
Ran Yanovich (7)

(1) Institute of Military Physiology, IDF Medical Corps, Israel (Israel); (2) Gynecology and Obstetrics Department, IDF Medical Corps, Isreal; Soroka University Medical Center and Faculty of Health Sciences, Ben-Gurion University of the Negev, Beer Sheva, Israel (Tel-Hashomer, Israel); (3) The Health Promotion Department, Preventive Medicine Branch, IDF Medical Corps, Israel (Tel-Hashomer, Israel); (4) Institute of Military Physiology, IDF Medical Corps, Israel; Heller Institute of Medical Research, Sheba Medical Center, Ramat-Gan, Israel (Ramat-Gan, Israel); (5) Data Analysis Section, Department of Medical Data, IDF Medical Corps, Israel (Tel-Hashomer, Israel); (6) Department of Orthopaedics, Assaf HaRofeh Medical Center, Zerifin and Sackler School of Medicine, Tel Aviv University, Tel Aviv, Israel; (Zerifin, Israel); (7) Institute of Military Physiology, IDF Medical Corps, Israel; Heller Institute of Medical Research, Sheba Medical Center, Ramat-Gan, Israel; Military Medicine Department, Faculty of Medicine, The Hebrew University, Jerusalem, Israel; Wingate College of Physical Education and Sport Sciences, Wingate Institute, Netanya, Israel (Ramat-Gan, Israel)

THE EFFECT OF OVERSIZED (ILL-FITTING) BODY ARMOUR SYSTEMS ON MUSCULOSKELETAL PAIN AND DISCOMFORT, MOBILITY AND OPERATIONAL PERFORMANCE AMONG FEMALE SOLDIERS

PURPOSE

Female soldiers are smaller in anthropometric measurements relevant to body armour sizing when compared to male soldiers [1]. The Australian Armys Tiered Body Armour System (TBAS) is available in a limited number of sizes. It is currently unknown whether TBAS sizing accommodates female soldiers, or the effect that oversized (ill-fitting) body armour has on female soldiers experience of musculoskeletal pain and discomfort, mobility, and operational performance.

METHODS

A custom questionnaire was completed by 147 female soldiers (TBAS users) from a range of combat and combat-support roles. Readability of the questionnaire was tested with Defence Science Technology Group and Diggerworks. The questionnaire included 59 questions about fit and function of TBAS, including perceived overall TBAS fit, musculoskeletal pain and discomfort, mobility, and operational performance. Responses to questions were coded and counted to determine frequency of responses. Participants were divided into two groups (Good-fit and Ill-fit) based on their self-report overall fit of TBAS. Mann-Whitney U-tests with Bonferroni correction were conducted to determine whether musculoskeletal pain and discomfort significantly ($p < 0.05$) differed between groups (SPSS v23, USA).

RESULTS

The overall fit of TBAS was oversized (ill-fit) for 56% of participants. Compared to participants who reported TBAS to be a good fit, participants with oversized TBAS reported significantly ($p < 0.05$) higher musculoskeletal pain scores (hip and abdomen) and reported a significantly higher prevalence of discomfort (pressure points, chaffing, pinching, bruising or abrasions) when wearing TBAS. Participants with ill-fitting armour also reported significantly greater mobility restrictions during bending, twisting, arm and neck movements, driving, shouldering a rifle, standing and prone rifle firing, running/jogging and going to the bathroom when wearing TBAS. Participants with oversized armour reported significantly greater interference between TBAS and other equipment, as well as reduced ability to complete some operation specific tasks.

CONCLUSION

Many female soldiers reported they are wearing oversized body armour. Oversized body armour was associated with increased musculoskeletal pain and discomfort, as well as reduced mobility and task performance. While maintaining protective requirements, there is a need for body armour systems that improve comfort, mobility and task performance for female soldiers.

OPERATIONAL RELEVANCE

This study demonstrates the negative impact of oversized body armour on operational performance among female soldiers. Body armour that improves accommodation for female soldiers is required.

AUTHORS

Celeste Coltman (1)

Richard Henry Molloy (2)

(1) University of Canberra Research Institute for Sport and Exercise, Faculty of Health, University of Canberra, Australia (Australia); (2) Human Systems Integration, Land Division, Defence Science and Technology Group, Department of Defence, Australia (Melbourne, Australia)

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STATIC AND DYNAMIC FIT OF EXOSYSTEMS FOR THE HUMAN OPERATOR

The overall fit of an exosystem needs to be operationalized in a task-specific manner and evaluated to the extent a soldiers capability is positively or negatively affected. Improper fitting can lead to inefficiencies such as decreased mission effectiveness and range of motion of the user as well as an increased likelihood of overexertion, fatigue, discomfort and injury. This presentation describes a framework to augment current practices of assessing exoskeletons in terms of static and dynamic fit. The framework will be conceptualized through representative use cases.

Static fit refers to the alignment between dimensions of the human and environment in one or a small number of standardized, fixed postures. Static fit considers both the anthropometric characteristics of a user, as well as the design of equipment. Initial sizing and fit evaluation of exosystems is currently based on scalar anthropometric dimensions and subjective assessment. Scalar dimensions provide valuable information on the overall size of the individual but do not provide good guidance on shape or posture. 3D body scanning technology has enabled the creation of population-based statistical models of human shape that quantify morphological variations as functions of overall descriptors such as age, stature, and body weight. These models will enable rigorous design and evaluation of exosystem geometry and population-based sizing.

Dynamic fit refers to how the human and equipment move and interact with each other through functional range of motion (ROM) activities and task performance, and is defined formally in the context of a specific activity. This characteristic is relevant as exosystems should minimize restrictions on mobility and minimize internal human-exosystem opposing forces such that operational tasks can be performed. When the kinematics of the human-exosystem are misaligned, forces exerted by the operator are countered by forces internal to the human-exosystem rather than transmitted to the environment. This inappropriate coupling creates inefficiency, increases fatigue and metabolic cost, and can lead to injury. Exosystem dynamic fit assessment must quantify the human-exosystem interface to define the relative alignment of the kinematic linkages between the two systems (e.g., the location of human joint center locations with respect to the exosystem). Similar to static fit concerns, dynamic fit measures should consider the large range of human anthropometric variability.

Design and evaluation for exosystems intended for military applications will benefit from considering measures of static and dynamic fit.

AUTHORS

Monica Jones (1)
Joseph Parham (2)
Hyeg Joo Choi (2)
Leia Stirling (3)
Byoung-Keon Daniel Park (4)
Matthew Reed (4)

(1) University of Michigan (Ann Arbor, United States); (2) U.S. Army Combat Capabilities Development Command Soldier Center (Natick, United States); (3) Massachusetts Institute of Technology (Cambridge, United States); (4) University of Michigan (Ann Arbor, United States)

NATO RESEARCH TASK GROUP: 3D SCANNING FOR CLOTHING FIT AND LOGISTICS

Issuing soldiers with clothing and equipment in an effective and cost-efficient manner is a challenge to military forces around the world. While operational challenges such as environment, ballistic and chemical threats and load carriage dictate the physical properties and design elements of the garment, it is critical that clothing and equipment are properly fit to the soldiers body. A well fitted garment is of appropriate dimensions, provides acceptable comfort and mobility, provides protection, and integrates well with other items of clothing, personal equipment and work spaces. Countering these is the requirement to accommodate an increasing diversity within NATOs participating nations. For example, Canadas Strong Secure and Engaged Defence Policy has expressed a desire for the Canadian Armed Forces to increase diversity by recruiting and training under-represented populations, with a specified target of 25% membership of women by 2026.

In response, NATO Science and Technology Organization (STO) has recognized the importance of providing guidance on the use of anthropometric data and advances in sizing and fitting methods to optimize current processes. In particular, it has identified the potential of 3D body scanning as a tool to rapidly acquire 3D anthropometry and body shape data. This has led to the establishment of NATO Research Task Group (RTG) HFM-266: 3D scanning for clothing fit and logistics.

A survey of NATO countries conducted by the RTG indicated that 30% of respondents use body scanning for clothing sizing and issuing, however, there is a high level of dissatisfaction with their clothing sizing systems. Over 80% of respondents expressed a requirement for better guidance on the development of sizing systems. In response, RTG 266 has developed a NATO Standardization Recommendation (STANREC) which provides guidance on the use of anthropometric data (traditional and 3D scan data) for design and fitting, describes fit testing methods (live and virtual) and sizing system development and provides an overview of 3D scanning system requirements for sizing and logistics.

This STANREC will benefit military users by identifying state-of-the-art tools methods to optimize the specification, design and evaluation of military clothing and equipment and modernize the development of clothing sizing standards across NATO countries.

AUTHORS

Allan Keefe (1)

Hein Daanen (2)

(1) Defence Research and Development Canada (Toronto, Canada); (2) Sizing Science (Amsterdam, Netherlands)

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OPTIMIZING SOLDIER PERFORMANCE THROUGH BETTER CLOTHING AND EQUIPMENT FIT
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PREDICTION OF COMBAT UNIFORM SIZE FROM 3D BODY SCAN DATA

PURPOSE

Traditionally, soldiers are measured using a tape measure to provide body shape information to enable allocation of clothing and equipment. Correct fitting clothing and equipment is important for comfort and performance. Prediction of combat uniform size from body scan data could have the potential to save militaries time and money, through sizing and fitting efficiencies and improved future requirements forecasting. To determine if body scan data could be used to predict correct fitting combat uniform sizes for the NZDF, the New Zealand Defence Force Anthropometry Survey (NZDFAS) body measurement database was interrogated using statistical learning models.

METHODS

Data from the NZDFAS database for 1003 participants (11% of the NZDF regular force population) were used. Various machine learning algorithms (i.e. linear support vector machine, polynomial support vector machine, gradient boosting, decision tree, random forest, feedforward neural network) were tested in R statistical analysis software. The most important measures for predicting correct uniform size for NZDFAS individuals who rated their clothing fit as Good or Very good were determined using the Mean Decrease Gini metric. The performance and generalisability of each model was examined using leave-one-participant-out cross-validation (LOOCV).

RESULTS

The model with the highest prediction accuracy during the LOOCV testing was the Breiman (2001) random forest model. Predictions were most accurate for the Army combat uniform, with up to 75% of individuals assigned the correct size. The model was most accurate for sizes in the mid-range (Small, Medium and Large) than the extreme sizes. The majority of incorrect predictions were either one size above or below the correct size prediction. The model also identified the best body measurement predictors for shirts and trousers.

CONCLUSIONS

This study showed that a machine learning algorithm could be used to predict combat uniform clothing size from 3D body scan data, and identified the best body measurement predictors for both shirt and trousers. Further testing is required to validate and enhance the accuracy of predictions.

OPERATIONAL RELEVANCE

Body measurements that strongly predict clothing size can be used for combat uniform size ordering and allocation, and to inform future garment design. Future applications of the model include the ability to size other clothing and equipment ensembles, such as the dress uniform, body armour and life jackets, all of which will impact soldier physical performance.

AUTHORS

Helen Kilding (1)
Stephven Kolose (1)
Patria Hume (2)
Tom Stewart (2)

(1) Defence Technology Agency (DTA), New Zealand Defence Force (New Zealand); (2) Sports Performance Research Institute (SPRINZ), Auckland University of Technology (Auckland, New Zealand)

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VIRTUAL FIT TESTING USING SOFT TISSUE SIMULATION

PURPOSE

Current systems for virtual fit testing utilize only geometric models of the human body ("hard avatars"). However, clothing, exoskeletons, and equipment can apply large compressive forces on the body that result in significant displacement of soft tissues, affecting fit and function. We investigated the hypothesis that finite element (FEM) models of the human body that include soft tissues ("soft avatars") can predict fit more accurately than models using hard avatars.

