# TSAC REPORT

ISSUE 59


NSCA®
NATIONAL STRENGTH AND
CONDITIONING ASSOCIATION

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*ISSN: 2378-7392*

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# SEASONAL CONSIDERATIONS FOR OUTDOOR FITNESS TESTING OF LAW ENFORCEMENT RECRUITS

Law enforcement officers have job demands that could include dragging an incapacitated person, using force to apprehend a suspect, or engaging in a foot pursuit (7,17). Job demands are typically characterized as low-intensity, with intermittent bouts of high-intensity efforts (i.e., sitting in a police vehicle to then pursuing a suspect on foot) (10). In addition to this, officers have virtually no control over the environment in which these job demands must be performed (e.g., urban versus rural depending on the patrol area, and in all weather conditions). As a result of these job demands, law enforcement agencies (LEAs) will often conduct fitness testing to assess the physical readiness of recruits prior to hiring (16). The tests are typically designed to ascertain academy completion potential (9,20), and to assess underlying fitness characteristics that could be essential to success in job tasks (6,17).

LEAs can vary in their physical fitness assessments depending on the requirements for that agency. Nonetheless, there are certain fitness characteristics that are commonly assessed by LEAs. These charactaristics include strength, power, muscular endurance, and aerobic capacity. Push-ups and sit-ups are common assessments of muscular endurance (2,4,9,20). Strength in law enforcement populations has been measured in different ways, including isometric grip force (7,22), isometric leg/back dynamometer force (7,8), and dynamic strength tests such as the bench press (26). Muscular power has been inferred by tests such as the vertical jump (9,18,22,26), and foot pursuit simulations such as the 75-yd pursuit run (2,4,19). Aerobic capacity is often assessed by tests such as the 1.5-mi (2.4-km) run and multistage fitness test (21,23).

Testing typically occurs on set dates throughout a calendar year, and depending on the agency, will often be performed outdoors. Ambient temperatures typically vary in each season, and could have the potential to alter physical performance (15,24,28). The more common tests performed outdoors include muscular endurance assessments such as push-ups and sit-ups, and running tests used to measure aerobic capacity (2,4,17,20,21,23). LEAs that administer their physical fitness assessments outdoors at different times throughout a calendar year will likely result in variability in the ambient testing conditions. Some recruits will complete testing in the winter when temperatures are cooler, while other recruits could be completing the same tests in the summer when temperatures are higher. As an example, the authors of this article are based in southern California. Even though southern California typically has more temperate conditions compared to other parts of the United States, Figure 1 displays how temperature and humidity can vary across each of the four seasons. These data were taken from the National Weather service website (https://www.weather.gov/) for testing dates that related to a specific LEA in Los Angeles County. Even though the summer date had the lowest temperature, it also had the highest humidity. Furthermore, recruits in southern California will likely have to contend with hotter days during their fitness testing and training.

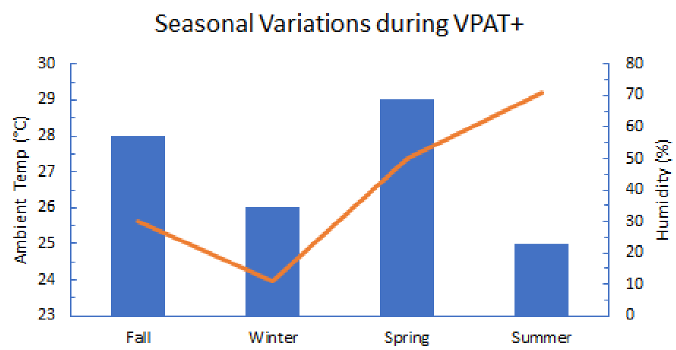


**FIGURE 1. AMBIENT TEMPERATURES AND RELATIVE HUMIDITY PERCENTAGES ACROSS FOUR DIFFERENT SEASONS IN SOUTHERN CALIFORNIA**

Warmer ambient temperatures have been shown to increase heat stress within the body, which decreases time to muscular fatigue (24,28). With an increased fatigue rate in warmer conditions, recruits may be unable to sustain the demands of the testing battery conducted by an agency. Aerobic activities have been shown to be greatly influenced by hot environments as a result of increased skin temperature, which decreases cardiac output (28). A decrease in cardiac output due to warmer environmental conditions can prevent adequate blood flow to the skeletal muscle and has been shown to decrease maximal aerobic capacity (11,28). Decreased maximal aerobic capacity as a result of heat stress could induce decreased time to muscular fatigue, resulting in recruits being unable to sustain the demands of the test for prolonged periods (11,24,27,28). This disadvantage in performance could negatively affect a recruit's physical performance during the hiring process or during academy training. In contrast, physical performance in cooler ambient temperatures may result in a decreased internal body temperature, increased cardiac output, and decreased glycogen utilization (11,27). This may allow recruits that perform fitness testing in cooler temperatures to have superior physical performance compared to those in warmer temperatures.

Furthermore, relative humidity levels could also play a role in the successful completion of fitness tests. Humidity prevents the evaporation of sweat from the body, which in turn raises the body's core temperature (11). As the body's core temperature rises, muscles fatigue at a faster rate (24). This could result in recruits who perform testing in warmer, more humid conditions being unable to sustain the demands of the test. Accordingly, potential recruits may receive poorer scores than their counterparts who perform in cooler, less humid conditions. While any of the LEA fitness tests could be affected, tests that include maximal running or stress aerobic capacity may be more impacted (28).

LEA staff should also recognize that physical performance could be negatively impacted by high ambient temperature and humidity. A candidate could suggest that they had less than ideal testing conditions that negatively impacted their chance of employment. This emphasizes the need for LEA staff to know the ambient temperature and humidity of their testing sessions if held outdoors, and what the acceptable ranges are for the LEA. However, these concepts have not been analyzed in the literature specific to law enforcement populations. This makes it challenging to provide specific guidelines to LEA staff. Nonetheless, the authors have provided some recommendations for LEA training staff.

A potential issue for LEA staff is that they should know the temperature of testing or training environments in case a recruit or officer experiences any form of heat illness. High ambient temperature not only adversely affects physical performance for recruits, but could also result in heat-related illnesses, such as heat edema, cramps, syncope, heat exhaustion, and heat stroke (3). Heat illness is a result of metabolic heat production from muscle activity or heat from the environment that becomes greater than the body's ability to dissipate the heat (5). This combination of heat accumulation from the environment and generating heat internally from high work rate increases the chances for compromised thermoregulation (5,12). It is imperative for skin temperature to remain low and for perspiration to be dissipated as a necessary means of cooling the body down, both internally and externally, to sustain physical activity (11,15,25). Training staff should be aware of, and record, ambient weather conditions as a precautionary measure to ensure recruit safety during physical fitness testing. This is especially important for training days where adverse conditions are forecasted.

There are several recommendations that can be provided on the basis of the literature reviewed in this paper. These include:

- LEA staff should record the ambient temperature and humidity of their testing and training sessions. LEA staff can monitor ambient temperature and relative humidity percentage via a digital hygrometer (13). This could provide beneficial insight into whether or not physical performance may be affected, and LEA staff could make accommodations to ensure any training sessions are performed safely. Accommodations to attenuate body core temperature could include employing precooling practices or cooling with ice packs (14,15). This would be useful in the academy training setting, especially from a duty of care perspective.
- While there are no current procedures in place to accommodate for environmental weather conditions, LEAs can be proactive in preventing dehydration from increased sweat rates by creating time allotments where recruits are required to take water breaks throughout testing and training sessions. The implementation of electrolytes to restore sodium levels could help with improving anaerobic power and heart rate recovery time (1). LEA staff should consult Registered Dietitian Nutritionists (RDN) for assistance with appropriate hydration strategies.
- On warmer, more humid days, LEA staff and recruits should be reminded to wear their cooler physical training attire, which typically is comprised of shorts and a cotton short-sleeved shirt. This attire is preferable due to its breathable material, which could assist in keeping the body temperature of recruits from rising to unsafe levels and prevent decreased rates to fatigue during testing and training (11).

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MICHAEL FANNING, DC, DACBSP, CSCS

# BONE STRESS RESPONSE INJURIES IN LAW ENFORCEMENT RECRUITS

Certified Strength and Conditioning Specialists® (CSCS®) are becoming more involved in settings such as law enforcement academies, and it is important they understand a common pathology affecting this population. Preparation for, and the duration of, a law enforcement academy (LEA) is both physically and mentally challenging. In California, the Commission on Peace Officer Standards and Training (POST) mandates a minimum of 664 hr and testing in 42 areas of instruction (9). For this reason, LEAs range from 18 – 26 weeks in duration. The minimum physical ability requirement mandated by POST for each Law Enforcement Recruit to meet is the Work Sample Test Battery (WSTB) (4,10). Outside of the WSTB, POST does not require any other physical training testing for graduation, but leaves administering physical training to each individual agency (16).

At the Southern California University of Health Sciences Tactical Sports Medicine Clinic, the majority of recruit injuries are lower extremity bone stress responses and stress fractures. This begs the question: "how do recruits develop these injuries and can we minimize this type of injury to increase LEA graduation rates?"

## PATHOPHYSIOLOGY OF A BONE STRESS RESPONSE

Musculoskeletal injuries are common with recruits, not just in the military, but also paramilitary organizations. This includes an overuse injury; specifically bone stress injuries (20). Bone stress injuries are a spectrum, which includes a bone stress response and stress fractures. Stress fractures are sometimes referred to as "fatigue fractures" and include breakdown of both trabecular and cortical bone. A bone stress response is breakdown of the inner trabecular, sparing the cortical bone (5). These types of injuries manifest themselves when recovery is insufficient for the demands placed on the system. In fact, bone stress injuries are one of the most common injuries in military recruits (5,20). The development of bone stress injuries is not straightforward. It is multi-factorial and may require a collaborative approach to treatment (13).

Bone is made up of two types, the inner trabeculae and the outer cortical bone. At a physiological level, bone is constantly being remodeled. There is osteoblastic activity (building tissue) and osteoclastic activity (breaking down of tissue) within bone at all times (5). There remains an equilibrium as long as individuals have adequate nutrient intake and rest to allow for recovery. When nutritional intake, rest, and recovery are insufficient, coupled with hormonal imbalances that come with overtraining and high-stress environments (increased cortisol levels), osteoclastic activity can occur at a higher rate than osteoblastic activity. When that occurs, the inner trabeculae begins to break down causing a bone stress response. If enough trabeculae breakdown occurs, it can lead to cortical bone weakening, and ultimately a stress fracture (5,12).

Incidence of stress fractures can be as high as 12% in military recruits, compared to 1% in the general population, because of recruits' high volume of training and marching in formation (20). The most common sites of a stress response are in the bones of the foot (65%) and the tibia (24%) (20). These areas are fully weight-bearing structures and, when injured, require the recruit to be placed on bilateral axillary crutches and removed from training.

## RECRUIT PHYSICAL TRAINING

In California, the hiring process for many LEAs can be long and arduous due to a variety of factors, including background checks, psychological evaluations, polygraph tests, and medical physicals (10). While agencies perform a pre-entry physical fitness test, POST does not mandate a specific test. For example, the Los Angeles Sheriff's Department (LASD) utilizes the Validated Physical Ability Test (VPAT) and the Los Angeles Police Department (LAPD) utilizes their own Physical Fitness Qualifier (PFQ) (13,17).

For a comparison, the LASD VPAT consists of:

1. Maximum push-ups in one-minute
2. A 75-yd run
3. Maximum sit-ups in one minute
4. 20-m shuttle run (beep test)

The LAPD PFQ consists of:

1. Maximum sit-ups in one minute
2. 300-m sprint
3. Maximum push-ups in one minute
4. 1.5-mi run

Due to the extensive application process, the wait time can vary from person to person upon application submission for an academy. The LASD states that if a recruit "remains actively engaged in the process, submits all necessary documentation in a timely matter, and keeps scheduled appointments, is expected to complete the process within eight months," (7). In that eight-month period or beyond, many recruits attend department specific "pre-academy" workout programs that follow POST guidelines. POST guidelines state that aerobic conditioning, muscular endurance, and flexibility are the key components to the academy physical conditioning program (4,11).

It is not uncommon for recruits to receive a 4 – 6-week advanced notice prior to starting a law enforcement academy. This 4 – 6-week timeline is when extrinsic motivation factors are high, and recruits increase their training load significantly. Due to the relative ease of access and focus of running in many of the academies, recruits typically increase their weekly miles. A RAND Corporation review of activities of recruits who reported regularly engaging prior to an LEA stated that about half of recruits would run to condition themselves for the impending class start (6).

## ACADEMY PHYSICAL REQUIREMENTS FOR GRADUATION

LEAs within California focus their physical training (PT) towards POST guidelines for physical conditioning (4). POST recommends aerobic conditioning for 20 – 60 min 3 – 5 days per week; this is usually conducted in the form of running. Muscular strength and endurance training is recommended 2 – 3 days per week (including upper body, core, and legs) 8 – 10 exercises for 8 – 20 repetitions. Finally, flexibility training, which is described as static stretching (including holding various stretches for 15 – 30 s), is recommended for 2 – 3 days per week (11). The focus of the physical conditioning program is to pass the POST WSTB.

