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POST-CONCUSSION EFFECTS ON NEUROCOGNITIVE PERFORMANCE IN TACTICAL ATHLETES

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Concussion is a concerning injury and recovery can last days, weeks, or even months. Becoming familiar with post-concussion symptoms and the ensuing health-related sequelae is essential for those aiming to optimize the physical performance of tactical athletes.

The brain conducts an array of complex tasks orchestrated by approximately 100 billion interconnected neurons responsible for processing information with amazing speed and accuracy (4). The ability to process visual stimuli, negotiate obstacles, coordinate posture and locomotion, and react to varying external stimuli are just a few examples of tasks simultaneously modulated by the brain along with other central nervous system structures. Tactical athletes are trained to respond rapidly, safely, and effectively to a myriad of dangerous and stressful situations that demand high workloads and mental acuity. Optimal neurocognitive performance and physical capacity are needed for successful occupational performance. The significance of the brain’s neuro-operating system may be taken for granted until neurocognitive performance decrements manifest following head trauma.

Identifying neurocognitive deficits resulting from mild traumatic brain injury (mTBI) may improve the safety and effectiveness of tactical athletes. An mTBI or concussion following head trauma can deleteriously affect short- and long-term neurocognitive performance. mTBI may occur during rapid movement of the brain inside the skull and may result from physical impact with an object or other sudden energy transfer to the body (e.g., blast wave). Presentation of one or more of the following symptoms is used to define mTBI: headache, nausea, vomiting, dizziness, balance issues, confusion, disorientation, loss of consciousness for less than 30 min, amnesia, blurred vision, and difficulty concentrating (8). These symptoms may represent post-concussive syndrome (PCS), and may continue for days, weeks, or months. Persistent PCS is diagnosed when at least three of the following eight clinical manifestations persist for more than one month: 1) fatigue; 2) alterations in sleep; 3) irritability or aggression; 4) anxiety, depression, and emotional distress; 5) headache; 6) vertigo; 7) changes in personality; and 8) apathy or loss of spontaneity (7). Understandably, tactical personnel with PCS will have duty restrictions set forth by qualified health professionals. It is important to know that exercise too soon following mTBI is not advised and can result in re-injury, delayed recovery, and the return of PCS symptoms (5). Untreated PCS can increase the risk for long-term neurocognitive health issues and compromise the safety of the tactical athlete (e.g., learning disability, Alzheimer’s disease, musculoskeletal injury, etc.) (6).

Tactical athletes must be prepared to endure physical and psychological stressors, often in austere, unfamiliar, and dangerous environments. Tactical athletes must remain physically fit and are often required to meet minimum cut-off standards of physical fitness (17). For this reason, injury related dysfunction of either physical or neurocognitive domains can potentially threaten physical readiness, survivability, and long-term health. Neurocognitive performance, in the context of athletic performance, has been defined as visual attention, self-monitoring, agility and fine motor skills, processing speed and reaction time, and dual tasking (2). Thus, effectively executing neurocognitive and physical tasks simultaneously (multitasking) has a direct impact on the tactical athlete’s physical capacity and job performance. Physical capacity, or ability, dictates the workload that can be tolerated before fatigue ensues. Physical capacity can be influenced by factors such as the nature of the work, somatic factors (e.g., age, health, etc.), psychological factors, environmental factors (e.g., heat, altitude, noise, etc.), and training adaptations (1). Physical capacity is also associated with physiological regulation, neuromuscular control, and motor learning, all of which are modulated by sensory processing, attention, and motor planning (2). All of this suggests that deficits in neurocognitive function, such as those seen with PCS, may put the tactical athlete at an increased risk for musculoskeletal injury.

This was observed by Nordstrom et al. in a study that examined short- and long-term sequelae of concussion in 1,665 elite European football (soccer) players over a 12-year span (13). The study reported that concussion was a significant risk factor for subsequent injury. Of the 1,665 players, 71 concussions were reported among 66 players. In the year following the concussion, the risk of injury was progressively higher in concussed vs. non-concussed players. Risk of injury in concussed players was 1.56, 2.78, and 4.07 (hazard ratios) at 0 – 3 months, 3 – 6 months, and 6 – 12 months, respectively. A study by Pietrosimone et al. utilized a survey instrument to examine the association of concussion with musculoskeletal injuries in 2,552 retired American football players from the National Football League (NFL) (15). After adjusting for NFL years played, body mass, and playing position, the risk for lower extremity musculoskeletal injuries was 1.59, 2.29, and 2.86 times higher in players reporting 1, 2, and 3 or more concussions,
Tactical athletes must be physically fit and demonstrate a high degree of neurocognitive function. mTBI is a concerning injury and tactical athletes must be evaluated by qualified healthcare professionals if a suspected head injury has occurred. PCS negatively impacts the tactical athlete’s ability to perform multitasking operations and may leave them at a greater risk of musculoskeletal injury. Returning to duty before PCS has completely resolved can potentially compromise safety, increase injury risk, and result in long-term neurocognitive deficits. New, more sensitive mTBI assessment tools and therapy strategies aim to improve PCS recovery and return-to-duty. Tactical facilitators need to be aware of the factors, signs and symptoms, and consequential risks involved for tactical athletes dealing with mTBI and PCS to refer them to a certified healthcare professional when needed. Investigating more in depth and sensitive mTBI assessment tools that can be used in conjunction with current clinical guidelines, as well as emerging concussion treatment modalities, may help improve recovery and facilitate return-to-duty.