METHODS

We developed a new data-driven human body template, called VitalBody. Tissues of the human body are spatially varying, anisotropic, and highly non-linear in compression. VitalBody captures these characteristics with a Sliding Thick Skin (STS) FEM tissue model and measured tissue properties (Pai et al., 2018), and includes a skeletal rig to animate the body. The template is registered to 3D scans or parameterized shapes to construct soft avatars. We also constructed FEM models of garments, taking care to represent material properties of both fabrics and construction. Finally, we developed a software system VitalFit for simulating garment-body interaction and visualizing results in 3D.

We evaluated VitalFit with female soft avatars wearing a test garment, a sports bra. Soft avatars were constructed from both commercial hard avatars and 3D full body scans of fit models. The garment pattern was constructed and stitched using in-house tools and third-party CAD tools.

RESULTS

VitalFit simulations displayed realistic soft tissue and garment deformations. Simulations reproduced physical correlates of garment fit, both traditional metrics (ease, drape) and novel metrics (tissue displacements, pressure). Results using soft and hard avatars were compared to scans of fit models wearing the garment; soft avatar predictions were more accurate.

CONCLUSIONS

The results support the hypothesis that simulating fit using soft avatars is feasible and provides more realistic predictions of the physical correlates of fit.

OPERATIONAL RELEVANCE

A significant challenge for development and deployment of clothing and equipment is evaluating fit with human subjects. Virtual fit testing with realistic soft avatars can significantly reduce the time and costs, and facilitate fit mapping analysis. Soft avatars can also enable rapid design and performance optimization of new protective equipment and wearable sensors, and ensure that diverse body types, especially female bodies, are taken into account.

AUTHORS

Dinesh Pai (1)
Yuan Tian (1)
Ye Fan (1)
Egor Larionov (1)
Tim Straubinger (2)

(1) UBC and Vital Mechanics (Vancouver, Canada); (2) Vital Mechanics (Vancouver, Canada)

Pai et al. The human touch: measuring contact with real human soft tissues, ACM Transactions on Graphics (SIGGRAPH), 37(4):58, 2018.

COGNITIVE FIT OF EXOSYSTEMS FOR THE HUMAN OPERATOR

Fit is broadly considered as an optimized status between the human and their immediate environment (inclusive of clothing or worn devices and extending to the workplace). Poor fit may lead to deeper changes in motor-plan selection, as well as increased attentional demands towards using the exosystem, increasing overall physical and cognitive workload, and risking diminished operational performance. Fit has three key characteristics: (1) static, (2) dynamic, and (3) cognitive. Considerations of static and dynamic fit provide a physical representation of human-exosystem alignment and changes in these alignments across a task. However, they do not guarantee a user will be able to efficiently move with the system. Human motor control includes feedforward and feedback mechanisms that may be affected by the presence of an exosystem. Measuring the cognitive characteristic of fit provides additional insight on exosystem usability.

This presentation highlights the cognitive fit characteristic, which considers the stages of human-information processing, including somatosensation, executive function, and motor selection. This characteristic is relevant to exosystem fit as the operators cognitive capacity must be maintained such that operational tasks, including appropriate situation awareness and decision making, can be adequately performed. The operator should be free to process task-and stimulus-related information, as well as to choose and complete appropriate physical actions that the exoskeleton supports. Somatosensation includes sensory feedback related to touch, pressure, temperature, and movement of the muscles and tendons. Executive function refers to cognitive processes that enable goal-directed behavior, including inhibition of behavior (cognitive and motor), working memory (holding and working with information in the mind), and cognitive flexibility (ability to adjust priorities). Depending on user experience with an exosystem, the users mental model (a memory structure providing a dynamic representation of the environment) may be used at a conscious or subconscious level, affecting attentional demand and the ability to complete goal-direction physical or cognitive tasks. Motor action selection includes mapping goals to commands for many underlying muscle units through intermediary levels (reflexes, synergies, and internal models) in a movement-system hierarchy. The use of exosystems changes the sensory feedback sent to the central nervous system, which may then create inappropriate motor actions until the internal models are updated.

Examples are presented that highlight cognitive tasks and changes in motor strategy for military-relevant exoskeletons. Testing frameworks should consider measures of static, dynamic, and cognitive fit when evaluating human-exosystem performance to minimize overall risk and create an improved understanding of performance capabilities.

AUTHORS

Leia Stirling (1)
Richard Fineman (2)
Damian Kelty-Stephen (3)

(1) University of Michigan (United States); (2) MIT (Cambridge, MA, United States); (3) Grinnell College (Grinnell, IA, United States)

GENETIC LANDSCAPE OF NEUROBEHAVIORAL RESILIENCY AND THE ABILITY OF CAFFEINE TO RESCUE PERFORMANCE UNDER REPEATED SLEEP LOSS

Previous studies have identified intra-individual variability in neurobehavioral performance under total sleep deprivation (TSD). It is hypothesized that intra-individual variability is under genetic regulation. Here, we examined intra-individual variation in targeted single-nucleotide polymorphisms (SNPs) associated with: a) resistance to sleep deprivation (ADORA2A [7 variants]; TNF-alpha, ADA1); b) morning preference (PER1, PER2); c) sleep intensity (BDNF); and d) daytime sleepiness (COMT) under one of the longest regimens of TSD conducted in sleep research. 12 subjects (6 males) underwent three cycles of 48 h of TSD separated by three days of recovery sleep (8 h, TIB). During TSD, caffeine was administered every 12 h at 13:00 and 01:00 (0 mg, 200 mg, and 300 mg) concurrently with the psychomotor vigilance test (PVT) to examine neurobehavioral performance. There was no significant association between the targeted SNPs and neurobehavioral responses to sleep deprivation ($p > 0.05$, all). One ADORA2A SNP (rs2298383) did show a trend towards association with PVT lapses ($p=0.049$, non-adjusted) and reaction time ($p=0.066$, non-adjusted). There was no significant association between the targeted SNPs and caffeine preservation of neurobehavioral performance under sleep deprivation. One CYP1A SNP (rs762551) did show a trend towards association with PVT lapses ($p=0.08$, Bonferroni-adjusted). We observed that targeted SNPs associated with sleep resiliency and caffeine sensitivity are loosely associated with neurobehavioral impairment under repeated cycles of TSD and possession of a unique SNP may not be enough to overcome the deleterious effects of total sleep deprivation. However, given that the trends observed agree with previous work, repetition with a larger cohort is warranted.

AUTHORS

Allison Brager (1)
Lilly Skeiky (2)
Devon Hansen (2)
Brieann Satterfield (2)
Martha Petrovick (3)
Thomas Balkin (1)
Hans Van Dongen (4)
Vincent Capaldi (1)

(1) Walter Reed Army Institute of Research (Silver Spring, United States); (2) Washington State University (Spokane, United States); (3) MIT – Lincoln Laboratories (Lexington, United States); (4) Washington State University (Spokane, United States)

CHRONIC SLEEP DEBT AND EXCESSIVE DAYTIME SLEEPINESS IN SOLDIERS IS EXACERBATED BY 72-HOUR MISSION TRAINING

PURPOSE

Military operations require vigilance and high-level performance under stressful conditions while functioning with little sleep. Performance impairments (i.e., marksmanship, vigilance, executive function) have been linked with reduced sleep duration and sleep quality, as well as perceived sleepiness, fatigue, and mood changes. This research assessed changes in Soldier subjective and objective sleep profiles when conducting a 72-hour military exercise during a stateside period between deployments.

METHODS

Forty-six Soldier volunteers [42 males (mean age 24.5+4.2 years)] from three platoon-groups were assessed during a company-wide mission exercise. Subjective sleep quality and sleepiness were collected two weeks prior to the mission and immediately post-mission, utilizing a modified Pittsburg Sleep Quality Index (PSQI) and the Epworth Sleepiness Scale (ESS). Objective sleep profiles were also collected via actigraphy for the two weeks prior to mission start, and throughout the 72-hour mission.

RESULTS

Objective sleep duration based on actigraphy during pre-mission (4.93h+2.37h) was significantly higher than during the 72h-mission (1.74+1.39h) ($p<.0001$), but there were no differences across platoon-group. Furthermore, the mean pre-mission sleep duration was less than the Army-recommended 7-8 hours, indicating chronic sleep debt across platoons prior to mission commencement. Subjective sleep quality as measured by PSQI showed no differences across pre-and post-mission or across platoon-group, with 83% categorized as poor sleepers (PSQI > 5) during pre-mission (7.85+3.83) which increased to 98% poor sleepers during the 72h-mission (8.71+2.45). Perceived sleepiness significantly increased across the mission ($p<.0001$) and platoon-group ($p<.01$); however, ESS scores for both pre-and post-mission across all platoons indicated clinically relevant levels of excessive daytime sleepiness (ESS > 10) (pre: 10.61+5.76; post: 17.57+7.48).

CONCLUSIONS/OPERATIONAL RELEVANCE

The time between deployments is intended as a recovery period, where Soldiers can recharge, reconnect, and train. However, even when stateside, Soldiers may be at risk for chronic sleep restriction and poor sleep quality leading to excessive daytime sleepiness even before participating in intensive mission training exercises and future deployment. Further investigation of potential influencing factors is warranted (i.e., Unit type, command climate, training regimes, work-life balance). Furthermore, platoon characteristics (i.e. leadership style, group cohesiveness, trust, motivation) may influence factors leading to sleep behaviors and sleepiness during mission activities. Further analysis will explore performance impairment associated with daytime sleepiness and individual platoon differences, such as leadership, qualifications, and group cohesion.

AUTHORS

Stephanie Brown (1)
Tina Burke (2)
Carolyn Mickelson (2)
Jaime Devine (2)
Kajsa Carlsson (2)
Jake Choyonowski (2)
Walter Sowden (2)
John Ramsay (1)
Erika Hussey (1)

(1) U.S. Army Combat Capabilities Development Command Soldier Center (Natick, United States); (2) U.S. Army Walter Reed Army Institute of Research (Silver Springs, MD, United States)

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THE EFFECTS OF ONE-NIGHT SLEEP DEPRIVATION AND ONE-NIGHT RECOVERY SLEEP ON ENDURANCE PERFORMANCE

PURPOSE

It has been demonstrated that sleep deprivation (SD) might negatively affect endurance performance; however, no data are available on how long it takes to recover from SD as yet. Therefore, the aim of the study was to investigate the acute effects of SD and recovery sleep on endurance performance by evaluating exercise and cognitive performance changes.

METHODS

26 male trained cyclists/triathletes (means ± standard deviation: age 30.7 ± 8.1 yr, body mass 73 ± 10 kg, height 1.77 ± 0.09 m, VO2max 54.2 ± 4.8 ml/kg/min) have been randomly allocated to two groups (SD and Control) and tested over three consecutive days. After baseline testing on Day 1, subjects in the SD group have been asked not to sleep for 25-h (SD condition) on Day 2, and then sleep normally the following night (recovery sleep condition) (Day 3). Subjects in the control group have been required to sleep normally throughout the entire experiment and to attend the same testing sessions. Endurance performance during a 20-min Time-Trial have been measured after 40 minutes of cycling at 60% of participants VO2max. A 10-min psychomotor vigilance test have been used to assess cognitive performance.

RESULTS

Ratings of sleepiness revealed a trend for a significant effect of SD (group x day interaction) ($P = 0.050$). However, a 2-way mixed model ANOVA (group x day) revealed no significant interaction effect of SD on Time-Trial work. A pairwise comparison showed a decline on Day 2 (Day 1 298.5 ± 43.7 kJ, Day 2 292.5 ± 45.1 kJ, $P = 0.002$) and a subsequent improvement on Day 3 compared to Day 2 (Day 3 301.9 ± 46.0 kJ, $P = 0.009$). Pairwise comparisons in both groups combined also showed significant impairments and subsequent improvements in reaction time in the SD group following SD ($P = 0.000$) and recovery sleep ($P = 0.002$), respectively. Significant differences between SD and Control were also found on Day 2 ($P = 0.007$).