According to POST guidelines, the only physical ability assessment required to graduate from a LEA is the WSTB. The WSTB is a five-station course that tests agility, strength, and speed. Recruits must run a 99-yd obstacle course with sharp turns and curb height obstacles. They must then drag a 165-lb body drag over 32 ft. Then recruits must scale a six-foot chain link fence, followed by a six-foot solid fence. The final station is a 500-yd run (21). California POST has delegated other physical fitness testing to each individual LEA. For example, the LASD utilizes the Physical Training 500 (PT-500). The PT-500 compromises: maximum push-ups, sit-ups, mountain climbers, and pull-ups in two minutes, as well as a 1.5-mi run (17).

## RECRUIT PREPARATION FOR ACADEMY

Recruits should train for not just their physical training assessment, but also for the job requirements. The California POST Commission Report of Job Analysis of Law Enforcement Officer (LEO) in 2016 lists physical activity and use of force as entities of the LEO's job. Some of the tasks are listed here, but not limited to: "engage in foot pursuits, subdue subjects, sit in one place for an extended period of time, walk for an extended period of time, climb, jump, crawl, wear duty equipment, drag or pull hard to move objects or persons, bend or stoop, reach overhead, maintain physical fitness…" (19). This task analysis reveals a diverse set of work requirements that access the spectrum of energy systems.

However, due to the typically large class size, many of LEAs take an approach to PT that includes running intervals, long slow running, and local muscular endurance (5). Due to this physical training approach, many recruits train to run in their respective LEA (10,17). Many police departments offer "pre-academy" training and training programs for recruits to prepare themselves (17,21) for their specific LEA. A glimpse into LAPD's program reveals a straightforward linear program that covers basic warm-up, endurance run, calisthenics, and stretching. The 16-week program endurance run begins with a 1.5-mi run and ends with a 4-mi run (3).

While the linear program addresses the basics for a LEA fitness program, they do not necessarily transfer to the daily demands of a LEO. In the LASD Patrol School, for example, female recruits carry (13 +/- 3%) their bodyweight and male recruits carry (12 +/- 2%) in load-carriage while performing the aforementioned tasks of a LEO (2). Additionally, identifing areas of training to help mitigate injury risk associated with load-carriage are trunk stability, strength, work tolerance, and fatigue resistance (15). Aerobic training alone has less improvement on load carriage without the addition of strength training, power resistance, or hypertrophy training (14). Recruits who do not follow a linear program and run without appropriate programming prior to a LEA may be in a pre-physiological overtraining state. Once they begin their LEA, the high stress, increased physical activity, and relatively little recovery time may send a recruit into overtraining and place themselves at greater risk for injury (20).

Common injuries in recruits are bone stress responses and stress fractures. Recruits who overtrain can be at risk for this injury under relative energy deficiency in sport (RED-S), which is a risk factor for stress fractures (11). RED-S is a comprehensive overview of an individual's response to overtraining. Compromises in hormone balance, bone health, cardiovascular response, immunological stress, and gastrointestinal and metabolic changes can result from overtraining. With overtraining, recruits may experience decreased muscle strength, decreased performance, increased injury risk, decreased glycogen stores, depression, and decreased concentration (12).

## INJURY MITIGATION

The demands of any LEA are physically and psychologically demanding. There are aspects of a LEA that cannot be altered because mandated academic standards and requirements must be met. In addition to the daily requirements, recruits must also factor in commute and homework, which leaves less time for adequate recovery. Insufficient sleep and recovery is common with LEOs, but during a LEA, inadequate sleep to aid in recovery can increase risk of injury (18).

What we can control is how recruits physically prepare for a LEA and ensuring they do not overtrain prior to the start of their LEA. Rather than training for a LEA that focuses on running middle to long distances, calisthenics, and stretching, a different approach with greater specificity of training for the demands of the job is warranted to prevent physiological overtraining (9). A training program that emphasizes strength, power, work tolerance, and trunk stability to compliment cardiovascular training and fatigue resistance may be specific to the demands of a LEO versus the former approach to recruit training (14,15).

Strength training can help improve running economy up to 8%, which may transfer to LEA PT (3). Strength training can also improve time trial performance of up to 10 km and anaerobic running performance (3). Cardiovascular fitness and anaerobic performance are essential to many LEA PT programs and to the LEO job tasks, but should not be the only aim of a program (1).

## CONCLUSION

There is a strong need for CSCSs to help guide recruits in the period preceding their LEA. Recruits will need to pass mandated physical assessments during a LEA (8,10). Focusing the training on the daily demands of the LEO, along with strength training, may help prevent overtraining prior to a LEA and subsequent bone stress injuries (2,3,15,19). Finally, there is a need for an appropriate strength program that guides recruits to meet the POST Academy Guidelines and the everyday demands of LEO, rather than just training for a PT test (4,9,21).

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# A REVIEW OF HYDRATION AND BODY COMPOSITION FOR WILDLAND FIRE SUPPRESSION AIDS

## INTRODUCTION

Wildland firefighting is an arduous profession that entails cyclical and extensive work shifts (approximately 12 – 16 hr per day), typically over 14-day sequences with two days of rest in between (5,6). The fire season for these male and female professionals, known as seasonal fire suppression aids (FSAs), typically lasts from May – September in the Western United States (5). Previous studies have concluded the energy expenditure ranges of FSAs to be 2,719 – 6,260 kcal/day (3,5,6,15). It should be noted that energy expenditure is heavily influenced by the location of the fire, work assignment, and self-selected work intensity (3,5,6,15). In addition, wildland FSAs average 6.7 ± 1.4 L/day of water turnover over a five-day period (5,16). This turnover is impacted by self-selected behavioral cues that control ingestion (i.e., water in) and ambient conditions that influence metabolic work rate and sweat rate (i.e., water out) (5,6). Water loss is exacerbated by the standard equipment all wildland FSAs generally wear: a hard hat, 100% cotton short-sleeve undershirt, leather gloves, Nomex® long-sleeve shirt and pants, mid-calf leather logger boots (heavy-duty footwear), and a 12 – 20-kg pack containing food, water, safety gear, and work tools (4,15).

Although up to 66% of wildland FSAs' work activity is completed at a light intensity, intermittent bouts of moderate and/or vigorous activity can occur. This indicates that daily work efforts and hydration demands of FSAs should be higher than most field occupations (5,6). Wildland FSAs are also at considerable risk for heat-related injuries during training or a work shift. These injuries are a result of frequent exposure to high ambient temperatures, elevated work intensity, fatigue, wearing protective gear/uniforms, carrying packs, and particularly, hydration difficulties. Accordingly, academy training is utilized to prepare FSA candidates for numerous wildland firefighting tasks.

During training and when deployed, FSAs should sustain adequate levels of hydration to remain safe and to be effective in their strenuous occupational duties. Appropriate hydration can also positively influence body composition (1,2,4,17); which can be estimated by variables such as intracellular water, extracellular water, fat mass, and dry lean body mass (DLBM) (10,16,18,19). The storage sites of water fluctuate, as total body water is composed of intracellular water (i.e., water inside a cell) and extracellular water (i.e., water outside a cell) (18). As a result, water constantly moves into and out of cells and the circulatory system (18). Ample hydration levels, along with the presence of adequate muscle mass, may positively impact wildland FSA performance, as excess body fat can hinder occupational success (1,2). A surplus of fat mass in FSAs can lead to a greater rise in core temperature, act as deadweight when working against gravity, and is linked to low levels of cardiorespiratory fitness, a risk factor for cardiovascular morbidities (1). Extra non-functional weight, such as fat mass, can lead to greater energy expenditure, such as when digging line on a slanted mountain. Greater DLBM can positively influence both anaerobic and aerobic performance in wildland FSAs (1,2,4). Although common tasks of FSAs, such as cutting line, moving heavy objects, and prolonged hiking carrying equipment, utilize both anaerobic and aerobic energy systems, more research is required to quantify these relationships specific to wildland FSAs. Particular to the academy environment, it is necessary for firefighting agencies to ensure candidates have positive fluid profiles. They must have ample hydration and optimal body composition levels due to the need for safety and optimization of training and potential job performance (1,17). Optimal body composition means that the individual has sufficient muscle mass, and typically lower body fat. To maintain hydration and DLBM of candidates during academy training, agencies habitually introduce various interventions (e.g., hydration supplements, readiness monitoring, education) (1,17).

## HYDRATION IN FIREFIGHTERS

There are several different methods used to measure or estimate hydration levels in active FSAs and FSA candidates. These include bioelectrical impedance and body water analyzers, osmolality measurements (e.g., salivary, plasma, urine), urine specific gravity (USG), and urine color (8,10,12,13,16,19). Certain contemporary bioelectrical impedance and body water analyzers do not require empirical data, such as sex and age, to estimate body composition (e.g., intracellular water, extracellular water, fat mass, DLBM) (10,19). Osmolality techniques measure the number of dissolved particles in a fluid, while USG illuminates the concentration of molecules and solutes an individual excretes in urine (8,12,13). The guidelines for utilizing urine color to determine an active FSA's and FSA candidate's current hydration level is based on each individual fire agency's current procedures; however, most agency guidelines follow the typical spectrum of lighter urine representing adequate hydration and darker urine indicating inadequate hydration (12,13).

A common tendency of wildland FSAs is to enter a work shift already dehydrated (8,12,13). By not being adequately hydrated, firefighters may be at a higher risk for heat injury, physical injury, and a psychologically compromised state during a shift (5,6,8,12,13). Moreover, FSAs can lose considerable amounts of DLBM (~3.0 ± 0.1 kg) during training or a work shift, which can be exacerbated when dehydrated upon arrival (8,16). Exact numbers have not been provided in the literature; nonetheless, losses in fluid and DLBM over the course of a shift would likely be detrimental, and in some cases hazardous, for wildland FSAs. Over time, methods to maintain hydration during training or deployment have varied among firefighter agencies, both in nature and implementation. When working with FSA candidates for a limited amount of time during an academy training, the most appropriate method to estimate the hydration of candidates should be implemented. Fire agencies and their exercise physiologists need to consider the environment in which the academy is taking place, how easily can the measurement tools be accessed, the accuracy of measurement tools, and the funding available to incorporate these tools in an academy scenario.

During academy training, firefighting agencies routinely educate FSA candidates on how to maintain sufficient levels of hydration and DLBM through numerous interventions. Educational activities may be in the form of lectures on hydration techniques, hydration supplements, and readiness monitoring (1,17). However, as previously stated, it is common for wildland FSAs to arrive at a work shift dehydrated (8,12,13). This would suggest the provision of information regarding fluid intake should continue regularly over the course of a firefighter's career. Nonetheless, many wildland firefighter departments and FSAs have attempted to develop and incorporate numerous techniques to maintain adequate levels of hydration. Hydration techniques employed by wildland firefighters include pre-shift drinking bolus defenses, prescribed fluid volumes during shift phases, self-selected *ad libitum* approaches, and supplements (e.g., carbohydrate, electrolyte, sports drinks) (4,7,9,12,13,17).

While several distinct hydration techniques result in hydration and effective wildland FSA performance, *ad libitum* fluid consumption approaches have been found to facilitate equivalent success when compared to the aforementioned methods (12). For instance, firefighters exercising while wearing thermal protective clothing did not differ in heart rate, core temperature, total exercise time, or time to exhaustion, when assigned to a water, sports drink, or intravenous infusion hydration group (9). Another study showed that during a work shift when firefighters were assigned to a 1200 mL of liquid per hour group or an *ad libitum* group, there were no differences in cardiovascular strain, work activity, or shift distances covered (13). In a simulated heat environment, firefighters wearing thermal protective clothing and a self-contained breathing apparatus (SCBA) improved their tolerance time of work completed during intermittent exercise using both high (78% of body fluid loss) and moderate (63% of body fluid loss) liquid replacement quantities (17). Interestingly, Selkirk et al. found no difference between the two fluid replacement quantities (17). Furthermore, firefighters with fluid replacement quantities of both low (37% of body fluid loss) and no hydration during intermittent exercise experienced lower tolerance times of total work accomplished (17). Intermittent exercise was stopped when one of the following occurred: 39.5°C rectal temperature during work, 40.0°C rectal temperature during rest, 95% of maximum heart rate reached, or exhaustion (17). It should be noted that this study was completed in a simulated setting, and support staff would be more available and responsive to a firefighter who is not receiving sufficient fluid intake during an actual fire. Nevertheless, wildland FSAs should aim to consume moderate quantities of fluids to promote occupational success (5,17). This could diminish the gastrointestinal distress and bathroom time of firefighters during a work shift. Research has highlighted that wildland firefighters who leave for the fireground prior to a work shift in a euhydrated state can successfully complete occupational duties with self-regulated fluid consumption and work rates (12,13). Although percentage volumes of liquid intake were not provided in these studies, what was detailed was the absolute volume of self-regulated fluid consumption: 218 ± 198 mL per hour in mild to warm weather conditions (12,13). This further emphasizes the importance of a firefighter agency educating their wildland FSAs on how to stay properly and effectively hydrated before, during, and after a work shift (1,17).

