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TACTICAL FITNESS RESEARCH 2018

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The American College of Sports Medicine (ACSM) 65th Annual Meeting was held in Minneapolis, MN May 29 – June 2, 2018. Overall, there were more than 50 presentations with a military focus, which included a poster session on military physiology, a thematic poster session on military energy expenditure, a tutorial lecture on Special Operations Forces (SOF), two lectures on the challenges of feeding active duty while deployed, and a presentation discussing an intervention for treating post-traumatic stress disorder (PTSD) in military retirees.

Military nutrition strategies were an important theme at the meeting. One such study attempted to generate a prediction equation which would accurately estimate daily energy expenditure of individual SOF in a field setting (13). The authors used a retrospective analysis of SOF energy expenditure while engaged in 12 different training scenarios. Energy use and total body water were determined by the doubly labeled water (DLW) technique (13). Physical activity level was defined as daily energy expenditure divided by resting metabolic rate. Physical activity level was broken into quartiles (0 = mission prep, 1 = common warrior tasks, 2 = battle drills, and 3 = specialized intense activity) in order to generate a physical activity factor (PAF). Regression was used to construct two predictive equations (Model A: body mass and PAF; Model B: fat-free mass and PAF). Measured daily energy expenditure ranged from 3,700 – 6,300 kcals/day, with an average of 4,468 kcals/day per soldier. Regression analysis revealed that physical activity level ($r = 0.91$; $p < 0.05$) and body mass ($r = 0.28$; $p < 0.05$; Model A), or fat-free mass (FFM; $r = 0.32$; $p < 0.05$; Model B) were the factors that most highly predicted energy expenditures. Model A and Model B predicted energy expenditure comparably well ($r = 0.74$ and $r = 0.76$, respectively) with no significant differences (mean + SEM: Model A; 4463 + 65 kcals/day, Model B; 4462 + 61 kcals/day) from DLW derived expenditures. As both models predicted energy expenditure equally well, this indicates body composition does not have to be known to use the equation. Practical applications of this research will permit the design of SOF food plans specific to their mission profiles.

Military personnel frequently train and/or deploy to locations with hot, humid environments. Active duty members also frequently consume caffeine, and research indicates 13 – 14% of personnel are "high utilizers" of caffeine (defined as > 400 mg per day caffeine for men, and > 300 mg for women) (9). It has been heavily debated over the last few years whether the diuretic effect of caffeine would inhibit the tactical performance of personnel in hot environments (1). This study investigated the effect of caffeine ingestion (CAFF) on core temperature during exercise in a hot, humid environment (1). Twenty-one physically active male subjects performed a maximal graded exercise test (GXT) and two endurance exercise tests (EET), separated by at least 48 hr. Subjects were randomly assigned to consume either 6 mg/kg body mass of a placebo (PLAC) or CAFF supplement for one EET and the opposite substance for the second test. The subjects also ingested a core temperature sensor to measure core body temperature during each test. Each EET consisted of cycling on a cycle ergometer at 65% of VO_2max for 40 min in a controlled hot (36.37+0.58C) humid environment (59.46+5.14% RH). The results indicated no significant difference between groups for core body temperature or heart rate at any time point, except for an elevated heart rate (HR) five minutes post-exercise in the CAFF group when compared to PLAC. A significant increase in HR from pre-exercise to 40 min was observed in both groups, but CAFF consumption elicited no synergistic effects on HR or core body temperature before, during, or after exercise. This study suggests that caffeine consumption does not impair thermoregulation in a hot, humid environment. Caffeine consumption did result in a blunted HR recovery for the first five minutes post-exercise test, possibly indicating a greater degree of heat stress in the CAFF group. Future directions for research could involve cycling for longer durations (> 60 min) to examine if the diminished HR recovery in the CAFF subjects would become more pronounced. In addition, comparing subjects who were regular users of caffeine versus subjects who were caffeine naïve might be useful, as caffeine tolerance could affect responses.