CONCLUSION

In the context of three repeated bouts of endurance exercise where cumulated fatigue and pacing strategy may play a role, one-night SD did not affect physical performance. As in previous studies, cognitive performance declined after SD and restored to baseline levels with one-night recovery sleep.

OPERATIONAL RELEVANCE

The current results suggest that young adults can maintain their physical performance after one-night SD and that one-night recovery sleep is sufficient to recover from cognitive performance impairments due to one-night.

AUTHORS

Chiara Gattoni (1)

(1) University of Kent (Chatham Maritime, United Kingdom)

THE IMPACT OF A REVERSE SLEEP CYCLE ON SOLDIER COGNITIVE AND PHYSICAL PERFORMANCE

PURPOSE

During deployment and training, specialized soldier units operate on a reverse sleep cycle, which requires soldiers to be awake / vigilant during the night and resting / asleep during the day. However, abruptly flipping to a reverse sleep cycle may bring about jetlag (i.e., circadian misalignment) and sleep loss. The purpose of the current study was to assess how switching to a reverse sleep cycle impacts performance in an elite unit of soldiers.

METHODS

Eighty four male soldiers participated from one company of a specialized battalion. We tested the impact of flipping to a reverse sleep cycle by measuring cognitive performance (reaction time, decision-making, response inhibition), physical performance (vertical jump, grip strength, balance), and physiological markers of health (testosterone, inflammatory cytokines) before, during, and after a switch to a reverse sleep cycle during a 10-day training mission.

RESULTS

Relative to a baseline day when soldiers were well-rested, immediately after the transition to the new cycle (when soldiers had been awake for roughly 30 hours), we found reaction time was significantly slower (paired-sample t-test: $t(60) = 3.42$, $p < .001$) but decision-making and response inhibition were unaffected. We also found balance was significantly poorer after sleep loss ($t(49) = -2.46$, $p = .017$), while grip strength and vertical jump height did not change. Lastly, subjective feelings of physical readiness ($t(62) = 4.72$, $p < .001$), mood ($t(66) = 5.09$, $p < .001$), motivation ($t(66) = 5.72$, $p < .001$), and morale ($t(66) = 4.37$, $p < .001$) were poorer following sleep loss.

CONCLUSIONS

Soldiers were broadly impacted by the abrupt flip to a new circadian cycle. Our findings suggest adequate time should be built in between the switch to the reverse sleep cycle and operational missions. Ongoing analyses will determine how quickly these metrics return to baseline when soldiers have normalized to the new circadian cycle. Future studies will try to quicken the normalization process through simple behavioral means (e.g., light/dark environmental manipulation).

OPERATIONAL RELEVANCE

These results provide critical data on how sleep loss and circadian misalignment impact operational performance in soldiers. Given that many specialized units operate on a reverse sleep cycle, these results are directly applicable to those units.

AUTHORS

Janna Mantua (1)
Bradley Ritland (2)
Jacob Naylor (3)
Tina Burke (1)
Alexxa Bessey (1)
Vincent Capaldi (1)
Ashlee McKeon (1)

(1) Walter Reed Army Institute of Research (WRAIR) (Silver Spring, United States); (2) United States Army Research Institute of Environmental Medicine (USARIEM) (Natick, United States); (3) 75th Ranger Regiment (Joint Base Lewis-McChord, United States)

SELF-REPORTED INSOMNIA SYMPTOMS ROBUSTLY PREDICTS POSTTRAUMATIC STRESS ACROSS THE DEPLOYMENT CYCLE IN A U.S. ARMY ARMORED BRIGADE COMBAT TEAM

PURPOSE

Inadequate sleep has been established as a robust risk factor for adverse psychological health outcomes. Therefore, shortened total sleep time (TST) and sleep disruption commonly experienced by the Warfighter may increase risk for acute stress responses in the operational environment. This study characterized and tested predictive relationships between inadequate sleep and posttraumatic stress symptoms (PTSS) in an armored brigade combat team across a deployment cycle, which included a simulated training exercise and contingency operations.

METHODS

427 U.S. Army service members (24.9 y/o±5.57; 89% male) completed self-report surveys on sleep and psychological health at seven time points. Summary scores from the Insomnia Severity Index (ISI), TST, and the 4-item Posttraumatic Stress Disorder Checklist-Military were analyzed using t-tests, analysis of variance, and multiple linear regression, and controlled for related military variables.

RESULTS

At baseline, Soldiers reported sleeping on average 5.48±1.11 hours per night. Soldiers with at least 11 years of service had significantly less TST than recently enlisted Soldiers, ($p=.021$). Moreover, when considering rank, senior NCOs reported sleeping the least amount of time, while officers or warrant officers reported sleeping the most ($p=.042$). Average ISI indicated subthreshold insomnia ($M=8.33\pm3.72$); however, no group differences in ISI were observed across military variables. Soldiers self-reported moderate PTSS ($M=9.29\pm2.35$) overall, and recently enlisted Soldiers had significantly lower PTSS compared to Soldiers with at least one year of service, ($p=.013$). Multiple linear regression showed baseline ISI and TST individually and synergistically predicted PTSS both at post-training and post-deployment. However, the model of best fit contained only ISI as a significant predictor of PTSS ($p=.001$) and explained 44.2% of the variance in PTSS ($p=.001$).

CONCLUSION

This study is one of the first of its kind to track the predictive utility of inadequate sleep on PTSS across the deployment cycle, while also accounting for military variables. Future research will consider the contribution of additional military variables, such as nature of combat exposure and MOS, which are likely to be associated with insomnia symptoms and PTSS and test the effectiveness of preventative sleep-based interventions for reducing PTSS risk.

OPERATIONAL RELEVANCE

Sleep, like water, is fuel, and sleep loss is a threat to readiness. This research will determine novel sleep-related targets for engagement aimed at enhancing lethality by reducing PTSS risk. Soldiers and leaders who view sleep as fuel, and make resupply a priority of work, will always have the tactical advantage over near peer adversaries in close combat operations.

AUTHORS

Ashlee McKeon (1)
Maria St. Pierre (1)
Jake Choynowski (1)
Lillian Skeiky (1)
Julie Merrrill (2)
Walter Sowden (1)

(1) Walter Reed Army Institute of Research (Silver Spring, United States); (2) U.S. Army Medical Research Directorate-West (Tacoma, United States)

IMPLICATIONS ON ESTIMATED SUSCEPTIBILITY TO ENEMY FIRE FOLLOWING 5-DAYS OF SIMULATED MILITARY OPERATIONAL STRESS

PURPOSE

We assessed the effects of 5-days of simulated military operational stress (SMOS) on tactical mobility performance and possible baseline predictors of high versus low performers. We hypothesized that there would be a decline in physical performance during SMOS and that baseline fitness and self-reported measures of resilience would differentiate high and low performers in tactically-relevant tasks.

METHODS

Twenty-four male Soldiers (26.5±5.5 years, 175.8±6.35 cm, 81.2±14.3 kg, 19.8±7.1%BF) completed a 5-day/night SMOS protocol. During days 3 (D3) and 4 (D4), subjects were given 50% of caloric demands. On nights 1, 2, and 5 subjects slept from 2300-0700. During nights 3 and 4, subjects slept from 0100-0300 and 0500-0700. Baseline measures included VO2max, strength as measured by maximal voluntary contraction, GRIT, and the Connor-Davidson Resilience Scale (CD-RISC). After a familiarization day, participants underwent a Tactical Mobility Test (TMT) on D2-5: 2-minute water can carry (20-kg each hand), fire and movement course, 20-meter casualty drag (CD) (91-kg), 300-meter shuttle run unloaded (SRU) and loaded (SRL) (16-kg), and a 2-mile paced then 2-mile best effort timed ruck march (RM) (15-kg). Rate of movement (ms-1) was calculated from SRU using the Blount equation (Blount et al., 2013) to model susceptibility to enemy fire based on a fixed shooting cadence of 1.3 shots per second, an enemy shooting accuracy of 10%, and exposure time. Baseline measures were compared to high versus low TMT performance (tertile splits) via Mann-Whitney U. Freidman tests were used for differences between D2-5 followed by adjusted pairwise comparisons as appropriate ($p<0.05$, $p<0.008$, respectively).

RESULTS

SRU times increased during SMOS with a median increase ($z=2.68$, $p=.007$) between D2 and D4, while CD time improved ($z=-2.65$, $p=.008$). Performance in all other events remained stable. The differences in SRU translated to a ~4% increase in susceptibility to enemy fire. Participants with fastest RM times were stronger (mean rank=10.8 vs. 5.5 newtons, $p=.021$) and more aerobically fit (mean rank=12.0 vs. 5.0 mLkgmin-1, $p=.002$) at baseline compared to the slowest. No differences were observed in GRIT or CD-RISC ($p>.05$).

CONCLUSIONS

300-meter SRU was most negatively affected by SMOS, while other tactically-relevant events remained stable or improved over time. Strength and aerobic fitness, but not trait measures of resilience, influenced RM times.

OPERATIONAL RELEVANCE

Decreased speed on the battlefield has a direct impact on Soldier survivability. Commanders should consider sleep, nutrition, and adequate recovery in the context of operational tempos to optimize performance on the battlefield.

AUTHORS

William Conkright (1)
Aaron Sinnott (2)
Meaghan Beckner (1)
Shawn Eagle (1)
Brian Martin (1)
Shawn Flanagan (1)
Christopher Connaboy (1)
Anne Germain (3)
Bradley Nindl (1)

(1) Neuromuscular Research Laboratory, Department of Sports Medicine and Nutrition, School of Health and Rehabilitation Sciences, University of Pittsburgh, Pittsburgh, PA (Pittsburgh, United States); (2) Neuromuscular Research Laboratory, Department of Sports Medicine and Nutrition, School of Health and Rehabilitation Sciences, University of Pittsburgh, Pittsburgh, PA; University of Pittsburgh Medical Center Rooney Sports Medicine-Concussion Program, University of Pittsburgh, Department of Orthopedic Surgery, School of Medicine, Pittsburgh, PA (Pittsburgh, United States); (3) Military Sleep Tactics and Resilience Research Team, Department of Psychiatry, School of Medicine, University of Pittsburgh, Pittsburgh, PA (Pittsburgh, United States)

BRAIN BOOTCAMP: AN INTEGRATED BEHAVIOURAL HEALTH INTERVENTION FOR MILITARY MEMBERS WITH REDUCED COGNITIVE FUNCTIONING AFTER SUSTAINING A MILD TRAUMATIC BRAIN INJURY

PURPOSE

Canadian Armed Forces (CAF) Service Members (SMs) experience higher rates of mild traumatic brain injuries (mTBIs) and post-concussion symptoms than civilians. One common, and often unaddressed, symptom of a mTBI is cognitive dysfunction. Functional impairment in day-to-day activities and operational military contexts can result. This study aimed to determine if Brain Bootcamp, an integrated behavioural health intervention within a CAF Physical Rehabilitation Department mTBI protocol, improves cognitive performance, reduces concussion-related symptoms, and increases external aid utilization among CAF-SMs who have sustained a mTBI.

METHOD

A quasi-experimental study was conducted of clinical outcomes collected from 65 participants who participated in Brain Bootcamp. Changes in client cognitive performance prior to and following participation in Brain Bootcamp were captured using the Montreal Cognitive Assessment (MoCA), Rivermead Post-Concussion Symptom Questionnaire (RPQ), and External Aids Utilization Survey (EAUS). Additionally, the Global Resilience Questionnaire (GRQ) and Depression Anxiety and Stress Scale (DASS-21) was administered to 10 participants to determine if Brain Bootcamp has a perceived effect on resilience and mental health symptoms. Parametric and non-parametric statistical methods, such as paired sample T-tests, Mann-Whitney U, and chi-square analysis, were employed. Descriptive statistics were observed for demographics, mechanism of injury, injury severity, time since injury, presence of concurrent mental health disorder and tinnitus, as well as engagement in vestibular rehabilitation.