## IMPLICATIONS

Different markers and strategies have been utilized to explore the amount of success a FSA can achieve in a training session or work shift. These include heart rate (6,9,11,12,13,14), core temperature (5,6,9,11,12,13,14), skin temperature (5,6,11), water turnover (6), rehydration techniques (5,9,12,13,17), DLBM maintenance (8), total exercise tolerance time (9,17), total energy expenditure (6), cardiovascular strain (11), hydration level entering a work shift (8,12,13), and work/physical activity tracking devices (5,6,12,13). Training staff for wildland FSA candidates should select those methods most appropriate for their current situation. It should be noted that even though there has been analysis of hydration levels, the current available research of wildland FSAs has not simultaneously analyzed hydration levels and body composition. This lack of analysis has occurred even though it has been noted that the maintenance of hydration and DLBM are both key components to the occupational success of FSAs (1,2,4).

Nevertheless, it could be expected that the body composition in FSA candidates can generally be conserved through education and appropriate interventions (e.g., fluid replacement strategies) during wildland firefighter academy training (1,18). Even with the strenuous tasks completed in academy, agency staff can ensure appropriate hydration and body composition of their candidates if they teach and adopt effective hydration interventions. Sustaining healthy body composition levels and preserving the DLBM of FSA candidates could result in the successful completion of occupational anaerobic and aerobic tasks (1,2,4). Moreover, it is necessary for firefighting agencies to ensure candidates are euhydrated due to the need for safety and optimization of training and potential job performance (1,18). Adequate hydration and appropriate body composition profiles will typically occur as a result of a variety of techniques implemented by the staff (1,18).

## FUTURE INVESTIGATIONS

As shown in Table 1, there are few studies that have scientifically analyzed hydration strategies for firefighters. This highlights the need for more work in this area. Fire department training staff should investigate any potential strategies that could ensure euhydration and suitable body composition profiles in both active FSAs and FSA candidates. One intervention that could be investigated is carbohydrate (CHO) drink supplementation on the maintenance of hydration levels and DLBM during training or a work shift. Sustaining hydration levels and conserving DLBM through CHO drink supplementation could be beneficial to wildland FSA candidate success, as individuals should discover what techniques work best to retain adequate energy within the dietary restrictions of a fire department (16). As much as anything, providing education as to the advantages of euhydration, establishing good habits around fluid replacement, and ensuring buy-in from the candidate could be the primary benefits during training. The maintenance and/or increase of muscle mass and the presence of appropriate levels of hydration in the body could constructively influence wildland FSA candidate performance during academy training or a work shift (1,2). Moreover, hydration and CHO supplements, without increasing the amount of liquid consumed, should create minimal-to-no gastrointestinal distress and continue to mitigate the time for bathroom breaks, as occupational duties will occur in unfavorable environments (7). Integrating CHO supplementation in combination with established fire agency hydration methods could aid in wildland FSAs conserving muscle mass and hydration values, while limiting gastrointestinal discomfort and maintaining sufficient energy intake during a work shift. This is especially important with a wildland FSA in an environment where their caloric expenditure is very high. Nonetheless, utilizing CHO could still be beneficial to candidate success, and may also create buy-in for implementation in active FSAs when they are in the workforce.

### TABLE 1. STRATEGIES TO ENHANCE HYDRATION STATUS AND BODY COMPOSITION

| REFERENCE | STRATEGY | KEY FINDINGS |
|---|---|---|
| **Raines et al. (12)** | Self-selected approach: *ad libitum* | Self-selected volume, beverage type (water or sports drink), and timing of fluid intake resulted in the adequate facilitation of rehydration in wildland FSAs, during a 12-hr work shift. |
| **Raines et al. (13)** | | Wildland FSAs can self-regulate fluid consumption and work rate during a 12-hr work shift, in mild to warm weather conditions and leave the fireground euhydrated. |
| **Selkirk et al. (17)** | Prescribed fluid volume: pre-shift/during shift/post-shift | While wearing protective clothing and a SCBA in a simulated heat environment, partial fluid replacement techniques improved the tolerance time of work completed during intermittent exercise in firefighters. |
| **Raines et al. (13)** | | A prescribed fluid volume of 1,200 mL/hour (600 mL of water/600 mL of sports drink) during a 12-hr work shift, did not lead to decreased cardiovascular strain, larger work activity, or greater shift distances covered in wildland FSAs. |
| **Raines et al. (12)** | Pre-shift drinking bolus defense | Consumption of a pre-shift fluid bolus (500 mL of water) elicited no benefit in work activity, heart rate, and core temperature in wildland FSAs during a 12-hr work shift. |
| **Hostler et al. (9)** | Supplements: sports drinks | Firefighters exercising in thermal protective clothing for two bouts of 50 min, did not differ in heart rate, core temperature, or time to exhaustion, when consuming water, sports drink, or an intravenous saline solution between sessions. |

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# STRATEGIES AIMED AT OPTIMIZING MENTAL RECOVERY FROM TRAINING AND OCCUPATIONAL PERFORMANCE

Previous research conducted in tactical populations has demonstrated links between stress and well-being, burnout, and suboptimal job performance (2,14,19). Prompted by contemporary sport science research, knowledge is becoming increasingly nuanced to account for the duration (e.g., acute versus chronic), source (e.g., work versus life), and volume (e.g., workload, training load, etc.) of stress experienced within and outside of the work environment. In addition, the process of recovery from stress is gaining traction among scientists and the public alike. Unfortunately, little research exists to support the importance of recovery from training or occupational performance among tactical athletes.

Informed by the occupational health and elite sport performance literature, the purpose of this article is to: 1) provide education surrounding the importance of recovery in tactical populations, 2) identify key aspects of the mental recovery process, and 3) identify strategies Tactical Strength and Conditioning Facilitators® (TSAC-F®) can implement to promote mental recovery when working with athletes.

## WHAT IS RECOVERY, AND HOW DOES IT WORK?

Recovery is the systematic process of restoration following imposed bouts of stress (8,15). Modern science has differentiated recovery as an outcome (i.e., "I am recovered or not") from recovery as a process (i.e., "I am engaging in specific behaviors to promote recovery"). As one might imagine, the recovery process is far more controllable and modifiable than the outcome. Depending on the stressors encountered, the recovery process involves the regeneration of physiological, cognitive, and emotional resources depleted during activity. Research studies have also demonstrated that chronic psychological stress from sources outside the training environment can have a measurable impact on the rate of muscle performance recovery following heavy resistance training (16,17). In their 2012 study, Stults-Kolehmainen and Bartholomew found that young adults reporting high scores in chronic psychological stress recovered less maximal isometric force (38.2% from immediate post-training protocol) after a one-hour rest period compared with their low score counterparts (60.3% from immediate post-training protocol) (16). Recovery is also a highly individualized process, meaning that even if two tactical athletes finish an identical work shift or training bout, it is likely that each athlete will need to apply different recovery modalities to restore performance (8).

As a thought exercise, consider that the total load experienced by an individual represents a sum of work, life, and training stressors or stimuli. The sport science literature indicates that long-term or chronic accumulation of total load in the absence of sufficient recovery often results in symptoms of overtraining, burnout, and performance decrements (10). For example, a tactical athlete may be working long hours, pulling extra overtime shifts, meeting the needs of a family, and pushing the limits of overload in the gym—accumulatively, this generates a considerable total load. This load must be paired with sufficient recovery to avoid illness, injury, occupational burnout, and performance errors (8,10,12,15). The overall concept of "load management" remains one of the hottest topics of applied research in the sport sciences.

To optimize performance among tactical athletes, implementation of post-work and post-training recovery routines should be considered. Understand that fatigue, both mental and physical, accumulates during the completion of any work or sporting task (4,5,7,11). Due to their rigorous occupational training, tactical athletes can accomplish a task when it counts the most; however, completing the task often comes at a cost (e.g., fatigue, soreness, pain, mood disturbance, etc.). The cost of each activity certainly depends on baseline levels of fitness, mental preparation, and overall demands of the task. Recovery activities could be strategically applied to restore the resources depleted during performance, thus increasing performance capacity for the next occupational challenge.

Researchers suggest that recovery promotes health and performance in several ways. First, recovery activities serve to facilitate mood repair and restoration (3,15). A recent meta-analysis revealed that after work recovery experiences explain 18% and 13% of the variance in the mood states of fatigue and vigor, respectively (3). This is consistent with the sports literature, where mood disturbance has long been considered one of the primary indicators of overtraining states among athletes (10,12). During the time following exercise, upregulations in parasympathetic nervous system activity (rest/digest) and downregulations in sympathetic nervous system activity (fight/flight/freeze) are observed (6). Among firefighters, Ebersole and colleagues also noted that the patterns of autonomic nervous system regulation during recovery differed between submaximal and maximal bouts of exercise (6). A recent review by Lee and colleagues comprehensively demonstrates that the recovery window following training may have a restorative effect on biomarkers of nutrition status, hydration status, muscle status, cardiovascular endurance, injury risk, and/or inflammation (9).

In their scoping review, Verbeek and colleagues found that 9 out of 17 (53%) person-directed interventions (e.g., relaxation) yielded significant and beneficial effects on occupational recovery among healthy working adults (18). By comparison, 5 out of 9 (55%) work-directed interventions (e.g., participatory changes, work breaks, variation in schedule, task switching) yielded significant and beneficial effects on occupational recovery (18). However, such strategies may not be feasible for tactical organizations or departments due to logistical reasons (e.g., minimum staffing for safety, budget constraints). Since such workplace interventions are uncontrollable to the individual worker, more controllable and personal intervention strategies are advised.

## MENTAL ASPECTS OF RECOVERY

Within occupational settings, any challenge requires a substantial amount of cognitive processing (e.g., decision-making, information processing) and emotional regulation (e.g., staying calm, managing anxiety and fear). These mental processes cost energy and resources, and after encountering substantial mental challenges, it is relatively common for individuals to report feeling completely exhausted. Also, for most adults, other tasks that are done during non-work time, such as household chores, childcare, running errands, etc., also contribute to the total load experienced within a given time (15). Thus, for people trying to keep up with the everyday demands of life, this leaves little fuel left in the mental tank by the end of the day or week.

Over a decade's worth of research in the occupational health literature has generated substantial support for the psychological factors which contribute to the overall recovery experience (15). Across occupational environments, recovery is best optimized when the following factors can be addressed:

- Mental detachment; "mentally switching off" from work.
- Perceived control of what to do (and how to do it) during non-work time.
- Relaxation for reduced sympathetic nervous system activation.
- Mastery by learning or experiencing new challenges (15).

Additionally, in a recent mixed-methods research study, Sawhney and colleagues identified work recovery strategies utilized by firefighters and assessed the buffering effect of work recovery strategies on firefighter mental health (13). Results of their study indicated that firefighters use work-related talks, stress-related talks, informal time with coworkers/supervisors, exercise, recreational activities (10%), relaxation, and mastery experiences (i.e., learning something new) as occupational recovery strategies. Significant proportions of variance in mental health symptoms were explained by work-related talks (10%), stress-related talks (48%), relaxation (17%), and recreational activities at work. Stress-related talks and relaxation moderated the occupational stress-mental health relationship among participants. The authors suggest that the team-based and cohesive nature of firefighting as an occupation explain some of these findings.

## STRATEGIES FOR OPTIMIZING MENTAL RECOVERY

In a recent *TSAC Report* article, Allen covered primarily physiological interventions (e.g., nutrition, sleep, hydration) for recovery enhancement, and alluded to the restorative benefits of mind-body interventions (e.g., yoga, tai chi, meditation) for recovery (1). In extending this work further, the following evidence-based strategies could be used to promote recovery following training or work (13,15):

- Relaxation: box breathing, tactical breathing, meditation, and mindfulness.
- Physical activity: structured workouts and going for a walk, yoga.
- Stress management: emotion-focused or problem-focused coping strategies.
- Mental detachment: taking mental breaks from work and engaging in hobbies or leisure.
- Social engagement: discussing work or stress with peers.

In a training environment, the strategies listed above are best paired with a physical recovery intervention to promote habit formation. As an example, one might engage in tactical breathing while foam rolling, or one might do yoga immediately following a heavy lifting session. Including a mental component of relaxation to a cool-down can further support the beneficial effects of physiological recovery strategies.