PRACTICAL CONSIDERATIONS:

- mTBI is a concerning injury and tactical athletes must be evaluated by qualified healthcare personnel if a suspected head injury has occurred.
- PCS may present subtle symptoms beyond 7 – 10 days, during which time the tactical athlete could be at greater risk for musculoskeletal injury.
- New assessments are currently being examined that aim to better identify PCS and neurocognitive performance by assessing the ability to perform physical and mental tasks simultaneously.
- Emerging PCS therapy, such as red/NIR LED, show promise for improving symptoms of PCS and return-to-duty.

Acknowledgements: The authors would like to thank Peter Rivoira and Dr. Carole Palumbo for their valuable contributions to mTBI research and review of this report.
REFERENCES

ABOUT THE AUTHOR
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Joseph Kardouni earned a Master of Physical Therapy degree from the United States Army-Baylor University Graduate Program in 2001 and a Doctorate of Physical Therapy degree from Baylor University in 2008. He completed his PhD at Virginia Commonwealth University in 2013. Kardouni currently serves as the Research Director for the Total Army Injury and Health Outcomes Database (TAIHOD). He is involved in research examining biomechanics of the shoulder and thoracic spine, as well as epidemiologic and treatment studies on injuries affecting soldiers. Kardouni has served over 16 years in the Army Medical Specialist Corps, including four years as the lead physical therapist assigned to 3rd Special Forces Group and a year as the Chief of Rehabilitation Services in Kuwait supporting Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). Kardouni has completed four tours of duty in support of OIF and OEF, assigned to both conventional and special operations units.
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TRAINING CONSIDERATIONS FOR WILDLAND FIREFIGHTERS

There are some training approaches and strategies that may appeal to all tactical populations (e.g., correct form as a prerequisite competency to adding load to a structural exercise). However, physiological, biomechanical, logistical, cultural, and organizational differences need to be taken into consideration when implementing a training program, for it is these factors which may impede potential benefits of a program as well as increase the risk of injury, illness, and frustration. Within specific tactical populations, these differences can be evident and should be addressed. For example, assuming a physical conditioning program designed for a group of structural firefighters would have the exact same carry-over to a group of wildland firefighters shows a lack of appreciation for the differences in the training needs across these contrasting firefighting roles. This article will discuss several specific considerations for developing a training program within wildland firefighter agencies and departments that could help direct strength and conditioning professionals whether from within the organization (e.g., current firefighters serving as the training coordinators) or certified individuals coming into the department from the outside.

IMPORANCE OF A NEEDS ANALYSIS
A needs analysis can be defined as a “multistage process composed of goal setting, assessment, and research,” (1). Despite often being overlooked, a proper needs analysis can be very useful in identifying fitness deficits and consequently training priorities on an individual and department level. A needs analysis may also help identify approaches that would comprise a plan of action for addressing these deficits and maintaining current strengths, while also taking into consideration potential obstacles to successful implementation. Finally, this type of analysis may help with identifying whether programs used with or developed for other tactical populations are appropriate or feasible for wildland firefighters. Considering this, tactical facilitators need to understand the population they are working with in order to evaluate the applicability of any potential program. For example, is the program modifiable for work schedules or emergency calls that cause fatigue to the extent that it may interfere with the program? Is the program inclusive of individuals with differing training ages and skills or is it a “one size fits all” approach? Does the program necessitate the use of equipment that is not readily available at the wildland firefighter base facility (as they typically cannot take time off to drive into town to use a fitness facility)?