Body composition was also addressed in various studies. Like the United States Air Force, (USAF) the United States Navy (USNAV) now uses abdominal circumference (AC) measurements, rather than Department of Defense-determined anthropomorphic body fat equations to assess body composition. One study tested whether differing AC measurement sites could be used with equivalent accuracy or not (18). The USAF and USNAV currently assess AC by using the iliac crest (IC) as a marker. This study tested the validity of measuring AC at the umbilicus (UMB) compared to the IC. UMB and IC measurements were taken on 115 subjects (79 males and 36 females) using a retractable tape measure. Three measurements were taken at both sites by the same researcher. Results indicated a high correlation between UMB and IC measurements in both males and females, and supports the use of the UMB as an alternate (and easier to locate) AC measuring site. Though this study did find that the UMB is a valid measuring site for AC, it did not address other problems with the AC test, which render the results invalid. The upper standards for passing are very lenient; previous research indicates that 95% of Air Force males with an AC > 35 in. and 98% of Air Force females who have an AC > 35.5 in. have unhealthy levels of body fat (11).

The second major problem with the AC test is that for it to have any validity, AC must be independent of skeletal height (8). Recent research demonstrates this assumption is incorrect; when adjusted for age and ethnicity, AC significantly correlates with height in males and females (8). Taller males/females have wider AC measurements because they are taller, not because they are fatter. In this case, assuming a single AC cutoff standard independent of height would result in subjects being misclassified as unhealthy when they are not. In addition, taller subjects might unfairly fail a fitness test component. Future research directions include directly comparing AC measurements with indices of cardiometabolic disease (cholesterol, fasting glucose, etc.) to more accurately determine AC cutoffs, which are indicative of a need for lifestyle intervention.

Another study examined relationships between various body composition ratios as determined via air displacement plethysmography and self-reported physical activity (10). Subjects consisted of males (n = 604) and females (n = 343) in the Air Force. Bod Pod® results were used to identify fat mass (FM), fat-free mass (FFM) and %fat. Subjects were stratified into four age groups, and into four activity groups (sedentary, low active, active, and very active). In addition to body mass index (BMI), fat-free mass index (FFMI) and fat mass index (FMI) were determined by evaluating each component relative to height (kg/m^2). Regardless of sex, BMI, FMI, and %fat were significantly higher in those groups reporting lower levels of physical activity than those groups which reported higher levels of physical activity. In addition, among age groups, FFMI and %fat were significantly different, and were higher/lower in the youngest age group compared with the oldest. An activity by age group (4 x 4) multivariate analysis of variance (MANOVA) was performed on each sex. In men, BMI, FMI and %fat were significantly different ($p < 0.001$) among activity and age groups. In women, BMI, FMI, and %fat were significantly different ($p < 0.007$) among activity groups.

Discriminant analysis identified FMI as the best discriminator of activity group in each sex. Interestingly, though FFMI differed by age, FFMI did not differ by activity group. This may indicate that Air Force personnel are engaging in suboptimal levels of resistance training, which would explain the independence of FFMI relative to activity group. This result is consistent with previous data indicating that a significant number of Air Force males and females have lower than desired amounts of FFM relative to BMI and abdominal circumference and might therefore be classified as "skinny fat" (11).

One study tested the use of heart rate reserve (the difference between resting heart rate and maximal heart rate, or HRR) as an objective measure of United States Army soldiers' physical exertion during field operations (5). Thirty-eight Army male soldiers volunteered for the six-session study. While wearing a HR monitor, they participated in three trials (one trial per session) of an experimenter-paced, 4.83-km foot march (FM) at a 4.83 km/h-1 speed and three trials (one trial per session) of a self-paced, maximum effort run of an obstacle course (OC) while carrying various military loads, which were randomized on each trial. In addition, maximum heart rate (MHR) was obtained in the last 20 s of VO_2peak testing. Resting heart rate (RHR) was recorded in the final 20 s of a five-minute period of sitting prior to trial initiation. The highest HR in a trial (MHRtrial) was also identified, and %HRR was calculated: ([MHRtrial-RHR]/[MHR-RHR]) x 100. On the FM, completion time was not significantly affected by load, though %HRR increased significantly with each load increase. On the OC, completion time increased significantly with each load increase, but HRR did not show a specific load effect. Based on this research %HRR could be utilized as a way to track operational performance in a downrange setting.

A related study examined factors which predict field march performance (FMP) (4). Two hundred and thirty relatively fit subjects participated in a one-day military school selection tryout that culminated with an approximate 8.5-mile FMP carrying a load of approximately 35 lb on terrain including several elevation changes each of at least 500 ft. Analysis revealed that service academy career two-mile run time (2MR) was the most potent factor impacting FMP; multiple R = .79, adjusted R2 = .62. Threshold measures appeared to be present; 12:30 or faster 2MR (13 vs. 0 subjects) and 2:38 or faster on an indoor obstacle course test (IOCT; 15 vs 2 subjects) resided in the top 10% fastest FMP group (4). Neither body mass or number of pull-ups impacted FMP. With an adjusted R2 = .62, that leaves 38% of the variance in FMP unaccounted for (4).