In an occupational environment, one of the distinct benefits of mental recovery strategies is that one seldom needs equipment or resources to complete the activities. As such, tactical athletes can complete short bouts (5 – 10 min) of recovery just about anywhere and at any time. Readers are encouraged to consider their recovery habits at the microlevel (i.e., hour-to-hour breaks during a workday) and macrolevel (i.e., a rest period analogous to a taper or extended break). Mental recovery strategies are best applied as a proactive means of preventing symptoms of overtraining or burnout.

In addition to these brief strategies that can be used on daily or weekly basis, the literature also supports the health and performance benefits of vacations or sabbaticals (15). As such, tactical athletes are certainly encouraged to take advantage of such paid leave opportunities for recovery, and fully detach oneself from work while on leave whenever possible. In this case, tactical athletes should refrain from checking email, taking calls, or other work-related tasks.

## CONCLUSIONS FOR THE TSAC-F

With little research on mental recovery among tactical populations, all practices should be considered as recommendations or guidelines rather than strict rules. In the daily training environment, TSAC-Fs should consider incorporating mental recovery strategies both within the daily workout and across periodized phases of programming. At the beginning of a workout, TSAC-Fs can reinforce clients' mental detachment from the rest of their day upon entering the gym space, thereby optimizing the client's focus on the workout as well as promoting their recovery from work and life stress. TSAC-Fs can also encourage clients to use strategies such as box or tactical breathing between sets. Yoga and/or other meditation practices could be incorporated or encouraged within cool-down and/or movement-oriented programming. If group training is an option, TSAC-Fs could consider the application of sporting games as a warm-up, as an alternative to a structured or dynamic warm-up. Playing a fun yet competitive game of soccer for a warm-up may facilitate detachment from work stress, promote engagement in mastery-oriented skills, and strengthen stress resilience. Further, clients should be encouraged to adopt longer-term lifestyle behaviors that promote stress management and mental recovery (e.g., taking a daily 20-min walk with your family, debriefing your stressful day with your colleague on-duty before going home, etc.). By promoting clients' adoption of mental recovery strategies at the micro- and macrolevels, their training and occupational performance may be optimized.

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# IMPLICATIONS OF AEROBIC FITNESS ON FIREFIGHTERS' OCCUPATIONAL PERFORMANCE, HEALTH, AND RISK OF INJURY

## INTRODUCTION

Firefighting is an inherently dangerous profession, yet the leading cause of on-duty fatalities among firefighters has consistently been sudden cardiac death (SCD) (14). Furthermore, approximately 45% of SCD events occurred while performing fire suppression tasks or physical training, with overexertion being a primary cause (14,18). While the total number of fires per year has decreased substantially (1,098,000 structural fires in 1977 compared to 499,000 in 2018), the proportion of on-duty fatalities attributed to SCD has remained stable (12,14). These data suggest that physical preparation for occupational tasks should be emphasized to a greater extent than they currently are, as cardiac-related health concerns are persistent among this population.

Furthermore, it has been suggested that many firefighters across the United States may not be meeting fitness levels required to successfully perform occupational tasks (5,10,39). While no federal fitness standards are currently mandated, the National Fire Protection Association (NFPA) recommends firefighters possess a maximal oxygen consumption ($VO_{2max}$) of ≥42 ml/kg/min (26). Several studies have reported that some firefighters do not meet this recommendation (5,10,39). For instance, Durand and colleagues indicated that 37% of firefighters (195 out of 527) did not achieve the NFPA recommendation for aerobic fitness (10). In addition, only 20% of firefighters met the recommended physical activity guidelines of aerobic exercise to derive health benefits (i.e., accumulation of 150 min of moderate-intensity exercise per week) (10). Furthermore, research indicates that participation in habitual vigorous-intensity exercise attenuates the risk of sudden death during vigorous exercise and work (2,25). Therefore, it is possible that firefighters may not possess the fitness levels required to perform sustained vigorous intensity occupational tasks, potentially leading to reductions in fire-task performance, overexertion, and SCD. Thus, the purpose of this article is to discuss the health and occupational implications of firefighters not currently meeting the NFPA aerobic capacity recommendations.

## AEROBIC DEMANDS OF FIRE SUPPRESSION TASKS

Table 1 describes the average oxygen consumption required to complete various occupational duties, as well as the relative intensities firefighters would experience while completing such tasks (17). The NFPA cut-off point for $VO_{2max}$ (42 ml/kg/min) was used to establish relative intensity rates. During fire suppression,

**TABLE 1. AEROBIC DEMAND AND RELATIVE INTENSITY FOR VARIOUS FIRE SUPPRESSION TASKS WITH AND WITHOUT USE OF PERSONAL PROTECTIVE EQUIPMENT (17)**

| FIRE SUPPRESSION TASK | REPORTED $VO_2$ RANGES (ml/kg/min) | RELATIVE INTENSITY (%) | RELATIVE INTENSITY (PPE8%) | RELATIVE INTENSITY (PPE22%) |
|---|---|---|---|---|
| Carrying equipment up high-rise stairs | 34.3 – 44.0 | 82 – 105 | 88 – 114 | 104 – 134 |
| Carrying equipment from truck | 22.5 – 29.7 | 54 – 71 | 58 – 77 | 69 – 91 |
| Forced entry | 28.3 – 30.5 | 67 – 73 | 73 – 79 | 86 – 93 |
| Advancing hoselines | 23.4 – 31.7 | 56 – 75 | 61 – 82 | 71 – 97 |
| Raising ladders | 16.8 – 30.6 | 40 – 73 | 43 – 79 | 51 – 93 |
| Victim rescue | 17.5 – 20.0 | 42 – 48 | 45 – 52 | 53 – 61 |
| Hoisting equipment | 23.2 – 26.7 | 55 – 64 | 60 – 69 | 71 – 82 |
| Automobile accidents | 19.2 – 22.1 | 46 – 53 | 50 – 57 | 59 – 67 |

*Key: Relative intensity = relative intensity without PPE use; relative intensity (PPE8%) = relative intensity if aerobic capacity is reduced 8% from PPE (19); relative intensity (PPE22%) = relative intensity if aerobic capacity is reduced by 22% from PPE (28).*

*Note: Reported fire suppression tasks are based on previous literature (17). All relative intensities use the NFPA aerobic fitness guideline of 42 ml/kg/min. Intensity classifications, based on percentage of $VO_{2max}$: very light intensity is <37%, light intensity is 37 – 45%, moderate intensity is 46 – 63%, vigorous intensity is 64 – 90%, and near maximal-to-maximal intensity is >90% (33).*

physical demands vary greatly based on the specific task being performed (e.g., equipment carry versus advancing hoselines) with some duties requiring a $VO_2$ greater than the NFPA minimum guideline. For example, carrying equipment (i.e., high-rise pack and halligan tool) during a stair ascent requires an average aerobic demand of about 44 ml/kg/min and rapidly advancing a charged hoseline requires about 47 ml/kg/min, on average (17,36). While most duties do not exceed 42 ml/kg/min, some are still highly demanding based on relative intensity. For instance, carrying equipment from the truck, forced entry, advancing hoselines, raising ladders, and hoisting equipment could all be indicative of vigorous-intensity tasks. Additionally, a recent study by Johnson and colleagues had teams of eight firefighters complete two simulated fire ground scenarios (one with the intent to control, one with the intent to suppress) involving live one-story structural fires (19). Firefighters collectively performed these tasks in 9 – 14.5 min. This supports the contention that although fire response consists of many high-intensity, anaerobic-based tasks, a strong aerobic component exists in order to sustain occupational duties.

While $VO_{2max}$ serves as a measure of aerobic performance, laboratory assessments are traditionally performed in athletic attire and do not reflect actual scenarios involving emergency operations. As such, a portion of the literature has described the effects of personal protective equipment (PPE) turnout gear on work-related outcomes (9,11,15,20,21,23,24,29,30,40). The use of PPE, along with a self-contained breathing apparatus (SCBA), encapsulates the body, preventing normal heat distribution (24). The PPE increases the aerobic demands of a given task due to the additional load (22 kg or more) (11,20,40). In addition, the combination of the positive pressure design of the SCBA regulator and the SCBA harness, which restricts the firefighter's ability to expand the chest cavity, increases the energy expenditure required to expel carbon dioxide, and produces decrements in aerobic capacity by 8 – 22% (11,13,20,23,28). Moreover, this protective ensemble increases heart rate by 20 – 30 beats per minute (bpm) and systolic blood pressure by 15 – 23 mmHg (15). From an occupational performance perspective, Lesniak and colleagues recently reported that SCBA use plus PPE yielded a relative increase of 44% in time to complete simulated fireground tasks compared to wearing physical training clothes only (21). Therefore, the effects of PPE and SCBA must be accounted for when discussing the strain associated with firefighting. Table 1 reflects the changes in relative intensity for a given task based on the additional energy requirements of PPE and SCBA.

Increasing exercise frequency can produce many favorable physical fitness and health outcomes, including improved $VO_{2max}$ and reduced cardiovascular disease risk factors (e.g., hypertension) (33). Through habitual aerobic conditioning, firefighters can also increase their exercise capacity and thereby experience a relatively lower physiological demand (e.g., heart rate, energy expenditure) at the same absolute workloads (6). This in turn may aid in the reduction of on-site injury or SCD. While the evidence-based practices for improving aerobic fitness specifically within firefighters can be found within previous literature (1,22,34,35), general guidelines recommend achieving five or more days per week of moderate-intensity (30 – 60 min), three or more days per week of vigorous-intensity exercise (20 – 60 min), or a combination of both moderate- and vigorous-intensity exercise 3 – 5 days per week (34). Furthermore, emphasis should be placed on aerobic modalities that involve major muscle groups (e.g., running, stair climber) (34).

## IMPLICATIONS OF FITNESS FOR HEALTH, OCCUPATIONAL PERFORMANCE, AND INJURY RISK

The heightened risk of SCD following fire suppression or physical training may be partially explained by the vast majority (approximately 80%) of firefighters that do not meet the guidelines for general fitness (10). Given that active fire suppression comprises a small percentage of a firefighter's duties (5% or less), the need to achieve the aerobic fitness guideline may not be readily apparent (18). However, vigorous activity is a known precipitator of fatal cardiac events, particularly among sedentary individuals (2,25). Therefore, a large-scale fire may quickly become catastrophic if firefighters lack the aerobic fitness levels required to perform at vigorous-, maximal-, or supramaximal-intensities for prolonged durations, and may contribute to the about 63% of SCDs that occur responding to, during, or returning from a fire scene (18). Furthermore, the relative risk of experiencing SCD during, or 30 min after, vigorous activity (versus light-to-no exertion activities) was 74.1% for those participating in vigorous exercise less than one time per week (2). However, for those participating in vigorous activity five or more times per week, the relative risk dropped to 10.9%; thus, stressing the importance of frequent participation in vigorous aerobic exercise.

Additionally, research suggests that the environmental conditions during fire suppression may produce the conditions likely to trigger a cardiac event in high-risk individuals (e.g., increased sympathetic activity, increased blood lactate concentrations, and rapid increases in body temperature) (27,28,37). Not limited to the environmental conditions, the high prevalence of uncontrolled hypertension, demonstrated within the fire service, further increases the likelihood of a cardiac event during intense activity (16,38). For instance, the increased platelet number and aggregation observed following fire drills, combined with near-maximal cardiac output, makes hypertensive firefighters even more susceptible to blood vessel rupture and blood clot formation, which can restrict blood flow back to the heart (37). Symptoms of hypertension are not always present, which emphasizes the importance of regular blood pressure screenings and appropriate treatment.

Moreover, high-intensity work rates, such as those presented in Table 1, are generally unsustainable without sufficient periods of rest (32). This combination may promote the early onset of fatigue and impede subsequent performance, most notably among less aerobically fit individuals (4,41). Thus, firefighters that lack adequate levels of aerobic fitness may exhibit suboptimal levels of occupational performance by demonstrating an impaired response time. It is important, though, that all firefighters perform professional duties at an occupationally relevant pace. Data supports this, as research indicates that three-person crews required 25% longer (5.1 min) to complete the same tasks when compared to four-person crews (3). If unable to successfully sustain duties, a firefighter may increase total response time, become a liability for crew members, and jeopardize personal and public safety.

Lastly, overexertion, resulting in strain, sprain, or muscular pain, is also the leading cause of on-duty injury for firefighters (8). The NFPA reports that 27% of total injuries result in lost work time, with overexertion frequently attributing to a large proportion of this time (up to 52%) (7,8). Furthermore, workers' compensation claims, based on overexertion, tend to be greater than other causes of injury ($9,715 compared to $5,168) (42). Research indicates that aerobic capacity is negatively associated with risk of injury, such that firefighters with a $VO_{2max}$ 42 ml/kg/min or less are 2.2 more times likely to incur an injury compared to more fit firefighters (above 48 ml/kg/min) (31). Thus, it is possible that improving overall fitness may reduce the likelihood of overexertion and therefore present departments with substantial financial benefits via decreases in the incidence of injury or death among employees. Firefighters who engage in regular physical training should see an improvement of job performance and a reduction of incident-related SCD.