RESULTS

Statistically significant changes pre/post-Brain Bootcamp intervention were observed, including improved cognitive performance and external aid utilization, as well as reduced self-reported mTBI symptoms. Descriptive statistics indicated that 60% of participants had at least one concurrent mental health diagnosis and 56.9% had received vestibular rehabilitation from a physiotherapist. Statistically significant change was not observed in the GRQ or DASS-21 although this sample was notably smaller.

CONCLUSIONS

Brain Bootcamp appears to be a promising-cognitive performance enhancing intervention for CAF-SMs who have sustained a mTBI and possibly those who have sustained a mental health diagnosis. Additional research would be beneficial to better understand, assess, and recognize predictors and indicators of cognitive dysfunction in CAF-SMs who have sustained mTBIs.

OPERATIONAL RELEVANCE

Associated challenges with ECF can significantly impede performance, engagement, deployability and the safety of self and others during military activities. Improvements in cognitive functioning may enable CAF-SMs to be operationally ready for service and have greater overall well-being at home and abroad.

AUTHORS

Chelsea Jones (1)
Suzette Bremault-Phillips (2)
Ashley Pike (3)

(1) Department of National Defense, University of Alberta Faculty of Rehabilitation Medicine, Heroes in Mind, Advocacy and Research Consortium (HiMARC) (Edmonton, Canada); (2) Heroes in Mind Advocacy and Research Consortium Director, Associate Professor, University of Alberta Faculty of Rehabilitation Medicine (Edmonton, Canada); (3) Post-Doctoral Fellow, University of Alberta Faculty of Rehabilitation Medicine (Edmonton, Canada)

NOISE-ROBUST, ON-BODY, MULTIMODAL VOICE MONITORING SYSTEM FOR COGNITIVE LOAD CLASSIFICATION DURING AN IMMERSIVE, VIRTUAL-REALITY MARKSMANSHIP EXPERIMENT

PURPOSE

Modern operational environments can place significant demands on Warfighters cognitive resources and capabilities, increasing the risk of errors or mishaps due to overburden and fatigue. Thus, the ability to monitor cognitive burden within operational environments is critical to improving Warfighter performance and mission readiness. As a key step toward a field-ready system, we tested an on-body, multimodal voice monitoring system using an immersive, virtual-reality marksmanship task, and assessed the systems ability to classify cognitive load based on vocal characteristics extracted from noise-robust sensors.

METHODS

Five vocally healthy individuals participated in a virtual-reality marksmanship study that included a working memory protocol. Participants were instructed to shoot at flying targets while holding in memory single-digit numbers displayed inside each target. After the trial, participants recalled the digits, in order of appearance, using a standardized response format. Low vs high cognitive load were defined as three-vs six-digit strings. An on-body system recorded the carrier phrases and digit strings. Data from three sensor modalities were collected to capture: acoustic data collected from a MEMS microphone (MIC); non-acoustic data collected from a uniaxial, neck-surface accelerometer (ACC); and neck-surface electrical impedance from an electroglottograph (EGG).

RESULTS

We extracted temporal and spectral vocal biomarkers that are robust to acoustic noise from the ACC and EGG signals. Here we focused on the extraction and analysis of the creaky voice feature (CVF), an important hesitation-based vocal biomarker, derived primarily from temporal cues that were degraded in the microphone signal but preserved in the accelerometer and electroglottograph signal domains. Comparable or greater effect sizes between low and high cognitive load were exhibited by dynamical complexity measures of the CVF derived from MIC, ACC, and EGG. Group-wide, subjects exhibited lower dynamical complexity of CVF when participants vocalized in the high cognitive load condition. This is consistent with the hypothesis that, under high load, speakers may produce expressive voice-based cues reflecting underlying hesitation and decreased confidence levels.

CONCLUSIONS

We demonstrated the potential of discriminating low versus high cognitive load using a novel voice feature, CVF, from multimodal sensors. In the field, MIC can be used as a noise dosimeter. Combining MIC, ACC, and EGG into an integrated system could provide complementary information for quantifying voice and speech biomarkers with a high degree of robustness to competing noise sources.

OPERATIONAL RELEVANCE

The on-body, multimodal system is a promising system in field-forward operational environments in which high levels of acoustic and vibration noise are expected.

AUTHORS

Daryush Mehta (1)
Jeff Palmer (1)
Laura Brattain (1)
Hirshikesh Rao (1)
Christopher Smalt (1)
Thomas Quatieri (1)
Kristin Heaton (2)

(1) MIT Lincoln Laboratory (United States); (2) US Army Research Institute of Environmental Medicine (Natick, MA, United States)

PERFORMANCE OF LOWER LIMBS AND COGNITIVE FUNCTION OF MILITARY FIREFIGHTERS BEFORE, DURING AND AFTER SEARCH, RESCUE AND SURVIVAL TRAINING

PURPOSE

Intense military trainings can cause changes in cognition and physical performance in the army personnel (Lieberman et al., 2016). This study aimed to verify the changes in vertical jump performance as well as the reaction and accuracy rates in cognition test in firefighter cadets submitted to the Search, Rescue and Survival Training (SRST), that firefighters execute to prepare for catastrophic situations.

METHODS

45 subjects completed the two modules (M1-nine days of restricted sleep and intense physical expenditure and M2-six days of food restriction and without high physical demand). They performed vertical counter-movement jumps, captured by cellular camera for calculation by application already validated (Balsalobre-Fernández, 2015) and the 45-second adapted Stroop Test (Scarpina & Tagini, 2017) at four time points: one week before (PRE), after M1, after M2 and after seven days of recovery (POST). Friedman's tests, followed by Wilcoxon with Bonferroni correction, were applied to the (non-parametric) data that were presented as median; first quartile-third quartile (SPSS, $p < 0.05$).

RESULTS

The vertical jump power decreased significantly and gradually during training (M1: 1241.8, 1063.7-1348.9 and M2: 1077.0; 954.0-1195.8 W). After one week of recovery (POST: 1360.8, 1199.5-1589.6 W), the values were significantly lower than PRE (1805.1, 1664.9-2426.4 W). The reaction rate showed a decline in M1 (~12.35% and ~16.39% for congruent and incongruent tasks, respectively), and gradually increased to POST, with values statistically higher than pre-training values. The accuracy rate did not present statistically significant differences at any time point.

CONCLUSIONS

Military training can cause decline in the physical and cognitive performance of trained military personnel. Cognitive functions present some recovery with longer rest time, even in the field. However, lower limb performance remains depressed even after a single week of recovery.

OPERATIONAL RELEVANCE

Reducing cognitive alertness can impact the safety in complex tasks execution. In addition, since lower limb performance is not recovered after single week, firefighter personnel should not be re-employed in training and/or real operations before this period, with regard to optimal outcomes and risks' prevention.

AUTHORS

Thiago de Barros Ramos (1)
Thalita Ponce Sobral (2)
Miriam Raquel Meira Mainenti (3)
Verônica Salerno Pinto (2)

(1) Academia de Bombeiro Militar Dom Pedro II (ABMDP II) (Rio de Janeiro, Brazil); (2) Escola de Educação Física e Desportos da Universidade Federal do Rio de Janeiro (EEFD/UFRJ) (Rio de Janeiro, Brazil); (3) Escola de Educação Física do Exército (EsEFEx) (Rio de Janeiro, Brazil)

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ASSESSMENT OF CANADIAN SPECIAL OPERATIONS FORCES PERSONNEL PERCEIVED NUTRITIONAL NEEDS

PURPOSE

Special Operations Forces (SOF) personnel operate in unique and challenging environments. They must maintain good overall health and high levels of physical fitness to sustain high operational tempo, at-risk deployments and rigorous exercises. Adequate nutrition is key to SOF personnels performance, physical health, fitness, and career longevity. The objective of this study was to better understand Canadian Special Operations Forces (CANSOF) personnels perceived main challenges regarding their physical health and fitness, and to identify nutritional needs.

METHODS

A sample of 58 CANSOF personnel were selected using a purposeful sampling method. A small number of participants with diverse characteristics (e.g., role, gender, age) and experiences were recruited. Trained researchers conducted semi-structured interviews. Content and thematic analyses were performed on the interview notes.

RESULTS

Participants identified key physical fitness and health-related issues. Many participants indicated struggling with recovery and management of compounding injuries while sustaining highly demanding and prolonged physical and mental efforts. Some non-operational participants indicated that their main challenge was related to maintaining a healthy weight and overall health. Several participants also mentioned that finding time to maintain a fitness routine in spite of high temp and heavy work load was challenging. When asked about their nutritional needs, several participants indicated a need for more information and education (e.g., specific diets, supplement use, meal planning, individualized sessions with a nutrition specialist) to sustain high physical and mental performance. Participants also identified several barriers to accessing quality foods in garrison and on deployment. The quality, accessibility, and quantity of food was reported by many participants as being limited in unit dining facilities and on deployment.

CONCLUSIONS

This qualitative study revealed key health and fitness challenges specific to CANSOF personnel. Findings highlight specific nutritional needs and barriers to accessing a quality diet. This study will directly inform quantitative research examining nutrition education needs, eating habits, and individual and environmental barriers to accessing a quality diet among CANSOF personnel. Findings will inform the formulation of a performance nutrition strategy that will be implemented in CANSOF units.

OPERATIONAL RELEVANCE

Nutrition is a key component of physical fitness and health and is especially important for military members who are required to sustain highly demanding and prolonged physical and mental efforts. The study results highlight the importance of nutrition in the maintenance of SOF personnel health and readiness, optimization of physical fitness, and performance in operational and non-operational roles.

AUTHORS

Isabelle Richer (1)
Christine Frank (1)

(1) Department of National Defence (Ottawa, Canada)

THE DEVELOPMENT OF TWO MILITARY SPECIFIC COGNITIVE PERFORMANCE ASSESSMENT TOOLS

PURPOSE

Dismounted military operations are cognitively demanding, typically requiring working memory, visual search, and inhibition competencies; especially during tactical load carriage and fire and manoeuvre tasks. However, limited military-specific cognitive assessment tools for use during physical activity exist. This study aimed to develop and provide baseline data for two applied assessment tools to assess changes in military-relevant cognitive performance parameters during military-task simulations.

METHODS

A literature review and subject matter experts discussions resulted in an auditory n-back task (ANT), and a shoot/dont shoot task (SDST) being selected. Scores for both tasks were collected in 20 civilians (mean ± SD; age, 27 ± 3 years; 10 male, 10 female), whilst seated. Prior pilot-testing informed variables including, stimuli characteristics, and intra-stimuli intervals. The ANT comprises of letter pairs described using the NATO phonetic alphabet; mimicking aspects of military radio communications. After hearing a string of letter pairs, an auditory beep sounds and subjects are required to identify the stimuli that were presented one prior to the last stimuli heard (2-back). The SDST comprises of a visual scene depicting a derelict warehouse containing 12 target locations. After a random intra-stimuli interval targets or non-targets were presented. For targets, a mouse click response was required as quickly as possible, non-targets required no response. For both assessments correct response percentages were recorded, with response time recorded for the SDST. A response time greater than 1 s was considered a non-response. Participants completed a familiarisation trial before both assessments. Data are presented as mean ± SD.

RESULTS

For the ANT mean correct response rate was 85.0 ± 15.0%. Of the incorrect responses 56.7%, were partially correct; with one of the letter pairings being identified. The correct SDST response rate was 93.3 ± 4.8%, with a response time of 0.572 ± 0.118 ms. Of the incorrect responses, 81.3% were the wrong response and 18.8% were non-responses.

CONCLUSIONS

The ANT and SDST assess critical competencies required of military personnel during operations. The practicality, expediency, and specificity of the ANT and SDST provide assessment tools that are neither time or equipment intensive and can be conducted in both field and laboratory settings.

OPERATIONAL RELEVANCE

The ANT and SDST provide assessment tools of cognitive function suitable for use in laboratory and field settings; allowing future application pre-, during-, and, post-military operations, thereby leading to an improved understanding of cognitive function during military operations.