Multiple presentations addressed various aspects of physical training. One study described kinematic changes over a two-minute continuous push-up assessment (7). Video recordings were made of 26 males from a military service academy to investigate changes in body positioning throughout the push-up test. The researchers focused on hand height (HH), distance the hand was in position relative to the shoulder; hand width (HW), distance between the 3rd metacarpophalangeal joint of each hand; and torso angle (TOR), angle of the torso to the horizontal axis. Three consecutive repetitions at the start/end of the bout were averaged for HH, HW, and TOR and analyzed. Both HH and TOR significantly decreased at the end of the bout, while HW significantly increased. The authors concluded that, "as participants became tired, they assumed a body position that likely allowed for a greater percentage of their body weight to be supported by their lower body (i.e., hands wider and closer to the shoulder with greater hip flexion)," (7). The authors suggested that strengthening the primary muscles (e.g., pectoralis, triceps brachii, and abdominals) used in this test might correct the kinematic changes observed (7). Future research could investigate female subjects, as it is possible there are gender-specific kinematic compensation patterns.

Another study looked at training strategies relative to United States Marines completing an Assessment and Selection (A&S)

course prior to becoming a United States Marine Corps Special Operations (MARSOC) Raider, as well as training for a nine-month Individualized Training Course (ITC) post-MARSOC selection (15). FFM, FM, anaerobic power (AP), anaerobic capacity (AC), aerobic capacity (VO_2max), knee flexion (KF), knee extension (KE), shoulder internal rotation (SIR), shoulder external rotation (SER), trunk extension (TE), and trunk flexion (TF) isokinetic strength were collected in a sample of 27 Marines at two time points: following A&S and directly prior to ITC. The results indicated no significant differences in any of these measures between A&S and the start of ITC. From this, the authors concluded that "performance characteristics were similar following selection and prior to the start of ITC, suggesting the current training strategies, as implemented and adopted for the varying time gaps post A&S, were effective at maintaining performance between courses," (15). Follow-up studies might wish to address potential differences in injury rates prior to MARSOC and the ITC.

In January 2017, the Uited States Army employed the Occupational Physical Assessment Test (OPAT) to determine the physical readiness of recruits (RCs) prior to initial entry training (IET). The OPAT consists of the standing long jump (SLJ), seated power throw (SPT), strength deadlift (SDL) and an interval aerobic run (IAR). This study attempted to discern whether performance on the OPAT was correlated to measures of psychological hardiness, as the former has been documented to predict recruit success (3). 945 United States Army male combat arms RCs performed the OPAT and completed the Dispositional Resilience Scale-Military (DRS-II-M) questionnaire, a validated 24-item, 5-point Likert scale (1 = definitely false to 5 = definitely true) measure. Both were completed within the first week of IET. The DRS-II-M provides three positive (control, commitment, and challenge) and three negative (alienation, powerlessness, and rigidity) hardiness dimensions. RCs were divided into two groups: one who achieved the OPAT black level score (n = 636) and those that did not (n = 309). RCs who scored at the black level on the OPAT scored higher on positive hardiness dimensions and significantly lower on negative hardiness dimensions relative to those that did not. This research suggests that RCs who score high on the OPAT also have increased hardiness, suggesting they will be successful in meeting the physical and psychological demands of combat arms positions. It would be interesting to replicate this with other tactical populations, to see if this relationship holds for other groups (Navy SEALs, Air Force Special Operations, etc.).

Predicting injury risk is of paramount importance in military populations, as injuries have significant effects on readiness (14). One study assessed injury risk in United States Navy Explosive Ordnance Disposal (EOD) operators (6). Fifty-one active duty men (age 35.6 + 1.0 yr) were evaluated for body fat percentage (BF%) using dual-energy x-ray absorptiometry, maximum oxygen consumption (VO_2max), muscular strength (one-repetition max [1RM] back squat and bench press), and injury risk assessments (Functional Movement Screen [FMS™] and Y-balance test [YBT]). A quartile split for VO_2max established the bottommost, low, high, and topmost VO_2max groups. Analysis of variance (ANOVA) and Pearson product-moment correlations were used to evaluate fitness and injury risk associations. Results indicated that FMS and YBT scores significantly (p = < .01) differed by quartiles, with the bottommost VO_2max group having the lowest scores. BF% was associated with FMS ($r = -.33$, $p < .05$) and YBT scores ($r = -.37$, $p < .01$). No associations were observed with 1RM. The authors concluded that "this study is consistent with accruing data that indicate more fit individuals have a lower injury risk," (16).