## PRACTICAL APPLICATIONS

Many fire suppression tasks could be considered vigorous intensity based on the aerobic fitness guidelines for firefighters and the occupational demands reported in previous literature. Therefore, the recommended guideline of 42 ml/kg/min should exist as a minimum threshold and firefighters should understand that PPE and SCBA can further impair functional $VO_{2max}$. While fitness and wellness initiatives are not mandated within the fire service, these data emphasize the importance of regular physical conditioning. Improving aerobic fitness may increase exercise tolerance to ultimately improve job performance and reduce the risk of SCD and injuries. Furthermore, it is critical for firefighters to receive annual health screenings intended to screen for cardiovascular dysfunction and disease risk factors.

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# BOOTS ON THE GROUND: REAL-WORLD STRENGTH AND CONDITIONING IMPLEMENTATION AT THE BATTALION LEVEL

Physical training (PT) across all branches of the military has evolved over the past three decades. Traditional PT consisted of long, steady-state runs and calisthenics. In recent years, a more modern strength and conditioning approach that includes strength training, power development, sprinting, and injury prevention has become more common. One of my primary goals while serving as the Battalion Commander, 1st Tank Battalion, was to implement the Marine Corps' Force Fitness program across the entire battalion. In this article, I will discuss some of the challenges we faced and lessons we learned implementing the program in a unit with over 600 United States Marines and Sailors. The intent is to share ideas that worked as well as those ideas that did not work with other Tactical Strength and Conditioning Facilitators® (TSAC-F®).

The Marine Corps' Force Fitness program is a holistic and balanced approach to tactical strength and conditioning. The program includes a six-week Force Fitness instructor course, which teaches strength and conditioning fundamentals to Marine students. The students return to their units after the course and assist the commander in designing and implementing a fitness program (2).

When I arrived as the battalion commander, the unit had one Force Fitness instructor. My initial observations were that PT was random in execution and loosely supervised. It was common to find small units rotating who oversaw PT each day. Subsequently, what was done one day usually was not related to what was done the previous day or what would be done the following day. Sometimes units executed effective PT sessions that had a strength component and some type of conditioning. However, poorly planned and executed PT sessions with no focus and bad technique were far more common. As I observed daily PT and talked to leaders at various levels, I assessed that the overall understanding of the Force Fitness program was low. It also seemed that most Marines did not understand how a balanced tactical fitness program should look. Just like trying to teach an athlete how to do a power clean, I realized that I could not fix everything all at once; I identified what I could control and what I could not control and made some changes.

One of the things that I could not control was operational commitments. In my 26 months in command, there were very few times that the entire unit was all present. Due to various training and real-world deployments, platoons and companies were consistently gone for stretches of one week to six months. This was a reality that we needed to embrace. As a battalion, we existed to provide armor protected firepower to the division. PT makes us more resilient when conducting our primary mission, but it is not why the battalion existed.

First, regarding things I could control, I made 0600 – 0800 "prime time" training for PT. I made it clear that I did not expect to see anyone at work until 0830 and that other than field training, nothing had a higher priority than PT from 0600 – 0800. While some eagerly latched on to this policy, others were reluctant and felt that certain maintenance or other requirements were more pressing. The dedicated PT time eventually set in with everyone after a few months. Next, I mandated that junior officers and senior enlisted leaders regularly conduct PT with their Marines. In my initial assessment, I found that some platoon commanders and platoon sergeants rarely conducted PT with their platoons. I observed that a lack of leadership contributed to many of the poorly planned and executed PT sessions.

Recognizing what I could control, I began developing a plan to overhaul how the battalion conducted PT and implement the tenets of the Force Fitness program. My initial plan was to send at least four Marines to the Force Fitness instructor course, then begin implementing the program upon their return. Due to operational commitments combined with the instructor course being six weeks long, six months later we only had one additional Force Fitness instructor and were not likely to get any more.

Once it became clear that we could not send as many Marines to the Force Fitness course as I had desired, we shifted to plan "B." In this case, plan "B" was an internal train the trainer program. It consisted of five training days and approximately 30 hr of practical application instruction from our certified Force Fitness Instructors (FFI). Every company was required to send at least two Marines, no rank requirement, and then these Marines would share with their units what they had learned during the course. We ran four iterations of this course during my time with the battalion and made improvements each time based on feedback from students. The primary objectives of the course were to have students know what correct movement patterns looked like and be able to teach the seven foundational movements identified by the Force Fitness program (plank, hinge, squat, lunge, push, pull, and rotation). Students had to be able to correct poor movement as well. Basic nutrition, mobility, and an introduction to programming were also part of the curriculum. In general, companies found that when they sent people who were willing to learn to this course, the entire company benefitted; conversely, when they sent people who were not willing to learn, the company did not gain anything from sending them.

Simultaneous to when we implemented the train the trainer course, we also designated the Battalion Force Fitness Instructor as a primary job. Until this point, it was a collateral duty. Taking a Marine out of their primary occupational specialty and having them serve as an FFI is a large commitment, but I found it effective. Our Battalion FFI observed various unit PT sessions every morning and assisted and made corrections when necessary. In addition, he worked with Marines assigned to the Body Composition Program as well as Marines who struggled with fitness in general. The battalion FFI also oversaw programming, assisted with physical fitness tests and combat fitness tests, and ran monthly battalion-level PT events.

Once we had the train the trainer course implemented and a full-time FFI, we began to focus on following a program. I continually emphasized that random acts of fitness lead to random acts of stupidity, which then leads to unnecessary injury. None of the random acts I observed were ill-intended, but we needed to move away from that and use more deliberate programming to maximize efficacy and reduce injury. The easy way to make PT more deliberate would have been to create one program for the entire battalion and have everyone follow the same program. I chose not to use this approach for two reasons. First, as mentioned previously, every company and platoon had different training schedules and were in the field at different times. Second, there would be no buy-in from small unit leaders with one mandated program. It became obvious that most non-commissioned officers (NCO) wanted ownership of their PT plan and wanted to develop their own program. Therefore, to achieve effective programming across the battalion, every unit was required to submit their PT plans for the following week by Thursday. The battalion FFI would then review them, make corrections/recommendations, consolidate them, and submit them to me. The ideal long-term goal was to have units layout 6 – 12-week training plans; however, we did not achieve that level during my time. That we were able to achiev every subordinate unit submitting weekly training plans was progress in implementing balanced tactical strength and conditioning programs. To achieve units building 6 – 12 week programs would require another 2 – 3 years.

To assist in Force Fitness implementation, we also used Warrior Athlete, a Marine Corps Community Services program unique to the Marine Corps Air Ground Combat Center in Twentynine Palms. Warrior Athlete is a group of professionals with various backgrounds whose mission is to assist FFIs. They provided us with foundational movement coaching, program design, injury prevention techniques, and nutrition. This program aided several platoons in making considerable progress and added substantial value (1).

Mindset and equipment were the two biggest challenges we faced. From day one at boot camp, intensity is driven into Marines. The cultural norm with regards to PT is that intensity is stressed far more than proper technique. Attempting to reverse that and have Marines understand that 10 good push-ups is far better than 35 bad ones is challenging. Another cultural norm is that long steady-state runs are the preferred way to train for the three-mile run on our physical fitness test. Some are starting to understand that interval training is required to become faster, however knowledge on how to conduct intervals is severely lacking. Finally, with respect to mindset, the idea of following a deliberately planned progressive physical training program is simply foreign to many, as all their experience with fitness to date has been random. Changing this mindset takes continual engagement and education.

The second major challenge we faced was a lack of equipment. The amount of equipment on Marine Corps bases to conduct effective strength and conditioning has improved substantially over the past 20 years. However, facilities are still limited for large groups. Other than the athletic field, we did not have a facility that could accommodate the whole battalion training at one time. Therefore, platoons and units all trained in different places. Furthermore, with limited equipment, creativity is often required to facilitate a group of 20 – 40 Marines effectively training. An experienced tactical facilitator knows how to be organized, break large groups into smaller groups, and creatively get everyone through the training session. However, as already discussed, small unit leaders do not have the background of a strength and conditioning professional and therefore do not always inherently maximize efficiency. For example, rather than figuring out a way to get 20 Marines through a squat workout with only two squat racks, they will just eliminate that part of the workout.

In conclusion, I offer the following learning points to anyone that leads large unit tactical strength and conditioning programs. First, small unit leaders are your strength and conditioning coaches. They are the ones who design the program and supervise execution. They also have extremely limited training and usually rely on what they have been shown in the past. It is easy to say, "train them in this capacity as a strength and conditioning coach and you will reap the rewards." However, Marine Corps small unit leaders' average age is 21, most have a high school diploma as their highest level of education, and they all have a long list of responsibilities associated with their primary military occupational specialty. Expectations must be managed, and as a professional strength coach for a Special Operations Forces unit told me in my final months, "determine the minimum dose for everyone, champions will do more."

Second, platoon commanders were the center of gravity for successful implementation. Across the board, platoons whose lieutenants bought-in to the process, were consistently engaged, and took feedback were the most successful.

Third, culture change is hard and takes time with large organizations. Do not become frustrated when things do not change overnight.

Fourth, education must be continuous and creative. Marines will not learn about energy pathways from PowerPoint slides. Education must come on the field or in the gym.

Finally, simple is always better. Sled pushes and box jumps are a far better option for power development than power cleans with a large group of Marines.

At the institutional level, the Marine Corps has made many positive changes toward improving the service's strength and conditioning program. We live in a challenging and dynamic environment and implementing some of these changes will take time.

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**U.S. ARMY TACTICAL ATHLETE PERFORMANCE CENTER**
MCoE, FT. BENNING

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# HIGH SCHOOL SPORTS AND STRENGTH AND CONDITIONING – IMPLICATIONS FOR TACTICAL ORGANIZATIONS

## INTRODUCTION

Certified Strength and Conditioning Specialists® (CSCS®) and Tactical Strength and Conditioning Facilitators® (TSAC-F®) can affect the health, fitness, and capabilities of tactical operators from law enforcement, firefighting, and the military. As a result, many tactical professions are utilizing structured strength and conditioning approaches to develop their recruits and incumbent operators (1,6,13). However, numerous organizations have detailed problems with recruitment and retention, perhaps most notably for the United States Army. Bornstein et al. has noted the reduction of males and females who meet the minimum fitness requirements for operational readiness (2). The authors analyzed this by considering fitness and injury data from recruits who entered basic combat training from 2010 – 2013. Specifically, Bornstein et al. found recruits from 10 states (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Texas) were in the bottom 25% fitness cluster as measured by two-mile run time (2). These recruits also had an injury incidence rate that was 22% higher than recruits from “fitter” states (2). It could be expected that there would be fewer people who could meet minimum fitness requirements for other military branches or physically demanding professions such as law enforcement or firefighting.

One major issue with poor fitness in recruits is how it affects attrition. Specific to law enforcement, tens of thousands of dollars are spent during the hiring process by an agency; the loss of recruits can create further financial costs via initial and potential ongoing medical treatment and compensation costs if a recruit is injured (26). Furthermore, multiple research studies have linked low physical fitness to injury risk in law enforcement (10,18), firefighter (3,14), and military (9,27) personnel. To provide specific examples, Pope et al. detailed that U.S. Army recruits who scored more poorly in the 20-m multistage fitness test (MSFT) were approximately 25 times more likely to fail basic training compared to fitter recruits (27). Dawes et al. found that push-up performance predicted 14% of the variance in whether law enforcement recruits separated from academy due to injury (10). More injuries in recruits could lead to fewer recruits graduating from training academies.

As most tactical organizations recruit individuals in their late teens or early 20s, there will likely be recruits for law enforcement (8), firefighting (29), and military (4,31) that fall within this age bracket. Accordingly, these individuals are not far removed from high school. Although not the only reason, it is worth considering how lifestyle behaviors encouraged at the high school-level could affect fitness during adulthood. This is the concept that will be explored in this paper, with a focus on both sport and strength and conditioning participation.

## HIGH SCHOOL SPORTS AND STRENGTH AND CONDITIONING

Sport participation can be vital in the physical development of high school-aged males and females, and depending on the school, a range of sports are available for students. Popular sports for boys include football, basketball, track and field, baseball, and soccer, while for girls, they are basketball, softball, track and field, volleyball, and soccer (25). Survey data provided by the National Federation of State High School Associations from 2018 – 2019 indicated that 4,534,758 boys participated in structured high school sports, while 3,402,733 girls participated in high school sports (25). In addition to traditional sports practice, the availability of strength and conditioning programs also benefits high school athletes.