AUTHORS

Christopher Vine (1)
Oliver Runswick (1)
Sam Blacker (1)
Sarah Coakley (1)
Stephen Myers (1)

(1) University of Chichester (Chichester, United Kingdom)

SCREENING AND KNOWING WHEN TO REFER FOR SLEEP PROBLEMS

PURPOSE

Despite growing recognition of the importance of sleep for overall health and wellness, general awareness of sleep requirements and healthy sleep behaviors is low. Furthermore, screening for sleep problems is disproportionately underperformed among healthcare practitioners compared to other health behaviors. A recent study found that just 43% of health history questionnaires included questions about sleep, compared to 93% for healthy dietary behaviors and 86% for regular physical activity. Screening for smoking, eating, and physical inactivity has dramatically improved awareness, diagnosis, and resolution of problems in these realms and, not surprisingly, research is beginning to demonstrate similar importance for sleep screening. The purpose of this session is to demonstrate how sleep screening can be easily and quickly incorporated into most healthcare and wellness visits.

METHODS

This session will discuss several user-friendly screening tools, including wearable technology and simple questionnaires, to identify problematic sleep patterns. These tools can assist clinicians and fitness professionals in the decision making process of knowing if, when, and where to refer a patient for specialty care in managing sleep disorders. We will introduce a novel algorithm to simplify interpretation of results from a handful of commonly used sleep questionnaires to easily identify poor sleep habits and deficient sleep quality.

RESULTS

Studies have shown that knowledge of healthy sleep behaviors is related to overall sleep quality and that, when identified, patients will act to address problematic sleep conditions. Results from one study indicated that 64% of patients identified at risk for sleep disorders and referred for specialty care acted on these referrals. Emerging evidence confirms the ability of providers and wellness professionals to facilitate positive changes in sleep behavior and reverse the negative effects of poor sleep.

CONCLUSIONS

As poor sleep is an underappreciated and underdiagnosed health concern, effective sleep screening needs to be more widely practiced by healthcare practitioners and fitness professionals. Knowing how to implement and interpret simple screening measures is critical in identifying those in need of sleep behavior interventions and knowing how best to intercede.

OPERATIONAL RELEVANCE

The information discussed in this session will assist healthcare providers and fitness professionals working with military populations to optimize soldier physical performance by identifying inadequate sleep.

AUTHORS

David Boland (1)

(1) Army-Baylor University Doctoral Program in Physical Therapy (San Antonio, United States)

FATIGUE RATING INCREASES WITH POOR SLEEP QUANTITY AND QUALITY IN MALES AND FEMALES DURING 6-MONTH MILITARY OFFICER TRAINING

PURPOSE

To compare self-reported sleep behaviors, sleep satisfaction and fatigue between male and female military officers following six months of secondary training (ST).

METHODS

Male and female officers completing a six month ST course were surveyed as part of a larger study. Self-reported sleep and fatigue over the past seven days were assessed. The two-item Pittsburgh Insomnia Rating Scale (PIRS-2) classified sleep quality as good, moderate, or poor. Two items from the U.S. Naval Unit Behavioral Health Needs Assessment Survey (NUBHNAS) classified respondents as having a sleep deficit or not. Another item from NUBHNAS asked officers to rate their fatigue (from 0-10; 10=severe fatigue). Chi-Square tests assessed sex differences in sleep quality and sleep deficit group proportions. Two-way ANOVAs assessed main effects of sleep deficit, sleep quality group, and sex, and sleep deficit*sex and sleep quality group*sex interaction effects on fatigue.

RESULTS

Officers (n=669: males=575; females=94, age 25.2±3.0) were surveyed. Based on the PIRS-2, 32.6% were classified as good sleepers (n=218; males=33% (188/575), females=32% (30/94)), 56.7% were classified as moderate sleepers (n=379, males=57% (n=330/575), females 52% (n=49/94)), and 10.8% were classified as poor sleepers (n=72, males 10% (n=57/575), females=16% (n=15/94)); distribution of sleep quality did not differ between sexes (2=3.15, p=0.21). For NUBHNAS, 54.7% reported a sleep deficit (n=366/669; males=53% (304/575); females=66% (62/94)); distribution between sleep deficit categories was different between sexes 2=5.86, p=0.02). There was a main effect of sleep deficit on fatigue: those with a deficit reported higher fatigue than those without ($F_{1,665}=64.2$, $p<0.001$). Also, a main effect of sleep quality on fatigue was noted: individuals who reported poor sleep quality, reported increased fatigue ($F_{2,663}=90.2$, $p<0.001$). No main effects of sex (Sleep quality, $F_{1,663}=3.7$, $p=0.06$; Sleep deficit, $F_{1,665}=0.54$, $p=0.50$) or interactions of sex with sleep deficit ($F_{1,665}=3.1$, $p=0.08$) or sleep quality ($F_{2,663}=1.7$, $p=0.18$) impacted fatigue.

CONCLUSIONS

Sleep deficits were present in more than half of officers completing ST and those reporting sleep deficits also described greater fatigue compared to those without, regardless of sex. Poor sleepers also reported higher levels of fatigue compared to moderate or good sleepers, regardless of sex. A higher percentage of females reported sleep deficits than males; however fatigue ratings did not differ by sex.

OPERATIONAL RELEVANCE

Military training requirements are known to create challenges for maintaining adequate sleep habits. Because chronic sleep disturbances are associated with numerous adverse health outcomes, strategies to promote better sleep should be encouraged following training.

AUTHORS

Amelia Barrett (1)
Daniel Clifton (2)
Emily Southmayd (1)
John Tra (1)
Carl Goforth (3)
Sarah de la Motte (4)
Daniel Clifton (2)

(1) Henry M. Jackson Foundation (Bethesda, United States); (2) Consortium for Health and Military Performance, Uniformed Services University (Bethesda, United States); (3) Naval Medical Research Center (Bethesda, United States); (4) Uniformed Services University (Bethesda, United States)

IMPACT OF SLEEP LOSS AND TIMING ON DECISION MAKING

PURPOSE

Mlitary personnel make numerous decisions every day, ranging from the mundane (which route do I take to work?) to those that impact livelihoods (should I reenlist?), lives (how do I allocate resources in an operation?), and even entire nations (when and how do we intervene in a conflict?). Data show the majority of military personnel regularly function on inadequate sleep (i.e., sleep restriction) and shift work, international travel, and around-the-clock operations require functioning during the biological night (i.e., circadian misalignment). Given these realities, it is important to understand how sleep loss and circadian misalignment impact decision making. If these factors impair decision making, those poor decisions could reduce operational readiness and effectiveness.

METHODS

This presentation will review our current state of knowledge related to the impact of sleep restriction and circadian misalignment of various components of decision making.

RESULTS

Early studies of sleep loss and decision making showed decrements on complex, multi-component tasks during sleep deprivation, such as business simulation games where sleep deprived individuals were more likely to bankrupt their business. Such studies were unable to determine which component of decision making was impaired due to the complex nature of the tasks. More recent work has focused on specific aspects of decision making. The most commonly examined type of decision is risk taking. In general, studies show individuals have a blunted response to risk during sleep deprivation, though this varies depending on how risk is framed. Another line of work argues individuals are less able to integrate multiple pieces of information into a single decision after sleep loss. Circadian misalignment (i.e., making decisions at the wrong time of day) appears to have similar effects as sleep deprivation. These and other studies will be reviewed in this presentation.

CONCLUSIONS

Understanding which basic components of decision making are impaired by operational realities like sleep loss and circadian misalignment is critical to predicting which higher level decisions are most vulnerable to impairments. Moreover, such knowledge is key to developing preventative measures and countermeasures to poor decision making in military personnel.

AUTHORS

Sean Drummond (1)

(1) Monash University (Clayton, Australia)

CHANGES IN ATTENTION DIVISIBILITY DURING SURVIVAL TRAININGS OF SOLDIERS

INTRODUCTION

Nowadays during military activities, a soldier is required to use various devices with precision and make accurate decisions irrespective of the psychophysical strain. The objective of the research was to determine changes in attention divisibility of soldiers from different formations during long-lasting survival trainings. The following hypothesis was proposed: a long-lasting survival training has an adverse impact on attention divisibility.

METHODS

The results of the research were analyzed in the following groups:

military pilots: n=13; age 36.3±8.3 yrs (Tomczak 2015)

soldiers of a special unit: n=8; age 29.0±2.7 yrs (Tomczak 2013)

cadets from Navy Academy: n=14, age 2.3±2.0 yrs (Tomczak et al. 2019)

The survival training lasted 32-36 hours. A long-lasting and moderate physical effort was enforced together with sleep deprivation. The research devoted to attention divisibility was carried out in accordance with the method described in the paper by Tomczak 2013. The test took around 90 seconds and attention indicators were defined. The tests were taken right before the training (M1) as well as after it (M2). The following statistical tests were incorporated: Kolmogorow-Smirnows test, Students test and one-way ANOVA with the post-hoc Scheffés. The significance was set at p0.05.

RESULTS

The following attention indicators were obtained [in%]:

military pilots: M1: 48.2±16.2; M2: 57.5±23.4

soldiers of a special unit: M1: 66.9±15.0; M2: 69.1±19.3

cadets: M1: 58.4±13.0; M2: 78.6±9.2* ($p<0.05$)

CONCLUSION

The hypothesis was not confirmed. The realization of a long-lasting survival training did not have an adverse impact on attention divisibility during a 90 seconds test.

OPERATIONAL RELEVANCE

Thus, it can be inferred that soldiers who are engaged in military activities which involve a long-lasting moderate effort and lack of sleep (or considerable sleep limitation) that last around a day and a half are still capable of effectively performing short tasks that require concentration and precision.

AUTHORS

Andrzej Tomczak (1)
Tomasz Lepionka (2)
Jerzy Bertrandt (3)
Ewelina Maculewicz (3)

(1) War studies University (Warsaw (Warszawa), Poland); (2) Laboratory of Food and Nutrition Hygiene, Military Institute of Hygiene and Epidemiology (Warsaw, Poland); (3) Military Institute of Hygiene and Epidemiology (Warsaw (Warszawa), Poland)

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TS1.
SLEEP: THE IMPACT OF SLEEP ON READINESS, PERFORMANCE, PAIN, HEALING AND WELLNESS

#ABS088

FEBRUARY 14, 2020

IMPACT OF SLEEP ON PAIN

PURPOSE

Pain is distinct from nociception, and the individual experience is influenced by many different factors. Disordered sleep is associated with chronic pain, post-traumatic stress disorder, anxiety, and depression. While adequate sleep enables muscle growth, tissue repair, hormone synthesis, and helps prevent lower pain thresholds. Chronic pain is present at epidemic proportions in the military, and at higher rates than in the civilian population. Disordered sleep is also highly prevalent in military populations. It is no coincidence that these comorbidities exist together. A bidirectional relationship between sleep and pain has been established in the medical literature. The purpose of this session is an in-depth exploration of the relationship between sleep and pain in military service members.

METHODS

The relationship between sleep and pain is presented in relations to 2 key end states: 1) the influence of cognition and memory on sleep and the pain experience, and 2) how many current pain management strategies can exacerbate sleep problems. Examples from data captured in military cohorts will be presented, and compared/contrasted with civilian populations. The session will discuss unique challenges to managing both pain and sleep in this very unique culture and setting.

RESULTS

Sleep culture in the military promotes disordered sleep. 1 in 20 Soldiers are prescribed sleep medication, and only 1 in 4 (23.2%) meet the MEDCOM established sleep targets. These individuals are less likely to be ready to medically deploy, and end up sustaining higher rates of comorbid conditions. Results from one large military cohort revealed that 85.1% of the unit had some sort of clinically relevant sleep disorder. The majority had obstructive sleep apnea (51.2%) followed by insomnia (24.7%). The problem is getting worse, with a 372% increase in sleep disorders between 2005 and 2014. The needle is slowly starting to shift back as awareness increases and initiatives focus on improving the integration of holistic health models.