Research presented at conferences such as the National Strength and Conditioning Association (NSCA) and ACSM provide the scientific foundation for evidence-based training and nutrition of military personnel. It is exciting to see more and more presentations with this focus. The ever-widening scope of this research also enables the fine tuning of operational performance to a degree not possible even five years ago. This type of information is critical in enabling tactical populations to successfully accomplish their missions.

REFERENCES

1. Bach, CW, and Ransone, JW. Caffeine does not increase heat stress during endurance exercise in a hot, humid environment. *Medicine and Science in Sports and Exercise* 50(5): S599, 2018.

2. Bushman, TT, Grier, TL, Canham-Chervak, M, et al. The Functional Movement Screen: Association and predictive value in active men. *American Journal of Sports Medicine* 44(2): 297-304, 2016.

3. Cohen, B, Foulis, S, Canino, M, et al. Psychological hardness and success on the occupational physical assessment test in Army combat arms soldiers. *Medicine and Science in Sports and Exercise* 50(5): S733, 2018.

4. Crowder, TA, and Rapuano, SK. Factors impacting field march performance of U.S. service academy cadets. *Medicine and Science in Sports and Exercise* 50(5): S734, 2018.

5. Hasselquist, L, Hancock, CL, and Bensel, CK. Heart rate reserve: An objective measure of soldiers' physical exertion during field operations. *Medicine and Science in Sports and Exercise* 50(5): S732, 2018.

6. Hernandez, LM, Coffin, SD, and Taylor, ML. Greater fitness is associated with reduced injury risk in specialized military men. *Medicine and Science in Sports and Exercise* 50(5): S730, 2018.

7. Hewit, J. Altered kinematics over a 2-minute continuous push-up assessment. *Medicine and Science in Sports and Exercise* 50(5): S613, 2018.

8. Heymsfield, SB, Heo, H, and Pietrobelli, A. Are adult body circumferences associated with height? Relevance to normative ranges and circumferential indices. *American Journal of Clinical Nutrition* 93: 302-307, 2011.

9. Knapik, JJ, Austin, KG, and McGraw, SM, et al. Caffeine consumption among active duty United States Air Force personnel. *Food Chemistry and Toxicology* 105: 377-386, 2017.

10. Leahy, GD, Crowder, TS, and Mayhew, JL. Body composition indices to classify activity levels in Air Force men and women. *Medicine and Science in Sports and Exercise* 50(5): S736, 2018.

11. Leahy, G, Friederich, D, Crowder, T, et al. Relationship of abdominal circumference and body mass index to body composition in Air Force men and women. *Journal of Strength and Conditioning Research* 28(Supp 2): S104-S105, 2014.

12. Leahy, G. Functional movement screening and the tactical athlete. *TSAC Report* 26: 9-12, 2013.

13. Margolis, LM, Barringer, ND, McClung, HL, et al. Prediction equation for estimating total daily energy requirements of Special Operations personnel. *Medicine and Science in Sports and Exercise* 50(5): S638, 2018.

14. Molloy, JM, Feltwell, DN, Scott, SJ, et al. Physical training injuries and interventions for military recruits. *Military Medicine* 177(5): 553-558, 2012.

15. Royer, SD, Winters, JD, Poploski, K, et al. Training strategies maintain performance characteristics for Marine Corps Special Operations individualized training course. *Medicine and Science in Sports and Exercise* 50(5): S781, 2018.

16. Savonen, K, Krachler, B, Hassinen, M, et al. The current standard measure of cardiorespiratory fitness introduces confounding by body mass: the DR's EXTRA study. *International Journal of Obesity* 36: 1135-1140, 2012.

17. Smith, CA, Chimera, NJ, and Warren, M. Association of Y-balance test reach asymmetry and injury in Division I athletes. *Medicine and Science in Sports and Exercise* 47(1): 136-141, 2015.

18. Wilson, KM, Jones, DM, Mandel, MP, et al. Abdominal circumference measurements in an U.S. Navy Active Duty population. *Medicine and Science in Sports and Exercise* 50(5): S735, 2018.

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