Strength and conditioning programs are generally designed to enhance the physical performance and reduce the injury risk to the individual (17). Specific to the high school environment, appropriate training in adolescents can improve multiple aspects of physical fitness. In teenage male rugby league players following a 12-week supervised resistance training program, muscular strength measured by the three-repetition maximum bench press and back squat increased by about 30% and about 40%, respectively. Additionally, the number of pull-up repetitions completed increased by about 97%; vertical jump performance improved by about 10%; and 20-m sprint time decreased by about 1% (7). In high school female basketball players, dynamic balance was significantly improved following specific training (39). McLeod et al. found that those females who completed the training program completed fewer errors in the Balance Error Scoring System compared to those that did not (7.9 ± 3.6 versus 14.2 ± 4.6), and could also reach further in the anteromedial, medial, posterior, and lateral directions from the Star Excursion Balance Test (39). Resistance training is a common focus of high school strength and conditioning coaches (28). The position stand from the National Strength and Conditioning Association (NSCA) highlights a range of potential benefits of resistance training for youth (12). In addition to improved muscular strength, power, and resistance to injury, other benefits could include enhanced motor skill performance and the promotion and development of good exercise habits (12).

Physical activity and exposure to different motor skills (such as those required when performing resistance training exercises) during an individual's formative years can influence what they do later in life. Individuals that display better motor competence during childhood or adolescence tend to be more physically active during adulthood, which can influence health outcomes (30,35). Athletic performance notwithstanding, strength and conditioning could have a potentially more substantial impact on high school boys and girls in their lifetimes. Research has indicated a decrease in physical activity and rise in obesity in adolescents and young adults in the United States (5,15,38). Reduced participation in physical activity, combined with obesity, can then have downstream effects of reduced movement competency and fitness in teenagers and young adults (30,35). For tactical organizations, the more potential recruits participating in high school sports and strength and conditioning, the more potential recruits will have greater fitness and movement capabilities.

A lack of availability of high school sports and strength and conditioning could have negative effects for males and females that attempt to progress into physically demanding occupations. In a survey of 57 collegiate strength and conditioning coaches, about 19 – 37% of respondents stated that Olympic-style lifting technique, core/lower extremities strength, flexibility/mobility, mental toughness, knowledge of exercise technique/recovery, and work capacity were areas that needed improvement in incoming freshmen athletes from high school (40). Wade et al. intimated that these results showed a lack of physical preparedness of high school athletes (40). While the focus of that study was collegiate sports, a lack of physical preparedness would also affect how young males and females could complete the tasks required in physically demanding occupations. A further confounding factor in 2020 is the COVID-19 pandemic. Due to COVID-19, the allowable high school sport varies from state to state (34). Some athletes may voluntarily choose not to compete. Further to this, the negative financial implications to schools and families from COVID-19 will likely affect school sports programs and participation (32).

If people who do not have or have a limited sports or strength and conditioning background from high school choose to apply to a physically demanding occupation, there are several problems they may encounter. Individuals may not be physically or mentally prepared for training or the required job tasks. While there is certainly a degree of personal responsibility for the individual to prepare for training needed to do for their potential profession, if the recruit pool is being diluted, training staff may need to make the best of the recruits they have. This issue has important implications for CSCSs and TSAC-Fs that work with young tactical recruits.

## IMPLICATIONS AND STRATEGIES

CSCSs and TSAC-Fs who work with tactical recruits and operators may not be in a position to directly influence what happens at the high school level in their communities. However, there are certain implications and strategies that could be adopted and recommended on the basis of the information presented in this article.

Staff at tactical organizations should recognize that there will be current recruits that may not have the movement coordination or physical fitness of recruits from the past. Accordingly, structuring training programs because "that's the way it was always done" may not be the best approach. Indeed, the physical abilities and fitness of recruits can vary greatly within and across academy classes (19). Several studies analyzing recruit training have shown the value for properly structured, periodized training programs to develop multiple aspects of fitness in law enforcement (6), firefighter (13), and military (4) personnel. This is even more important in today's environment, where recruits may not have the necessary physical capabilities prior to academy training.

A lack of sports and strength and conditioning participation could also negatively impact a recruit's resilience. Szivak and Kraemer defined resilience as the mental, physical, emotional, and behavioral ability to face and cope with adversity, adapt to change, recover, learn, and grow from setbacks (36). Individuals that have not regularly completed competitive, high-intensity activities prior to occupational-specific training may encounter difficulties when thrust into the type of environment where resilience is needed. Stress inoculation may be an important factor to consider, under the guidance of law enforcement, firefighting, or military training staff. For example, Holmes and Kornhauser introduced a "zero week" prior to their law enforcement academy to provide additional preparation time for recruits (16). Lockie et al. also inferred limitations in resilience from analyzing the relationships between the MSFT and 2.4-km (1.5-mile) run in law enforcement recruits (20). The estimated maximal aerobic capacity for the 2.4-km run (45.1 ± 4.8 ml·kg-1·min-1) was higher than that of the MSFT (34.3 ± 5.5 ml·kg-1·min-1) in 550 recruits (463 males and 87 females). Lockie et al. suggested that this was because recruits were more comfortable using the internal pacing strategy required for the 2.4-km run, as opposed to the external pacing strategy placed upon them by the MSFT (20). Sports participation and appropriate strength and conditioning programs can allow high school athletes to properly learn how to respond to external stimuli and adversity prior to their transition into occupational training. Nonetheless, it should be noted that while physical training can build some mental toughness, stress inoculation exercises should mimic the environment that the individual is expected to face in an actual tactical scenario.

TSAC-Fs should ensure they use a well-rounded and detailed assessment protocol for their recruits. Utilizing only fitness testing may not tell the full story of a recruit's physical capabilities. Indeed, Frost et al. have suggested that movement-oriented training should be adopted for tactical personnel (13). This type of training emphasizes that the same essential movement features (e.g., neutral spine and frontal plane knee alignment) are emphasized every time an exercise is performed. Frost et al. state that this ensures that proper movement patterns remain a primary focus during training and that different fitness qualities (e.g., strength, power, aerobic fitness) are enhanced in a progressive manner (13). McGuire and Lockie have designed and recommended a testing protocol for Reserve Officers' Training Corps (ROTC) cadets that incorporates assessment of basic motor skills, movement coordination, and a range of physical fitness qualities (e.g., muscular endurance, strength, power, running speed, and aerobic capacity). This type of testing approach could be extrapolated to other tactical populations as well (23).

Examination of high school students' motivation for sport and strength and conditioning participation would also be of value. Participation in some form of physical activity from childhood through adulthood can be attributed to the intrinsic motivation that is developed during early sports involvement (33). Intrinsic motivation can also influence whether tactical professionals maintain their physical fitness during their career (11). This is important, as even though men and women entering the U.S. Army have been found to carry more body fat, any negative effects can be counteracted by greater lean body mass (31). When compared to males and females entering basic training in 1978, Sharp et al. found men entering basic training in 1998 had a 15% greater body fat percentage, but 8% more fat-free mass measured in kilograms, compared to men from 20 years earlier (31). Women entering basic training in 1998 had a 5% greater body fat percentage, concurrent with 4% greater fat-free mass, compared to women in 1978. This helps support the need for tactical operators to be motivated enough to complete strength and conditioning programs to develop muscle mass. Having some understanding of why an individual may or may not have participated in strength and conditioning prior to joining a tactical organization could influence the program design and coaching techniques adopted.

If given the opportunity, TSAC-Fs should advocate for sport and strength and conditioning programs at high schools in their community. A further effect is that those high school students who experience these benefits could move onto physically demanding occupations in the community. Approximately 37% of Americans will stay in the town they grew up in, which could be impactful for law enforcement agencies (37). If law enforcement agencies recruit from the community they can ensure stronger bonds with the said community and also ensure that the officers within the agency are reflective of the area in which they serve (24). If sports and strength and conditioning are present within the majority of schools within a given community, this will mean that there would likely be more recruits physically prepared for the training they need to do to become an effective tactical operator.

To this end, ROTC programs for different military branches are also present at some high schools, and law enforcement and fire departments may also conduct programs to introduce high school students to tactical professions (21,22,23). Within these programs, it would be beneficial to introduce the students to strength and conditioning, especially if it is provided by CSCSs. This would assist with the physical development required to enhance survivability at training academies should the students pursue a career with a tactical organization.

## CONCLUSION

Many recruits for law enforcement, firefighting, and military organizations are in their late teens or early 20s, not far removed from high school. Appropriate high school strength and conditioning would benefit those individuals who wish to enter tactical professions. However, the availability and quality of strength and conditioning at the high school-level can vary, and this can affect the fitness and movement capabilities of tactical recruits. CSCSs and TSAC-Fs working in tactical agencies should recognize that the fitness and movement patterns of recruits will be influenced by their strength and conditioning history. Accordingly, CSCSs and TSAC-Fs should tailor their testing and training programs to encompass movement and fitness development. Where possible, tactical agencies and professionals should advocate for strength and conditioning in the high schools present in their communities.

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MEGAN LAUTZ, MS, RD, TSAC-F

# CAFFEINE USE IN TACTICAL ATHLETES

Tactical athletes are often awake while the community they protect are sleeping. Mental and physical performance are imperative, and when sleep-deprived, tactical athletes may rely on caffeine to enhance alertness. The purpose of this article is to discuss caffeine use in tactical populations and provide recommendations for responsible consumption.

## MECHANISM OF ACTION

Caffeine is a common drug for improving arousal, alertness, focus, and energy. In terms of fatigue mitigation, caffeine acts as an antagonist to adenosine (16). As adenosine binds to receptors, the neurotransmitter slows down neural activity and causes drowsiness (3). When caffeine binds to receptors in place of adenosine, neural activity increases, improving alertness and energy. Caffeine may also improve neuromuscular function by activating the motor unit pool more efficiently (3). Kalmar and Cafarelli noted a dose of six mg/kg significantly enhanced isometric leg extension strength and time to fatigue in submaximal isometric leg extension (6). Caffeine's effects on the body range widely and are dependent on a multitude of genetic and environmental factors (3,12).

## PREVALENCE IN TACTICAL POPULATIONS

A cross-sectional survey of caffeine use among United States active-duty Navy and Marine Corps personnel found that 87% reported using caffeinated beverages at least once per week (8). Coffee, soda, tea, and energy drinks were the most commonly used products. A study of Air Force personnel found similar results, with 84% of active-duty personnel consuming caffeinated products at least once per week (7). Energy drink consumption was twice as high in those less than 40 years old relative to those above 40 years old (67 versus 33 mg/day) (7). In deployed service members, 45% consumed one energy drink per day, and 14% drank three or more energy drinks per day (18). A study of 112 firefighters found that five percent of career firefighters reported caffeine overuse (more than 700 mg per day) (2). In law enforcement officers, caffeine intake was similar from day to night shifts; however, those who had trouble concentrating consumed more caffeine during the night shift (4).

## RECOMMENDED DOSE AND TIMING

Accounting for individual response to caffeine is imperative when considering dose. Even a moderate dose of caffeine may improve performance in one person but negatively impact performance in another (12). Genetic factors can impact caffeine clearance, performance response, and even predispose an individual to a higher level of anxiety or sleep disruptions after caffeine consumption (12). Considering the variation in individual response to caffeine, a tactical facilitator or sports dietitian should guide the athlete towards a more experimental approach.

Side effects of caffeine include insomnia, shakiness, anxiety, stomach irritation, restlessness, tremors, and tachycardia (1,9). These side effects can occur at doses as low as 250 – 300 mg (1). To mitigate potential side effects, athletes new to caffeine can start at a dose of two mg/kg (150 mg for a 75-kg tactical athlete) (12,14). Avoid caffeine within 3 – 10 hr of bedtime to prevent disturbances in sleep quality (15). The participant should note any changes in performance, anxiety levels, sleep quality, or other potential side effects. If no major side effects occur, the participant can gradually increase the dosage.

Certain doses of caffeine have been associated with impacts on tactical tasks. Target engagement significantly improved at a dose of 200 – 300 mg in sleep-deprived Navy Seals (16). However, a study of trained law enforcement officers found that consuming an energy shot (240 mg caffeine) reduced pistol aiming steadiness (10). Additional active ingredients may have added to the unsteadiness. Higher doses (more than nine mg/kg) do not improve performance and may increase the risk for side effects (3). For healthy adults, the FDA recommends no more than 400 mg per day, which is the equivalent of 4 – 5 eight-ounce cups of coffee (13).

Caffeine is most effective when consumed 60 min before exercise, and performance enhancement occurs within 15 – 30 min of ingestion (3). Caffeinated chewing gum (up to 200 mg) may absorb faster through the buccal mucosa (cheek lining) compared to capsule delivery (3). Chewing gum (200 mg caffeine) resulted in a rise of plasma caffeine concentration in 5 – 15 min, while capsule delivery resulted in a rise of plasma caffeine concentrations in 25 – 45 min (3). This may be relevant for military personnel who need to restore alertness and performance quickly (20).

## SOURCES OF CAFFEINE

Caffeine is primarily consumed in beverages like coffee, tea, soda, and energy drinks (3). It is naturally found in chocolate, coffee, and tea. Caffeine is synthetically added to a wide range of products, including energy bars, gum, drink mixes (e.g., MiO™, Crystal Light™), and candies (20).