CONCLUSION

Multiple lifestyle dimensions influence both sleep and pain. A holistic approach will likely be the only effective target of opportunity for decreasing the burden of sleep and pain in military service members. A thorough understanding of these mechanisms and relationships is critical in order to establish and implement effective mitigation strategies.

AUTHORS

Deydre Teyhen (1)

Dan Rhon (2)

(1) Walter Reed Army Institute of Research (Silver Spring, United States); (2) Physical Performance Service Line, Office of the Surgeon General (Falls Church, United States)

TS1.
SLEEP: THE IMPACT OF SLEEP ON READINESS, PERFORMANCE, PAIN, HEALING AND WELLNESS

#ABS089

FEBRUARY 14, 2020

IMPACT OF SLEEP ON HEALTH, SAFETY, AND READINESS

PURPOSE

Although 71% of Americans report getting 7-8 hours of sleep per night, only 41% of U.S. Soldiers get the required amount of sleep. Roughly 55% of Soldiers reported poor quality sleep, 60% report feeling fatigued at least once a week, and 1 in 20 are prescribed sleep medications that limit medical deployability. The purpose of this opening presentation is to provide a foundation for this session by describing the impact of sleep on Soldier health, safety, and military readiness.

METHODS

This session will review key literature to support the importance of sleep on Soldiers health, personal and unit safety, and military readiness.

RESULTS

Those that sleep < 5 hours are at a higher likelihood for diseases such as obesity, hypertension, diabetes, elevated lipids, stroke, and heart attacks compared to those that get over 7 hours of sleep/night. These changes are related to immune function and hormonal changes. Additionally, soldiers with limited sleep are at higher risk for PTSD, depression, mild traumatic brain injury, and panic syndrome. Additionally, it is known that getting < 5 hours of sleep for 5 nights in a row results in a 20% cognitive deficit; equivalent of being legally drunk. Sleep deprivation is responsible for 25% of all motor vehicle accidents. Finally, insufficient sleep has been found to degrade the ability to identify failed solutions, ability to generate novel solutions, anticipate problems, planning, prioritization, judgment, assuming appropriate levels of risk, problem-solving, vigilance, attention to detail, ability to multi-task, concentration, focus, emotional intelligence, response time, and motivation. After a 3-day field exercise errors associated with the ability to identify and shoot a target increased by 220%, errors at shooting at phantom targets increased by 164%, errors in decision-making increased by 86%, and reaction time decreased by 22%.

CONCLUSION

Sleep deprivation negatively impacts the health, safety, and readiness of Soldiers. This opening presentation will provide a foundation for this thematic session on sleep. It will be followed by the impact of sleep on pain and the timing of decision making. The session will then transition to discuss the importance of screening, referral guidelines, and treatment options for Soldiers with sleep concerns and disorders.

AUTHORS

Deydre Teyhen (1)

(1) Walter Reed Army Institute of Research (Silver Spring, United States)

EDUCATING AND COACHING PATIENTS ON SLEEP AND MANAGING INSOMNIA

PURPOSE

Though much is known about the physiology of sleep, practically applicable programs to teach sleep habits and address chronic insomnia are not common. Those that are available are often not familiar to leaders and health care professionals working with Service members with poor sleep and insomnia. While accurate prevalence and incidence data across military populations is not well developed, emerging early data indicate that sleep disruption, sleep disorders in general, and chronic insomnia in particular are common challenges for Service members.

METHODS

This education session will build on the foundational knowledge and focus on practical application of education and coaching. We will review key healthy sleep habits and how to implement them during garrison/home and in operational environments, how insomnia differs from insufficient sleep, and how to use concepts from Cognitive Behavioral Therapy (CBT) to help Service members and families improve their sleep behaviors and address insomnia.

RESULTS

Early clinical trials have demonstrated the efficacy of both brief educational interventions and structured cognitive behavioral therapy approaches for sleep habit improvement and insomnia management. This session will help participants apply these proven principles and connect them with resources to help address these problems at their units and facilities wherever they are, including online self-paced resources and training programs. Programs reviewed in this session are evidence-based, promoted by professional organizations, the result of consensus guidelines, and hosted/created by health systems including the United States Department of Defense and the United States Department of Veterans Affairs.

CONCLUSIONS

Since sleep restriction, chronic sleep loss, and insomnia are prevalent in military populations, theres a need to provide practically applicable training materials and strategies that can be applied to military units and groups wherever they might be operating and which have proven efficacy in clinical trials. This session delivers immediately implementable solutions for common problems around sleep loss in military populations.

AUTHORS

Jason Silvernail (1)
Deydre Teyhen (2)
Jason Silvernail

(1) US Army (Alamo Heights, United States); (2) Walter Reed Army Institute of Research (United States)

CONCEPTS AND ACTIONS TO ENHANCE US AIR FORCE 21ST CENTURY PHYSICAL FITNESS TESTING AND TRAINING: INCENTIVES, ACCOUNTABILITY, TEST ANXIETY, AND TEST RESOURCES

PURPOSE

the United States Air Force (USAF) Exercise Science Unit is working with USAF Senior Leadership on strategic concepts and tactical actions to improve USAF Airmens physical fitness. This effort addresses these potential concepts and actions in accordance with session theme of individual operational readiness.

METHODS

USAF Exercise Science Unit reviewed: 1) physical fitness test data, 2) lessons learned from historical physical fitness policies and procedures, 3) brainstorming options, and 4) physical fitness policy and procedures survey data. Twenty question survey of USAF Airmen, n = 571, ranks from enlisted Airmen (E-2) to general officer (O-7), addressed physical fitness ideas and actions. Airmen provided answers on a five point Likert scale.

RESULTS (survey data in percentage level of agreement)

Overall: physical fitness is a military duty, important to health and performance, an Airmans responsibility, and leaders must establish a culture of physical fitness (91% – 96%). Testing: USAF should incentivize high physical fitness test performance via altered test frequency (65%). USAF should reduce physical fitness test anxiety via a free test 45 days prior to official test; pass – counts, fail – no consequences (75%). USAF leaders must increase focus on Airmen with multiple physical fitness test exemptions (70%). USAF should include physical fitness test scores in Airmens annual performance reports (59%). Training: USAF should enhance physical fitness training accountability with controlled random testing (54%). USAF leaders must encourage (90%) / must mandate (51%) routine physical fitness training in their units. Education: Airmen understand physical fitness test rationale (14%). USAF needs consistent education and communication on proper exercise training across the human weapon system lifecycle (88%). USAF should offer an Exercise Principles and Methods Train-the-Trainer Course to unit physical training leaders (79%). Incentives: top selected incentive options to enhance exercise compliance: duty time off (78%) and monetary (47%).

CONCLUSIONS

survey data indicate USAF Airmen embrace the import of physical fitness, and desire improved physical fitness testing, training, and education. USAF leaders and exercise scientists need to focus more on physical fitness training than testing and employ incentive and accountability procedures to enhance exercise compliance.

OPERATIONAL RELEVANCE

updates to physical fitness testing and training policy have strong potential to slow physical inactivity trends and improve the current physical fitness and operational readiness of USAF Airmen.

AUTHORS

Neal Baumgartner (1)
Erin Flerlage (1)
Mark Latimer (1)
Kerry Sheridan (1)
Beth Bruker-Walos (1)
Melanie Frost (1)

(1) United States Air Force Exercise Science Unit (JBSA Randolph, United States)

COGNITIVE DEMANDS AND REQUIREMENTS OF SOLDIER TASKS: AN ARGUMENT FOR "PUTTING THE HEAD BACK ON THE SOLDIER

PURPOSE

Recent USARIEM research efforts to develop and validate the Occupational Physical Assessment Test (OPAT), in collaboration with U.S. Army Training and Doctrine Command, Center of Initial Military Training, have established an understanding of the physical demands required for Soldier job/task performances. However, awareness of the cognitive demands required for optimal Soldier performance is less well understood and relatedly, valid assessment metrics are limited; these were identified as key gaps by a convened U.S. Army Military Operational Medicine Research Program Working Group, tasked to detail U.S. Armys current capabilities for assessment of cognitive performance in military training and operational settings. In the presentation, a summary of the limited research findings to date related to specific cognitive demands associated with military (combat arms) jobs will be reviewed and a planned program to identify cognitive demands and requirements for military jobs and provide validated assessment metrics will be described.

METHODS

The USARIEM planned program of research will follow a multi-step design similar to the USARIEM Physical Demands Study that produced the Army Occupational Physical Assessment Test.

RESULTS

Key gaps in the current knowledge base related to operational cognitive performance include: i) lack of empirical evidence linking performance on cognitive assessments to military-relevant performance standards, coupled with ii) a poor understanding of the cognitively-demanding elements of military job requirements and related tasks and standards, and iii) lack of cognitive tools and metrics with adequate sensitivity, specificity and ecological validity to predict or detect changes in military task performance before operationally meaningful degradation occurs. To address these gaps, a modified occupational task framework model was developed. In the presentation, the planned multi-tier program of research will be detailed.

CONCLUSIONS

Utilizing a proven pathway for identifying physical demands and requirements for Soldier job/task performances, this planned program will contribute validated assessment metrics for the specific cognitive demands and requirements required for Soldier job/task performance.

OPERATIONAL RELEVANCE

Within the U.S. military arsenal, the Soldier is not only the most complex and sophisticated weapon system, but also may be the least well understood and most unpredictable system. Current models of human system performance often fail to reflect the dynamic and holistic (physical, mental/cognitive, behavioral) nature of job requirements and demands for Soldier readiness (e.g., maintain/sustain alertness to task, make decisions, and/or navigate in time/space), and thus are prone to overgeneralization. The planned program is addressing these key gaps in current understanding of operational cognitive performance.

AUTHORS

Kristin Heaton (1)
Susan Proctor (1)
(1) USARIEM (United States)

HEALTH & READINESS PROGRAMMES IN THE NETHERLANDS ARMED FORCES: A PIVOTAL ROLE FOR LIFESTYLE COACHING

PURPOSE

An increasingly complex world of technological growth, ageing and scarcity of personnel emphasize the need for strengthening the armed forces personnel. In 2017, the Netherlands Armed Forces Surgeon General initiated the program Sustainable Health and Readiness (SHR), aimed at assisting service members in coping with the challenges of life and work by providing them with tools to support a healthy lifestyle, both on and off the job. On an organizational level, the program intents to shift a (military) healthcare system that focuses on injury, disease and illness, towards a system that promotes health and readiness as an integral part of the care continuum.

METHODS

SHR focuses primarily on four topics and their interrelations: nutrition, sleep, physical exercise, and mental empowerment (i.e., promotion of resilience and prevention of poor psychological health). Within SHR, civilian tools and newly developed interventions are implemented. Moreover, (health) care professionals are empowered in using health promotion. Program activities take place at the individual, team/social, and organizational level. Examples include pilots of healthy food supply in Dutch military barracks, PhD-research on stigma of mental health problems, and research on the link between oral microbiome and preventative oral health care in operational settings.

The cornerstone of SHR, however, is the introduction of a new health professional within the military: the lifestyle coach. This certified coach can guide individuals or groups with health-related issues such as sleep deprivation, stress, or overweight. The lifestyle coach works in an integrative manner by connecting with other service support professionals, and makes use of a toolbox with an array of mainly scientifically based interventions (e.g., sensoring, interconnected web/mobile apps, advice based on laboratory diagnosis).

RESULTS

SHR lifestyle coaching programs are ongoing at two staff departments (total n1,500). Based on preliminary observations, a total of 30-40% participation rate is expected during each of the 2-year programs. Additional programs are being planned for 2019-2020 at brigade level. The SHR programs are being evaluated by means of a pre-post questionnaire design and process evaluation. First results will be available in the third quarter of 2019.