DISCOVERY AND GOAL SETTING
For whatever population the tactical facilitator works with, it is imperative to understand their occupational responsibilities, including the metabolic and biomechanical demands, the equipment that must be worn or maneuvered, and the health and injury risks involved. For example, many of the tasks may be multi-joint, involving large muscle groups, a combination of unilateral and bilateral movements, and may necessitate carrying or manipulating various loads/equipment. In order to accomplish this, the tactical facilitator should research the population and inquire with the agency, the specific fire department, and the individual firefighters to grasp a full, comprehensive appreciation for the physical and psychological stress often inherent in these occupational demands.

The National Fire Protection Association describes wildland firefighting as including “the activities of fire suppression and property conservation in woodlands, forests, grasslands, brush, prairies, and other such vegetation, or any combination of vegetation that is involved in a fire situation but is not within buildings or structures,” (16). This includes specialized teams such as Type 1 firefighters (e.g., smokejumpers, hotshots, rappellers, helitack, and engineers), and Type 2 firefighters (e.g., hand crews). However, a department under the guidance of a physical trainer may also include members of incident management, dispatchers, or other supervisory personnel. Additionally, many of these firefighters may have overlapping responsibilities, or distinctly different roles before, during, or after the fire season. Some of these populations are seasonal workers and some are employed throughout the year, again with some variation in the tasks they perform during and out of the fire season. For trainers coming from within the fire service, many of these occupational tasks will already be well known; however, information on health and injury trends may not be as well known. Several resources that will help provide insight for working with this population; for example, injury and illness/health trends in wildland firefighters (including several structural firefighter resources that may be applicable to wildland firefighters) can be found in Table 1.

Considering this, to more fully comprehend the reasons for a training program and the feasibility of program implementation, other questions may need to be addressed pertaining to goal setting and logistics (Table 2). For example, an important factor to appreciate with many wildland firefighters is the seasonal nature of their occupation. They may not have time, or it may not be appropriate or feasible for them to complete structured physical training programs during the season given the unpredictability of their assignments (e.g., location, extended call, and extreme environmental conditions). This suggests that pre-season conditioning and appropriate, purposeful training during the fire season is imperative in helping them maintain fitness throughout...
the fire season. This need was concisely summarized in the first edition of Fitness and Work Capacity: “fitness is the most important determinant of work capacity...the employee's ability to accomplish production goals without undue fatigue, and without becoming a hazard to oneself or coworkers,” (23).

**ASSESSMENT OF CURRENT STATUS**

A key component of goal setting is understanding the current status of the firefighters involved in the training program. All wildland firefighters must complete a medical health history or health screening questionnaire and a medical exam or health screening (that might involve physician evaluation) prior to each fire season. Additionally, before the fire season, they must take either the Pack Test (arduous), Field Test (moderate), or Walk Test (light), depending on the specific occupational type. This pre-screening should expose any concerns or contraindications that might influence physical training (e.g., high blood pressure or cholesterol). While this information provides a general guideline, a tactical facilitator may want to do a follow-up on physical status throughout the season given the physical stresses each firefighter may experience.

The third edition of Fitness and Work Capacity describes the current requirements and recommendations for physical fitness assessment of wildland firefighters across different disciplines (22). In addition to the Pack, Field, or Walk Test, the pre-season assessments may also include a 1.5-mi run (aerobic fitness); 10-repetition maximum (10RM) bench press and leg press (muscular strength); and sit-up, push-up, and pull-up tests (muscular endurance) (22). These assessments to evaluate fitness are relatively easy to administer at the beginning of the season, but can also be useful in tracking progress throughout the season. In addition, other areas of fitness or health may need to be evaluated based on current health concerns or fitness goals. The choice of assessments that a tactical facilitator may include for the agency, department, or specific individuals should consider the following:

- Choice of assessment should be appropriate for the population and related to the goal:
  - For example, if there is only time for one assessment of muscular endurance, then perhaps the pull-up test would be most appropriate for smokejumpers or rappellers given their job tasks (e.g., parachute jumping, rappelling, etc.). Tactical facilitators should discuss what assessments are currently required for their population with the appropriate agency, and be aware of new recommendations or requirements. This requires tactical facilitators to regularly check the websites and reports from governing agencies.
  - Current contraindications to testing should be considered, such as injuries and health status:
    - For example, if trunk strength is identified as an area in need of evaluation, but the firefighter has been struggling with low back pain, full sit-ups and back planks may not be advisable as they may aggravate the pre-existing issue.
  - Administrator/firefighter familiarity and competency with testing protocols and techniques:
    - For example, body composition can be evaluated in several ways. Due to the location of many wildland fire stations, access to underwater weighing tanks is not often viable. Conducting skinfold measures may be an option if the tactical facilitator is knowledgeable and qualified to do so. However, for some tactical facilitators, other techniques may have to be used that are more readily available and feasible, such as anthropometric measures (e.g., waist to hip ratio), to provide estimates of obesity status.
  - Assessments require a high level of motivation and honesty:
    - What does the tactical facilitator need to do to motivate the unmotivated? Is it how the trainer is selling the concept of physical training (and fitness assessments) to the firefighters? Where and with whom will the assessments be conducted? If people feel intimidated or under pressure, their willingness to engage and put forth maximal effort may be affected. The tactical facilitator may wish to consider how the results of assessments are shared with firefighters and who will see the results. Tactical facilitators should obtain appropriate medical clearance and consent before putting any firefighters through fitness assessment, and clarify the purpose of assessments before they are implemented along with whom the results will be distributed.