Synthetic caffeine or caffeine anhydrous is a dehydrated, concentrated form of caffeine that is available as a stand-alone supplement. The side effects of caffeine anhydrous and caffeine are similar. The dose of caffeine anhydrous should be carefully measured to prevent overconsumption. Capsules, tablets, and powders that contain caffeine anhydrous are more ergogenic relative to natural sources of caffeine like coffee (3). Caffeine anhydrous appears to enhance endurance performance and time to exhaustion when compared to a cup of coffee (3).

Portion sizes of caffeinated beverages and caffeine-containing food products have increased over time (15). A coffee mug can range from 10 – 16 oz, with travel mugs up to 24 oz. When compared ounce per ounce, brewed coffee has 32 mg more caffeine than an energy drink (19). This is an important education point for those looking to reducing their caffeine intake. Switching from the same amount of energy drink to coffee may actually increase caffeine intake.

Tactical athletes should be wary of energy drinks with a "proprietary energy blend" that does not list active ingredients or caffeine quantity on the label (10). Tactical athletes should consult their physician prior to consuming energy drinks or caffeine-containing supplements. Operation Supplement Safety is an online resource available to help evaluate supplement safety for both practitioners and athletes (11).

**TABLE 1. EXAMPLE OF CAFFEINE SOURCES**

| SOURCE* | CAFFEINE PER 16-OZ SERVING | AMOUNT TO REACH 400 MG |
|---|---|---|
| **Decaffeinated Brewed Coffee** | 5 mg | 1,280 oz |
| **Cola** | 47 mg | 136 oz |
| **Green Tea** | 58 mg | 110 oz |
| **Black Tea** | 96 mg | 66 oz |
| **Red Bull™ Energy Drink** | 152 mg | 42 oz |
| **C4™ Pre-Workout Powder** | 150 mg (1 level scoop) | 2.5 level scoops |
| **Monster™ or Rockstar™ Energy Drink** | 164 mg | 39 oz |
| **Brewed Coffee** | 192 mg | 34 oz |
| **5 Hour Energy "Extra Strength" Shot™** | 242 mg (2 oz) | 3.3 oz |

**Retrieved from USDA's FoodData Central Database (19)*

## CAFFEINE SAFETY

Caffeine toxicity can occur at an intake of 10 mg/kg bodyweight (750 mg for a 75-kg athlete) and death at 150 mg/kg (15). This level would be challenging to reach with beverages but may occur with caffeine anhydrous supplements if measured incorrectly. The risk of caffeine toxicity or death is low unless there are pre-existing health conditions (15).

As previously mentioned, caffeine intake should be tailored to the individual starting at smaller doses (2 mg/kg) (12,14). Moderate (400 mg per day), chronic caffeine consumption is not associated with adverse effects on cardiovascular health, bone status, or cancer risk in healthy individuals. Pregnant women should limit their caffeine intake to less than 200 mg per day (15). Tactical athletes with high blood pressure or pre-existing heart conditions should limit their caffeine intake, with the dose individualized by their physician. Tactical athletes with acid reflux or heartburn may consider reducing their consumption of caffeine if they notice an exacerbation of symptoms (15).

Tactical athletes should pay close attention to caffeine intake to prevent overconsumption. Caffeine tolerance can develop with regular use of caffeine, and increasing the dose may cause side effects in certain individuals (15). The proposed mechanism of caffeine tolerance suggests that daily intake reduces the adenosine-blocking action of caffeine (9). If a tactical athlete notices a reduction in benefits from the same amount of caffeine, it may be time to cycle off to help reduce caffeine tolerance. Cycling off caffeine would require cutting intake in half for a few days, then in half again for a few more days. After a week or two of reducing intake, the athlete can resume caffeine consumption. Gradually cycling off caffeine may reduce the likelihood of caffeine withdrawal symptoms like headaches, fatigue, and reduced alertness (9).

## ENERGY DRINKS AND TACTICAL POPULATIONS

Energy drink consumption is of particular concern in tactical populations. Popularity is attributed to sleep disruption and night shift work. However, energy drinks and shots are associated with a multitude of negative effects. The Substance Abuse and Mental Health Services Administration reported a ten-fold increase of emergency room visits involving energy drinks between 2005 – 2009, with a majority of visits (56%) involving energy drinks alone (5). Past month energy drink usage of U.S. service members has been reported at 75%, with 16% consuming two or more energy drinks per day (18). Toblin, Adrian, Hoge, and Adler found that mental health problems and aggressive behaviors were strongly associated with high levels of energy drink use (18). Aggressive behaviors are associated with relationship problems, suicidal behaviors and being less responsive to evidence-based treatment for post-traumatic stress disorder (PTSD) (17). A cross-sectional study of combat deployed military personnel found that energy drink use was associated with sleeping less and sleep disturbances (17).

Mixing alcohol with energy drinks is popular among young adults despite detrimental health effects (5,17). Adding caffeine counteracts the depressive effects of alcohol and can impact the consumers' perception of their own level of impairment. Consuming energy drinks with alcohol is associated with risky behaviors like heavy drinking, drinking and driving, injury while intoxicated, or engaging in unprotected sex (5). Excessive energy drink consumption and mixing alcohol with energy drinks should be addressed in education provided to tactical populations. Education should emphasize the promotion of proper sleep hygiene and strategies for reducing energy drink intake.

## KEY POINTS

- Individualize caffeine dosage, starting at two mg/kg. Observe for any side effects or performance changes before increasing dose.
- Cap caffeine consumption at 400 mg per day (in healthy adults).
- Caffeine is most effective when consumed 60 min prior to exercise.
- Caffeine anhydrous is more ergogenic than natural sources of caffeine, but the dose should be measured carefully.
- Caffeine can enhance alertness, but energy drinks/shots may negatively impact fine motor tasks like pistol aiming steadiness.
- Energy drinks are associated with higher levels of fatigue, mental health problems, and aggressive behavior.
- Avoid mixing energy drinks with alcohol.
- Avoid caffeine within 3 – 10 hr of bedtime to prevent disturbances in sleep quality.
- Avoid products with proprietary energy blends that do not list ingredients or caffeine content (e.g., energy drinks, pre-workout supplements).
- Limit caffeine intake if a person has pre-existing high blood pressure or a heart condition. Pregnant women and those with acid reflux may need to limit caffeine intake to less than 200 mg per day.

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# FEASIBILITY AND DIFFICULTIES OF CONDUCTING RESEARCH ON PROFESSIONAL FIREFIGHTERS

## INTRODUCTION

As the field of research applicable to tactical populations continues to grow, unique challenges and difficulties have presented themselves to the scientific community. Studies that utilize these populations can experience multiple hurdles that make the use of traditional research methods impractical, particularly when measuring the physiological responses to exercise. As a preventative treatment for chronic diseases, regular exercise is also required to maintain performance in the tactical athlete (6). With firefighters, there is a need for more strict physical fitness standards and specific exercise prescriptions compared to the general population, so these individuals can safely and effectively perform their duties (21,22). This need arises from the high prevalence of cardiovascular disease in these individuals, as well as the number of workplace injuries that occur due to lack of training and conditioning (18,21). Professional firefighters who adhere to a regular exercise program can prevent the onset of cardiovascular incidents by three-fold (1), reduce worker compensation claims through a decrease in work-related injuries by approximately $33,000 among first-year cadets (11), improve maximal oxygen consumption ($VO_2max$) by 28% (20), increase endurance in the back musculature by 12%, reduce the incidence of low-back pain (16), and improve body composition by 8% (17).

With these known benefits, it is important to document the difficulties of performing scientific research with firefighters, particularly in long training studies that can last for months at a time. There needs to be an emphasis on not only reporting meaningful findings, but also discussing limitations that arise with the tactical athlete subjected to a field-based research protocol. These limitations may go unnoticed but can have substantial implications on the design and outcomes of the studies that include firefighters as participants. Although specific aspects of lifestyle that present themselves as barriers or benefits with regards to exercise programming adherence have been reported, an examination of how lifestyle affects the scientific process when conducting research has not been documented (8). The purpose of this article is to identify and discuss the difficulties that can arise when performing physiological-based research with firefighters. Compliance, lifestyle, auto-regulation of exercise protocols, study recruitment, and injury rates will be discussed, and strategies will be offered to overcome these limitations.

## COMPLIANCE

A very limited amount of training interventions including firefighters have been published. More specifically, approximately ten randomized control trials published prior to May 2019 were located using search engines such Medline, PubMed, and Google Scholar. This lack of research may be inherently related to the occupations of tactical athletes. A major barrier affecting tactical athletes' motivation to train is the atypical work schedules, which is particularly evident with professional firefighters. Depending on rank and station assignment, these individuals typically work anywhere from 8 – 48 consecutive hours. Shifts are often separated by a period of 16 – 72 hours, and this irregular work schedule can present difficulties with research participation compliance. Factors that influence compliance include: 1) additional employment during scheduled off-duty time, 2) the opportunity for overtime pay, 3) the desire to be present as much as possible with family and home life, 4) commute times from the testing or training site to the station or home, and 5) lack of proper lifestyle choices when on a shift. When conducting research with firefighters, we hypothesize that many of these participants may not regularly attend training sessions held on specific days (e.g., weekend), may make poor dietary choices, and have poor quality of sleep when on shift. We also hypothesize that firefighters may miss training sessions because of an understaffed shift. Some departments have budgets that account for approximately one million dollars per year in overtime pay, so working these shifts is an option for many firefighters. Although some of these factors are unavoidable due to the nature of the profession, they should be considered when designing and executing research protocols with professional firefighters. Strategies can be used by researchers to enhance participation and compliance in research investigations. The use of academy training programs, designated workout spaces, and access to exercise programming could potentially enhance participation and compliance. In addition, compensation, either monetarily or other forms (e.g., apparel, gear), may be given to firefighters to further incentivize them to participate.

## LIFESTYLE

Due to the potential differences in job duties between shifts, the lifestyle choices of a firefighter can vary widely. This fact can make it difficult to control habits outside of the research protocol, particularly when implementing a long-term training study. This is particularly true when there are personal barriers that may prevent research participation while off duty, such as: 1) low personal motivation, 2) fear of interference with job performance, 3) dietary choices, 4) use of performance-enhancing supplements, and 5) adherence to a sleep schedule. Each of these variables can have a negative impact on a firefighter's lifestyle and compliance.

Personal motivation can be difficult to maintain when attempting to achieve optimal physical fitness. The stress that accompanies a firefighter's occupation, combined with any struggles in their personal or family life, may decrease the motivation to maintain a regular exercise schedule, and to participate in a prolonged training study (14). There is also fear of exercise study participation interfering with job performance. If a first responder arrives on a scene fatigued, particularly from a recently completed high-intensity workout with some muscle soreness, civilian lives may be put at risk (13). However, fit, but exercise-induced fatigued, firefighters have greater occupational physical abilities when compared to non-fatigued, sedentary firefighters (7). Poor dietary choices are also common with these individuals. While snacking and eating quick meals with little nutritional value take less time for preparation and planning, they may lack the required daily macro- and micronutrient amounts for those in this occupation (27). First responders on different shifts typically have different dietary habits, with those working overnight typically making poorer dietary choices (4). The use of performance-enhancing substances has not been well characterized with this specific population, including usage rates and effects on job performance. However, there is evidence from our laboratory (unpublished findings) that professional firefighters will often rely on the use of exogenous testosterone as they age, and heavily rely on the use of caffeine and other stimulants during their unconventional work shifts. In a research setting, it is difficult to control for the ingestion of supplements, including type and dosages with this population. Finally, irregular sleep patterns can negatively affect a firefighter's lifestyle. It is difficult to regulate these patterns due to the unknown workload expectations during a shift, and the additional work shifts that are scheduled outside of their normal occupation. The importance of sleep for optimal performance and recovery is well documented (25).

## AUTO-REGULATION

Auto-regulation allows the athlete to adjust aspects of exercise programming, including intensity, frequency, duration, and rest time, according to needs, fatigue, or stress levels (15). This allows a great degree of flexibility in a strength and conditioning professional's ability to modify daily programming variables, permitting recovery from fatiguing work schedules and other outside stressors (15). Auto-regulation can be performed with various measures, including a rating of perceived exertion, heart rate variability, vertical jump height, and grip strength (26). These daily metrics, when compared to a baseline measurement, can allow athletes to characterize effects of global stress. Using this information, prescribed exercise variables are then adjusted accordingly. Auto-regulation is effective in promoting an approximately 5.5% increase in strength when compared to traditional linear periodization among the athletic population (26). Typical programming variables in controlled research studies include intensity, frequency, duration, and rest time (24). While these variables may be kept uniform to limit inter-individual variability, statistical strategies (e.g., repeated measures designs) may also be used to overcome the issue of variability (12). This is critical for athletic populations, as injury rates are known to be proportional to training volume (10). Indeed, among those who regularly attend training sessions, injury rates can be as high as 56% among first responders (10). This is largely due to the high-intensity training protocol itself, the physical and mental stress related to their occupation, and scheduling conflicts. These potential obstacles may make it unrealistic for many first responders to meet exercise training requirements. Also, access to resistance training equipment and a proper training facility may create further limitations to meeting exercise training requirements (17). Therefore, it appears necessary to implement the auto-regulation of an exercise prescription when conducting long-term exercise training research studies with professional firefighters. However, there appears to be a recruitment bias towards firefighters who are more fit (17). This is problematic, as research is warranted on firefighters who are less fit. More research is also needed to address differences in controlled laboratory testing versus simulated fireground assessments in an effort to control for internal and external validity.