OPERATIONAL RELEVANCE

Health, broadly defined as a dynamic ability to adapt and manage ones own well-being, is considered to be a prerequisite for the sustainable employability of service members. By providing health promotion tools at different organizational levels, service members are supported to develop skills to improve health and readiness to better cope with their social and operational context.

AUTHORS

Pieter Helmhout (1)
Fenna Leijten (1)
Diewertje Sluik (1)
Tabe de Boer (1)

(1) Health & Readiness Core Team / Staff Joint Health Care Division / Command Service Center / Ministry of Defense The Netherlands (Utrecht, Netherlands)

BALANCE – THE CANADIAN ARMED FORCES PHYSICAL PERFORMANCE STRATEGY: CREATING THE CONDITIONS TO SUPPORT OPTIMAL PHYSICAL ACTIVITY, SLEEP, NUTRITION AND INJURY PREVENTION PRACTICES

PURPOSE

The demands of military operations require that personnel attain and maintain optimal levels of physical fitness. Most Canadian Armed Forces (CAF) personnel are not given time during the work day to engage in physical activity, and must therefore juggle this with other priorities in their lives. Given increases in sedentary time and obesity in CAF personnel over period from 2008-2014, it was decided that a new physical performance strategy was required to align efforts and ensure the operational effectiveness of CAF personnel.

METHODS

Extensive baseline data was collected and assembled, relating to individual behaviours, and physical/social environments. This needs assessment revealed that programming, physical facilities, the built environment, and leadership support/modeling could all be improved to better support active living in the CAF.

RESULTS

A strategy framework, based on McLeroys Social Ecological Model of Health, was developed in collaboration with stakeholders from all military commands in the CAF. The strategy contains lines of operation at the national level, related to behavioural surveillance, research/development and broad programming changes. Command-led steering committees on each base were provided with best practice infographics on promoting physical activity in the workplace, from which they selected interventions based on their baseline data and priorities. A reporting/evaluation framework has also been established, including indicators of process (short-term), behaviour (medium-term), and physical fitness/performance (long-term). Since the Strategy's launch in the spring of 2019, local bases have begun implementing some of the best practice suggestions, including walking maps and health fairs, as well as some larger initiatives related to developing programming and walking/cycling paths. These will be presented in detail. The positioning of Health Promotion and Physical Fitness personnel as primary advisors to their local chains of command in the context of this strategy is key to its success.

CONCLUSIONS

This strategy represents some very novel elements for the CAF including its decentralized nature, the balance of individual and organizational responsibility for fitness, as well as the acknowledgement of the influence of environmental determinants. The national steering committee that developed the strategy will continue to report annually to the most senior ranks of the CAF on interventions, behaviours and fitness outcomes. Annual activity plans at the local and national levels will be updated as initiatives are completed and new needs arise.

OPERATIONAL RELEVANCE

This Strategy is specifically designed to enhance physical operational readiness, as measured by the CAF's FORCE Fitness Profile.

AUTHORS

Michael Spivock (1)
Daryl Allard (2)
Wayne Eyre (1)

(1) Canadian Armed Forces (Ottawa, Canada); (2) Canadan Armed Forces (Ottawa, Canada)

OPTIONS AND STRATEGIES TO ENHANCE INDIVIDUAL OPERATIONAL READINESS: A GERMAN RESEARCH PERSPECTIVE

PURPOSE

Operational readiness of individual soldiers is increasingly affected negatively by declining physical fitness and adoption of unhealthy lifestyle habits. The development of new individualized strategies is necessary to boost and support motivation for and adoption of health and fitness oriented behavior. Given the key role of physical performance capability for operational readiness, the goal of these strategies should be enhancement and maintenance of individual physical performance capabilities. This area has been a focus of attention both in the military ranks as well as among military scientists in Germany.

Purpose of this presentation is to present a birds-eye view on the issue at large as well as approaches and options from a German perspective.

METHODS

A selective literature search was conducted with a thematic focus on interventions targeted at improving health, fitness, well-being, resilience, and behavior beneficial for health, physical performance, and operational readiness. Special attention was given to examples of incentive systems, independent of setting (work, leisure time, at home, public or private sector etc.).

RESULTS

There is an abundance of intervention programs and incentive systems intended to influence individual health and fitness related behavior. Rough estimates of their efficiency indicate that both positive and negative incentives can affect participation and adherence to health and performance oriented behavior-modifying programs.

CONCLUSION

The results suggest that transfer of this empirical knowledge into the German Bundeswehr may offer further and promising options for the improvement of individual physical fitness, resilience, and healthy behavior of soldiers. For example, nudging and incentives may constitute appropriate measures to further enhance and boost results of existing health and fitness promotion campaigns. However, it is equally important for military policy makers to recognize that empowering soldiers to maintain and enhance their individual operational readiness by ways of adequate educating and training is an effective way to maximize military effectiveness.

OPERATIONAL RELEVANCE

The enhancement of individual soldiers operational readiness is of utmost operational relevance. The approaches and data presented indicate viable options to achieve this goal.

AUTHORS

Alexander Witzki (1)

Dieter Leyk (1)

(1) Bundeswehr Institute for Preventive Medicine (Andernach, Germany)

THE EFFECT OF WEARING BODY ARMOUR AND ADDITIONAL LOAD ON PULMONARY FUNCTION AND SOLDIER PERFORMANCE

PURPOSE

To provide an evidence-base to inform the test and evaluation of future soldier systems so that they minimise breathing restriction. The hypothesis that restrictions to pulmonary function would limit the performance of military tasks was tested.

METHOD

Four separate studies were conducted to quantify the effect of wearing body armour with backpack loads on infantry soldiers at rest and whilst marching. The load configurations tested ranged from no load to 50 kg. Pulmonary function, mouth pressures (for estimation of respiratory muscle fatigue), shoulder pressure/force and cardiopulmonary parameters were measured pre/post and during a loaded march. The loaded marches were between 40 to 180 minutes in duration and included light to very heavy exercise intensities. Data were analysed using a two-way repeated measures ANOVA or paired t-test; effects / differences reported below identify where statistical differences were observed ($p<0.05$).

RESULTS

Wearing body armour with additional load caused a restrictive ventilatory impairment which ranged from 6% to 18% depending on the load carried. Soldiers developed a rapid and shallow breathing pattern whilst marching with load which led to respiratory muscle fatigue. During long duration moderate intensity marches, mouth pressures were reduced by 11% to 13% (inspiratory) and 13% to 21% (expiratory) depending on the march duration and load carried. Increasing the load carried during the long duration march (from body armour worn alone to a 40 kg marching order load) did not affect the time to complete a subsequent 2.4 km best effort test in Assault Order Loads (25 kg). Expiratory flow limitation was evident in 72% of participants tested during high intensity exercise.

CONCLUSIONS

Breathing restriction has the potential to limit the performance of high intensity military tasks, but did not limit longer duration moderate intensity loaded marches or effect the time to complete subsequent tasks under the conditions investigated. The mouth pressures of the infantry soldiers tested were greater than observed by others using an active civilian population. This may be indicative of adaptions which occur with regular load carriage training. Lung function should be assessed objectively during future equipment procurements that include load carriage on the torso.

OPERATIONAL RELEVANCE

The outputs from this work will be used to inform future soldier equipment procurement programmes. This work is also being exploited as part of on-going work investigating the ventilatory systems adaptations to load carriage and ways to increase the efficiency of load carriage training.

AUTHORS

Nicola Armstrong (1)
Mitch Lomax (2)
Michael Tipton (3)
James House (2)

(1) Defence Science Technology Laboratory (United Kingdom); (2) University of Portsmouth (Portsmouth, United Kingdom); (3) Univerisity of Portmouth (Portsmouth, United Kingdom)

TS11.
UNDERSTANDING THE PROTECTION-PERFORMANCE - VULNERABILITY TRADESPACE TO ENHANCE OVERALL SOLDIER SURVIVABILITY AND EFFECTIVENESS
#ABS280

FEBRUARY 14, 2020

THE EFFECT OF BODY ARMOUR DESIGN ON SOLDIER COMBAT MOBILITY

PURPOSE

Canada has used the Load Effects Assessment Program (LEAP) course to better understand how soldier system factors (user, task, equipment, environmental) affect soldier combat mobility. This paper will summarize what Canada has learned about the impact of soldier body armour design parameters on soldier combat mobility performance.

METHODS

LEAP comprises a series of ten operationally-relevant obstacles, and ancillary test stands (simulated marksmanship, load handling, jumps). Several studies have manipulated soldier armour conditions, each using a balanced repeated measures design. Two have employed a pre-fatiguing protocol. Dependent measures have included: time to complete course and individual obstacles; marksmanship accuracy, precision and engagement speed; distance jumped; and subjective ratings of acceptability. Independent variables have included equipment factors (load, armour coverage, weight, protection level), soldier factors (anthropometry, strength, aerobic fitness) and system factors (encumbered soldier weight, bulk, range of motion).

RESULTS

In terms of total course completion time, LEAP performance was significantly affected by adding torso armour (soft or hard armour plates) and minimal soft armour protection to parts of the body beyond the torso (to shoulders and groin simultaneously). LEAP performance did not discriminate between torso armour conditions differing in stiffness or bulk for the same protection level and weight unless a pre-fatiguing protocol was used, in which case, for torso protection only, results indicate that it is better to make armour less stiff than to make it less bulky. When controlling for weight in a study of soft armour torso coverage, no significant LEAP performance differences were observed, even using a pre-fatiguing protocol, although there is the possibility that the load carriage system employed (not in-service) might have masked any armour effects. Several soldier, equipment and encumbered system factors are significantly correlated with LEAP performance.

CONCLUSIONS

Weight of armour is the main determinant of mobility performance as measured using LEAP. Stiffness and bulk of the encumbered soldier are significant correlates. Studies to date have used real armour which does not permit independent manipulation of weight, bulk, stiffness, and coverage. A Load Effects Testbed is being designed to permit this research going forward.

OPERATIONAL RELEVANCE

The tradespace between providing adequate protection to defeat threats, while enabling sufficient mobility to avoid these same threats, is poorly understood. Mobility decrements due to body armour design can increase soldier exposure, thus vulnerability to enemy fire. Future body armour design can be influenced by knowledge of these mobility effects.

AUTHORS

Linda Bossi (1)
Andrew Morton (2)
Monica Jones (3)
Kristina Gruevski (4)
Thomas Karakolis (1)

(1) Defence R&D Canada (Toronto, Canada); (2) HumanSystems Incorporated, Senior Consultant (Guelph, Canada); (3) University of Michigan Transportation Research Institute (Ann Arbor, United States); (4) University of Ottawa, Post doctoral fellow (Ottawa, Canada)

A NOVEL FRAMEWORK FOR ASSESSING THE TRADESPACE BETWEEN SOLDIER PHYSICAL PERFORMANCE, SURVIVABILITY, AND HEALTH

PURPOSE

To develop a machine-learning framework that produces morphable models that emulate soldier movement behaviours under differing body-borne loads (BBLs) and to implement these models into battle simulators and musculoskeletal models to assess survivability and joint loading.

METHODS

Motion capture data were collected on 16 civilians performing eight randomly assigned military-based movements: walking, running, prone-to-run, run-to-prone, kneel-to-run, run-to-kneel, prone-to-kneel, and kneel-to-prone under three randomly assigned loaded conditions: slick (~5.5 kg), full fighting order (FFO; ~20 kg), and FFO + backpack (~32 kg). All data were collected using a full-body inertial measurement unit (IMU) suit (Xsens, MVN BIOMECH, Netherlands) that outputs time-series marker positional data.

Marker data from each movement trial were time normalized using dynamic time warping in Matlab (2018b, The MathWorks, USA). Principal component analyses (PCA) were used to reduce the dimensionality of the time-series marker positional data. Only the principal components (PCs) that explained 90% of the variance were retained for further processing. A multi-class linear discriminant function (LDF) was calculated for the retained PCs with the classifier of BBL. The LDF to ±3 standard deviations were used to create representative, morphable models to emulate movement under different BBLs. The morphable models were exported into compatible file formats for both musculoskeletal (e.g.c3d and.trc) and battle simulator software (e.g.fbx).