The discovery, goal-setting, and assessment stages will help identify areas in need of improvement, or “gaps.” These stages can also help to highlight factors in wildland firefighter communities that facilitate improvements as well as obstacles that may need to be addressed or overcome for improvement to occur. In wildland firefighter crews, it is important to appreciate that these “gaps” will not be the same for everyone—there are a wide variety of ages, years of employment with the fire service, variety of occupational responsibilities, and differences in level of concern or motivation for positive health behavior change through engagement in physical training practices; again, highlighting the need for a targeted approach.
DEVELOPING THE PLAN OF ACTION

There is no one training style or program that fits all wildland firefighter agencies or departments, not even those with the same crews. Table 1 provides some examples of possible programs that could be implemented with or without modification for various wildland firefighting crews. But as with many tactical populations, tactical facilitators may find themselves needing to modify a training program in multiple ways within one department. The tactical facilitator may need to ask several questions to identify the attributes of a training program that is appropriate for wildland firefighters. For example:

- Who is responsible for implementing the plan? Is supervision going to be necessary or required?
- Do the wildland firefighters have the necessary competency and understanding of how to train?
- Have they fulfilled certain prerequisite competencies recommended for various exercises or programming approaches (2,3)?
- What is the likelihood that they will be compliant with the prescribed program? If they are not compliant, is it acceptable or does their behavior increase injury risk?
- What are the consequences if the planned approach is not implemented correctly or the goal is not attained?
- What additional facilities, equipment, and technologies are needed? Can the recommended equipment be modified (e.g., can pieces of firefighting equipment be used safely to simulate weights)?
- Can the program be modified in response to the unpredictable climate, demands, and schedule of wildland firefighters?

These are just a few of the possible questions a trainer working with wildland firefighters may need to ask when developing a training program or evaluating the applicability of an existing program. Given the highly mobile nature of wildland firefighting crews, the person tasked with guiding physical training practices will likely be a current firefighter, who may or may not have training or certifications in this domain and therefore, may not have adequate fitness knowledge or expertise to work with the variety of needs in a firefighting crew. For tactical facilitators who have not had hands-on experience as a firefighter, it is important to ask questions, get to know the population, and be humble. It is paramount to listen to feedback and work as a team with the firefighters in order to help increase the likelihood that the physical training program will be successful and reduce the risk of injury.

REFERENCES


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**ABOUT THE AUTHOR**

Katie Sell is an Associate Professor in the Department of Health Professions at Hofstra University, where she coordinates the Undergraduate Exercise Science Program. She currently teaches undergraduate and graduate courses in exercise physiology, physical fitness assessment, and the interpretation of research. Her primary research interests lie in the area of physical fitness assessment in wildland firefighters and collegiate student-athletes. She is currently on the National Strength and Conditioning Association (NSCA) Tactical Strength and Conditioning (TSAC) Special Interest Group (SIG) Executive Council, which focuses on disseminating information on physical training for tactical athletes.