## RECRUITMENT

The need to include both male and female participants in research, with an equal representation of ethnicities, is evident with scientific research today. The Office of Research on Women's Health, within the National Institutes of Health (NIH), has called for research scientists to consider adding sex as a covariate when analyzing health-related data. Research investigations that include firefighters make this task difficult, especially because the profession is dominated primarily by white males. According to a recent survey, an estimated 95.5% of firefighters in the United States are male (9). This is noteworthy, as males and females possess differing physiology that influences the distribution of muscle mass and body fat, which may affect outcomes with exercise science-related studies (3). In our laboratory (unpublished findings), we recently experienced the discrepancy in the prevalence of male and female firefighters in a training study, with male firefighters consisting of more than 90% of the study sample. As both male and female firefighters are responsible for completing similar job tasks, it is important to test both sexes equally to determine their fitness and functional abilities. Future investigations are needed to determine the inherent variability between sexes following a long-term training intervention. Ethnicities are also not evenly distributed throughout the profession of firefighting, as evident with the following classifications: 1) 81.8% White, 2) 9.0% African American, 3) 8.3% Hispanic, and 4) 1.0% Asian (9). These findings expose a gap in a literature concerning the variability of sex and ethnicity in professional firefighters that needs to be addressed.

## INJURY RATES

Professional and volunteer firefighters are exposed to multiple occupational hazards on a daily basis that may lead to injury. From motor vehicle accidents to the extreme demands on the musculoskeletal system, these individuals require a considerable amount of physical preparation to mitigate injury in the field. The injuries with the highest incidence rates suffered by emergency responders in the U.S. are sprains and strains located in the lower trunk, ankles, and knees (19). These injuries do not fully account for the unique physical demands of the profession that may elicit injury to the neck, back, and shoulders (2). As a result of these injuries, the risk of long-term disability increases. First responders in the U.S. are at a higher risk of work-related injury and death when compared to first responders in Japan and Australia (5). This is possibly due to the differences in the methods of reporting work-related incidents between countries, and a higher call volume in the U.S. (5). In addition to musculoskeletal injury, cardiopulmonary injury, which can take years to develop with chronic exposure to environmental particulates and poor lifestyle choices, can affect firefighters (23). The potential for these injuries can greatly affect protocols of training studies, particularly with participant screening and data collection. These risks demonstrate the need for these athletes to be physically prepared for the demands of their job, and for research to be correctly performed to mitigate injury and keep the public safe. To address these concerns, potential participants should be properly screened for risk factors including, but not limited to a family history of cardiovascular, pulmonary, or metabolic disease; tobacco use; elevated fasting glucose;l body mass index and obesity; and physical activity habits.

## CONCLUSION

In the current report, the challenges of utilizing professional firefighters in research are documented. More specifically, compliance, lifestyle, auto-regulation of exercise protocols, study recruitment, and injury rates may present as barriers to conduct rigorous research with this understudied population. Strategies to overcome these limitations were also discussed. Researchers should work to combat these challenges creatively by integrating academy training programs, designated workout areas, and access to specialized programming where possible, while also incentivizing participation, allowing for auto-regulation of training, recruiting a diverse sample, and including a battery of screening tools. Despite these challenges, future research studies that include firefighters is necessary. With this evidence, the risk of injury may be mitigated, which may help alleviate the financial burden associated with injury-related healthcare costs.

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DUSTIN DUNNICK, MS, CSCS, AND BRIAN SCHILLING, PHD, CSCS

# TSAC REPORT—JULY 2020 RESEARCH COLUMN

## TRIPLE HOP FOR DISTANCE AS A PREDICTOR OF LOWER EXTREMITY PERFORMANCE IN FIREFIGHTER EQUIPMENT. *INTERNATIONAL JOURNAL OF EXERCISE SCIENCE*, 2019.

**ROGERS, S, WINKELMANN, Z, EBERMANN, L, AND GAMES, K.**

Lower-body strength and power are important attributes for tactical athletes. Researchers recently examined how the use of the triple hop movement may be a predictor of lower-body performance. Thirty-one healthy participants performed a variety of tests while wearing full firefighter personal protective equipment (PPE) (e.g., helmet, pants, jacket, facemask, oxygen tank, boots, and fire-resistant hood). All participants were physically active and free of injury for at least six months but did not have any experience wearing firefighter PPE. Along with the triple hop for distance (THD), participants also performed a vertical jump and concentric knee extension/flexion test. Each test was performed unilaterally with the dominant leg, which was identified via the Functional Leg Dominance assessment.

The THD test had participants standing on one leg at the start line. They had to jump using the same leg three times with the marking of the third heel strike used to measure the total distance. Participants need to complete three acceptable trials to establish a mean distance. Trials were considered unsuccessful if they did not follow instructions, lost their balance during any portion of the test, or could not hold the final stance on a single leg for at least two seconds. The vertical jump was assessed using a jump mat to estimate jump height based on flight time. An isokinetic dynamometer was utilized for the knee extension/flexion test at angular velocities of 60 degrees/s and 180 degrees/s.

The performance of the THD was able to predict 66.5% of the variance in vertical jump height using the dominant leg and 63.2% using the non-dominant leg. The THD performance was a moderate predictor of knee extension/flexion strength with about 27% and about 38% of variance predicted using the dominant and non-dominant legs, respectively. Tactical Strength and Conditioning Facilitators® (TSAC-F®) may utilize the unilateral THD test for firefighters wearing PPE gear as a way of measuring lower-body power, and to a lesser extent, strength. Other populations that wear heavy PPE might also benefit from using this test.

## IMPACT OF A 12-WEEK POSTGRADUATE TRAINING COURSE ON THE BODY COMPOSITION AND PHYSICAL ABILITIES OF POLICE TRAINEES. *JOURNAL OF STRENGTH AND CONDITIONING RESEARCH*, 2018.

**ČVOROVIĆ, A, KUKIĆ, F, ORR, R, DAWES, J, JEKNIĆ, V, AND STOJKOVIĆ, M.**

After graduating from the police academy, it is important for police trainees to continue to train and maintain an adequate body composition to perform their job at a high level. A study of the Abu Dhabi police force examined how police trainees responded to a 12-week training course. A total of 325 healthy male trainees (age = 29 ± 5 years; height = 173.1 ± 5.8 cm; body mass = 78.9 ± 11.5 kg) participated in the 12-week training course after they had completed at least 80% of the police academy physical education courses. Anthropometric measurements, along with a variety of physical performance tests, were performed during weeks 1, 7, and 13. Anthropometric data included height, body mass, and waist circumference. Physical performance tests included: one-minute push-ups, one-minute sit-ups, and a 2.4-km run.

The 12-week training course was split into two six-week mesocycles to allow for midpoint testing. The first mesocycle was focused on circuit training using bodyweight exercises. The second mesocycle was focused on increasing training volume and intensity and included resistance training using supersets, compound sets, and plyometrics. Cardiovascular training

**TABLE 1. ANTHROPOMETRIC AND PERFORMANCE CHANGES OVER THE STUDY**

| | WEEKS 1 TO 7 | WEEKS 8 TO 13 | WEEKS 1 TO 13 (TOTAL) |
|---|---|---|---|
| **Body Mass (kg)** | -4.0 (p < 0.001) | -1.9 (p = 0.047) | -5.9 (p < 0.001) |
| **Waist Circumference (cm)** | -5.6 (p < 0.001) | -1.9 (p = 0.012) | -7.5 (p < 0.001) |
| **Push-ups (reps)** | 9.3 (p < 0.001) | 4.4 (p < 0.001) | 13.6 (p < 0.001) |
| **Sit-ups (reps)** | 9.3 (p < 0.001) | 2.2 (p < 0.001) | 11.6 (p < 0.001) |
| **2.4-km (sec)** | -86.9 (p < 0.001) | -33.4 (p < 0.001) | -120.2 (p < 0.001) |

*Table 1 displays the significant changes in anthropometric and performance data from week 1 to week 7 and 13. The improvements of both anthropometric measurements and physical performance highlight the importance of a training plan that has proper progression for the athlete, especially trainees new to the police force. Overtraining is an important factor for TSAC-F and athletes when entering a training program either during or post-academy, and it may be wise to start with bodyweight exercises and progress up to external resistance training.*

consisted of intervals with pace and distance progressing up to the 2.4-km test.

## DIFFERENCES IN TRAINING ADAPTATIONS OF ENDURANCE PERFORMANCE DURING COMBINED STRENGTH AND ENDURANCE TRAINING IN A 6-MONTH CRISIS MANAGEMENT OPERATION. *INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH*, 2020.

**PIHLAINEN, K, HÄKKINEN, K, SANTTILA, M, RAITANEN, J, AND KYRÖLÄINEN, H.**

Soldier endurance is an important attribute to improve and maintain. Unfortunately, aerobic fitness tends to decrease during military operations. Researchers recently examined the effect of strength and endurance training on aerobic fitness during a six-month long crisis management operation. Sixty-six male soldiers (age = 29.8 ± 8.5 years; height = 180 ± 7 cm; body mass = 79.4 ± 8.2 kg) volunteered to have body composition, blood panel, physical performance, and military simulation test (MST) performance data collected both pre- and post-operation.

Maximal isometric force was measured using an electromechanical dynamometer for both the lower and upper body extensor muscles. Lower-body power production was tested using the standing long jump. Muscle endurance was assessed using the one-minute sit-up, push-up, and pull-up tests. A 3,000-m run was used to assess aerobic endurance. The MST was designed to assess military-specific performance of crisis-management soldiers. Tasks included: rushes, jumps, change-of-direction maneuvers, crawling, load carriage, and casualty drag. The total length of the course was 243 m and was performed wearing full combat dress (boots, combat gear, body armor, helmet, and replica rifle) with an average weight of 22.5 kg.

Soldiers' training was analyzed six weeks before deployment and tracked during the operation via training logs. During the operation, soldiers were randomly placed into three groups with different training plans. The three groups consisted of high-endurance (75% endurance training), 50/50% strength and endurance training, and high-strength (75% strength training). Soldiers performed their given training twice per week and were encouraged to maintain any of their normal training habits as well. Each training program came with proper instructions for exercise technique and selection as well as what intensity and volume to use.

At the end of the six-month operation, 49 soldiers' data were analyzed. Using the data from the 3,000-m run, the soldiers were grouped into two groups (high responders and low responders). High responders consisted of soldiers whose 3,000-m time decreased (n=25) while low-responders' 3,000-m time increased or stayed the same (n=24). While endurance training frequency did not differ among the two groups, low responders did perform strength training significantly more than high responders (2.9 ± 1.2 versus 1.8 ± 1.4 times per week, $p = 0.008$). Significant baseline differences between the high responders and low responders groups were observed in muscle mass (38.0 ± 3.9 versus 40.3 ± 4.1 kg, $p = 0.046$), body fat (12.8 ± 3.6 versus 9.6 ± 5.7 kg, $p < 0.001$), lower body strength (3959 ± 532 versus 4564 ± 1116 N, $p = 0.049$), standing long jump (227 ± 16 versus 242 ± 27 cm, $p = 0.016$), and MST performance (156 ± 23 versus 143 ± 24 s, $p = 0.028$). After the operation, there was a significant difference in the relative changes between high and low responders in body mass (-1.0 ± 2.5% versus 2.3 ± 2.8%, $p < 0.001$), body fat (-7.6 ± 11.7% versus 14.2 ± 20.4%, $p < 0.001$), one-minure push-up (27.7 ± 21.9% versus 11.7 ± 26.1%, $p = 0.004$), and MST performance (-13.6 ± 6.8% versus -7.5 ± 6.5%, $p = 0.006$).

Based on post-operation interviews, the high responder group reported a significantly higher endurance training frequency compared to the low responders (28% versus -40%, $p < 0.001$) based on their pre-operation training. This would indicate that those who already train for endurance are more likely to maintain their training. Additionally, the increase in body mass and body fat in the low responder group indicates that maintaining pre-operation body composition may be important when it comes to aerobic endurance during a long operation. TSAC-Fs working with military personnel about to partake in an operation should emphasize the importance of endurance training during their time away. Furthermore, working with a registered dietician may help in maintaining body mass, thus aiding in the soldier's ability to maintain good endurance performance.

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