RESULTS

We have used our framework to successfully reproduce representative movers for the eight military-based movements studied based on BBL as the classifier. The models were successfully imported into both musculoskeletal (Visual 3D, C-motion, USA; OpenSim, SimTK, USA, SantosHuman, USA) and battle simulator software (Virtual BattleSpace 3, Bohemia Interactive, Czech Republic).

CONCLUSIONS

Our framework is designed to create morphable models that represent movers based on desired classifiers. Our framework with a classifier of BBL has been successfully utilized as an input for musculoskeletal and battle simulator software. Future directions include integrating more classifiers within our framework (e.g. sex, physical fitness, occupational stress) and to run simulations that assess joint loading and soldier survivability.

OPERATIONAL RELEVANCE

Our framework advances the development of an objective decision-making tool to assess the tradeoffs between protection, mobility, musculoskeletal injury risk, and susceptibility to fire. The ability to alter realistic movement behaviours based on classifiers allows for the execution of many simulations without the need to recollect motion capture data. For the first time, we can objectively assess optimal BBLs that maintain soldier performance, survivability, and musculoskeletal health.

AUTHORS

Ryan Graham (1)
Matthew Mavor (1)
Gwyneth Ross (1)
Thomas Karakolis (2)
Linda Bossi (2)

(1) University of Ottawa (Ottawa, Canada); (2) Defence Research and Development (DRDC) Canada (Toronto, Canada)

THE EFFECT OF LOAD-INDUCED MOBILITY DECREMENT ON SOLDIER VULNERABILITY TO ENEMY FIRE IN A DANGER CROSSING SCENARIO

PURPOSE

The detrimental effects of load on individual soldier mobility have been established with the Load Effects Assessment Program, however the operational effects of soldier encumbrance remain poorly understood. The goal of this study was to better understand the relationship between mobility and vulnerability to improve survivability of dismounted infantry soldiers.

METHODS

The experimental paradigm of this study used CAF soldier participants as enemy shooters engaging targets moving at four speeds associated with different levels of mobility decrement in a danger crossing scenario. Movement speeds were drawn from literature corresponding to a range of soldier encumbrance from a basic combat load to an extended load. The Virtual Immersive Soldier Simulator was used to present targets and participants engaged the virtual targets moving across gaps between barriers with a C8 carbine simulator. Independent variables included target speed, direction, gap width, left or right gap, range, and training. Vulnerability, and the relationships with target conditions, were explored through hit probability as well as other target and shot metrics. Analyses of variance were used to test for statistical significance and regression modeling was used to examine probability of hit by movement speed and engagement range.

RESULTS

Decrements in mobility translated to increased vulnerability, with the speed of target movement a significant main effect in hit probability and other metrics examined. The regression model enabled analysis of relationships with probability of hit and demonstrated the significant effects of target speed and engagement range. Accuracy results show strong effects of both speed and range, as well as gap width. A speed-accuracy trade-off demonstrated that faster moving targets are not only less likely to be hit but, when hit, are impacted further from the centre of mass.

CONCLUSIONS

This study developed a foundational understanding of the relationship between mobility and vulnerability. The importance of mobility must be emphasized, as target speed not only influenced the probability of hit but also shot accuracy. Together with models of load induced mobility decrement, an empirical understanding of the effect of load on soldier vulnerability is emerging.

OPERATIONAL RELEVANCE

Understanding the true cost of soldier load is the first step in addressing the issue of soldier overload. This study has quantified this cost and made explicit the linkage from load to vulnerability. Small unit commanders, capability planners, equipment developers, and policy makers can all benefit from this knowledge in their decision making.

AUTHORS

Andrew Morton (1)
Jordan Bray-Miners (1)
David Tack (1)
Ken Ueno (2)
Linda Bossi (2)

(1) HumanSystems Incorporated (Guelph, Canada); (2) Defence Research and Development Canada (Toronto, Canada)

SURVIVABILITY AND PHYSICAL PERFORMANCE TESTING: A HUMAN-CENTERED DESIGN APPROACH OF PERSONAL PROTECTION SYSTEMS FOR COMBAT OPERATIONS

PURPOSE

Survivability is the ability to exist and function through and after exposure to hostile circumstances (e.g., opposing force and adverse environments). The trade-off between body armor coverage, threat level, and mobility or operational effectiveness translates directly to survivability. Development of measurement techniques and standards in a controlled environment is critical to rapidly and effectively quantify the effects of gear configurations on warfighter performance. A set of standard test measures capable of replicating dismounted combat tasks while obtaining physical, cognitive, and physiological data for objective evaluation of personal protective equipment (PPE) is needed.

METHODS

Biomechanical, physiological, and performance measurements were collected during selected tasks to determine which assessments were likely to show differences between varying types of PPE. Active duty U.S. Marines completed the series of tasks with systematic variations in load and design believed to have varying effects on performance. Tasks were based on elements of the U.S. Marine Corps Combat Fitness Test, Load Effects Assessment Program, and day-to-day operations and training regimens. They included joint ranges of motion, level and sloped walking, ammo can lifts, jumps, stair climbing, agility tasks, and simulated marksmanship drills. In addition, the effects of different helmet designs were assessed using neck range of motion and field of view. Self-report questionnaires of comfort and task difficulty were also acquired.

RESULTS

Several iterations of testing occurred to refine assessments to provide better distinction between PPE types. Testing of service members has shown initial ability to distinguish differences between configurations in outcomes such as walking and running speed, shooting performance, and muscle recruitment level. The correlation between objective outcomes with subjective reports as well as with field performance is being assessed.

CONCLUSIONS

Quantitative parameters such as eye gaze, reaction time, heart rate, muscle activation, and biomechanical measures (i.e., joint kinematics, ground reaction forces) provided objective measures of performance under load. Evaluation of gear configurations that employ operational tasks with physical and cognitive challenges is important for proof of concept as well as for down-selection processes prior to engaging in costly and lengthy field evaluations.

OPERATIONAL RELEVANCE

There are currently no comprehensive methods to objectively evaluate PPE and the concurrent effects of both load and motion restriction on performance and thus survivability. Development of a validated sequence of tasks relevant to ground combat will be beneficial for gear testing and evaluation, with direct transition to field operations.

AUTHORS

Pinata Sessoms (1)
Aaron Wolf (2)
Trevor Viboch (2)
Jordan Sturdy (3)

(1) Naval Health Research Center (San Diego, United States); (2) Leidos Inc; Naval Health Research Center (San Diego, CA, United States); (3) Colorado School of Mines (Golden, CO, United States)

TS11.
UNDERSTANDING THE PROTECTION-PERFORMANCE - VULNERABILITY TRADESPACE TO ENHANCE OVERALL SOLDIER SURVIVABILITY AND EFFECTIVENESS
#ABS401

FEBRUARY 14, 2020

IMPACT OF LIGHT-WEIGHT HARD ARMOUR SYSTEMS ON MARINE VULNERABILITY

PURPOSE

The U.S. Marine Corps needed to compare the vulnerability of Marines to enemy fire while wearing the in-service Enhanced Small Arms Protective Insert (ESAPI) system to a lighter (7 lbs), less protective hard armor system of Light Weight Plates (LWP). While the ballistic performance differences between the two hard armor systems were known, the impact of faster Marine mobility, due to the lighter plates, on Marine hit probability was not.

METHODS

Sprint results from a previous Load Effects Assessment Program (LEAP) trial, comparing pre-fatigued Marines wearing the ESAPI or LWP system, were used as input to this trial: slow (5.5 mph), medium (6.3 mph), and fast (6.9 mph). The intent of this trial was to determine the likelihood and location of hits on robotic targets operating at these speeds. Target engagement testing included Scenario Testing, involving an attack scenario with robots maneuvering between positions of cover across a 200m x 200m area, and Systematic Testing, with robotic targets making a series of single runs across danger areas between positions of cover from two engagement distances (100m and 200m). Robotic targets were engaged by foreign weapons trained Marines using AK-47 rifles and foreign ammunition.

RESULTS

During scenario testing, the robotic targets were hit more often at the slowest speed than at the medium (18% less) and fast (55% less) speeds. During systematic testing, the same trend of fewer hits with faster speeds was observed. At the closer engagement range (100m), robots at the medium and fast speeds had similarly 30% fewer hits than the slowest speed. At the farther range (200m), the robotic targets were hit more often at the slowest speed than the medium (12% less) and fast (29% less) speeds. An inspection of hit locations revealed a very low probability of multiple plate hits and a higher likelihood of hits to the head/neck at slower speeds.

CONCLUSIONS

Relating the sprint speeds used in this trial back to the ESAPI and LWP systems, the faster sprint speeds resulting from a lighter hard armour plate system resulted in a noticeably lower hit probability, as compared to the heavier in-service plate system. The likelihood of multiple hits to a single plate during a single exposure to enemy fire was very low.

OPERATIONAL RELEVANCE

Improvements in Marine and soldier mobility performance can translate directly into reduced vulnerability.

AUTHORS

Mark Richter (1)
David Tack (2)
David Tack (2)
Andrew Morton (2)

(1) U.S. Marine Corps, Marine Corps Systems Command (Quantico, United States); (2) Humansystems Incorporated (Guelph, Canada)

EFFECT OF PERSONAL PROTECTIVE EQUIPMENT ON AGILITY IN U.S. MARINES

PURPOSE

U.S. Marines need to operate in austere environments against a range of threats while being outfitted with personal protective equipment (PPE) such as plate carriers and combat helmets. This creates added burden. Most assessments of PPEs effect on mobility have focused on sagittal plane movements like running or walking. This study aimed to evaluate the effect of PPE on mobility in a multiplanar agility task that assesses forward, lateral, and backward running.

METHODS

Five healthy, active duty, male U.S. Marines with Physical Fitness Test scores of good or better were recruited. Participants were instructed how to perform the agility T-test (T-drill), which consists of running forward 10 yards (Seg1), shuffling left 5 yards, shuffling right 10 yards, shuffling left 5 yards (Seg2), and finally running backward 10 yards to the origin (Seg3). Distances were marked with cones and a laser timing system (Brower Timing Systems, Draper, UT) measured time of each segment. Following instructions, a familiarization trial was performed. Participants wore nonrestrictive athletic clothing and Marine Corps-issued boots. In addition to this condition (No-PPE), participants performed two other trials wearing PPE (plate carriers and combat helmets) of greater coverage and weight (Low-PPE and High-PPE, respectively). The order of these three trials was randomized.

RESULTS

A repeated measures two-way analysis of variance (ANOVA) was performed for effect of PPE, T-drill segment, and interaction on time. A significant interaction (defined as p.05) and main effect for PPE and T-drill segment were found. Repeated measures ANOVAs were performed to determine if the effect of armor on time depends upon the T-drill segment performed. For Seg1, significantly faster times were found in the No-PPE condition compared with High-PPE. For Seg2, significantly faster times were found in the No-PPE condition compared with Low-PPE and High-PPE and between Low-PPE and High-PPE conditions. No significant differences were found for Seg3.

CONCLUSIONS

Findings indicate that PPE significantly diminishes performance of the T-drill, resulting in poorer agility, with the greatest deficits shown in lateral running. Future research should also consider agility drills that demand movement in the transverse plane.

OPERATIONAL RELEVANCE

This study provides evidence that PPE diminishes agility, particularly in the frontal plane. In combat, this may mean a decreased ability to outmaneuver and evade threats. This trade-off should be considered when designing and selecting PPE.

AUTHORS

Trevor Viboch (1)
Aaron Wolf (1)
Dr. Pinata Sessoms (2)

(1) Naval Health Research Center, Leidos, Inc. (San Diego, United States); (2) Naval Health Research Center (San Diego, United States)

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