Bequi Livingston has spent the past 35+ years involved in the fitness and wellness and wildland fire management profession. During this time, Livingston has served in a multitude of wildland fire positions including engines, helitack, fire prevention, fire lookout, law enforcement, dispatch, and is one of the first two women hired by the United States Forest Service on the prestigious Smokey Bear hotshot crew. Livingston owns a personal fitness and wellness consulting business and is currently an instructor at Central New Mexico Community College, where she teaches in the Wildland Fire Science Program. She was instrumental in the development of the Are You FireFit? program, is an American Council on Exercise (ACE) Certified Personal Fitness Trainer, Aerobics and Fitness Association of America (AFAA) Group Fitness Instructor, Duke University Integrative Health Coach and Human Performance/Corporate Athlete Trainer, and teaches a variety of fitness programs including Stretch-Out-Stress, Bequi Blast, and Fireline Fitness Boot Camp.
<table>
<thead>
<tr>
<th>AREAS THAT MAY IMPACT PROGRAM IMPLEMENTATION</th>
<th>REPORTS/ WEBSITES</th>
<th>ARTICLES/BOOKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Centers for Disease Control and Prevention/National Institute of Occupational Safety and Health (CDC/NIOSH)—wildland firefighter information: <a href="http://www.cdc.gov/niosh/topics/">http://www.cdc.gov/niosh/topics/</a> firefighting/</td>
<td>Hofman (2015a, 2015b) (11,12) Other NFPA journal articles</td>
</tr>
<tr>
<td>Occupational health risks</td>
<td>CDC/NIOSH website</td>
<td>Gaughan et al. (2008) (10)</td>
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<tr>
<td></td>
<td>USFS/MTDC website/reports</td>
<td>Hofman (2015a, 2015b) (11,12)</td>
</tr>
<tr>
<td>Occupational tasks</td>
<td>NWCG website</td>
<td>Sharkey and Gaskill (2009) (22)</td>
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<tr>
<td>(including physiological and metabolic demands)</td>
<td>NIFC website</td>
<td></td>
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<tr>
<td></td>
<td>NFPA reports: NFPA 1051 (2012) (18)</td>
<td></td>
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<tr>
<td></td>
<td>BLM website and interagency reports</td>
<td></td>
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<tr>
<td>Standards governing professional practice for firefighters, tactical facilitators, and healthcare professionals</td>
<td>TSAC Report</td>
<td>Sharkey and Davis (2008) (24)</td>
</tr>
<tr>
<td></td>
<td>TSAC Conference presentations</td>
<td>Sharkey and Gaskill (2009) (22)</td>
</tr>
<tr>
<td></td>
<td>International Association of Firefighters/International Association of Fire Chiefs (IAFF/IAFC) Wellness Fitness Initiative (IAFF/IAFC, 2008) (13)</td>
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### TABLE 1. RESOURCES TO ASSIST WITH PROGRAM IMPLEMENTATION (CONTINUED)

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<thead>
<tr>
<th>AREAS THAT MAY IMPACT PROGRAM IMPLEMENTATION</th>
<th>REPORTS/ WEBSITES</th>
<th>ARTICLES/BOOKS</th>
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<tbody>
<tr>
<td>Sample training programs and exercise selection</td>
<td><em>TSAC Report</em></td>
<td>Sharkey and Gaskill (2009) (22)</td>
</tr>
<tr>
<td></td>
<td>TSAC Conference presentations</td>
<td>Malley (2008) (15)</td>
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<td></td>
<td>BLM website</td>
<td>Are You FireFit? (Quick Series Publishing, 2008)</td>
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<td></td>
<td>The First Twenty: <a href="http://www.thefirsttwenty.org/">http://www.thefirsttwenty.org/</a></td>
<td><em>TSAC Report</em> articles</td>
</tr>
<tr>
<td></td>
<td>FireRescue1: <a href="http://www.firerescue1.com/firefighter-training/">http://www.firerescue1.com/firefighter-training/</a></td>
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<td></td>
<td>FireFit Program: <a href="http://www.nifc.gov/fire/firefit/">http://www.nifc.gov/fire/firefit/</a></td>
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<tr>
<td>CONSIDERATIONS</td>
<td>POSSIBLE QUESTIONS</td>
<td>EXAMPLES OF SPECIFIC WILDLAND FIREFIGHTER APPLICATION</td>
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<td>------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------</td>
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<tr>
<td><strong>Personal (Goal-Setting)</strong></td>
<td>Who is the intended target population?</td>
<td>Umbrella goals:</td>
</tr>
<tr>
<td></td>
<td>What does the population want to achieve?</td>
<td>• Risk management</td>
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<tr>
<td></td>
<td>What has prompted the needs analysis?</td>
<td>• Minimize injury/illness/adverse events</td>
</tr>
<tr>
<td></td>
<td>Why set up or revise pre-existing training program?</td>
<td>• Increase cardiovascular fitness</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td>What are the potential competing factors?</td>
<td>Specific goals:</td>
</tr>
<tr>
<td></td>
<td>• Occupational responsibilities?</td>
<td>• Each firefighter completes Pack Test each season; is training needed to prepare?</td>
</tr>
<tr>
<td></td>
<td>• Nutritional habits?</td>
<td>• Recover from extended calls</td>
</tr>
<tr>
<td></td>
<td>• Fatigue?</td>
<td>• Maintain fitness capacity throughout fire season</td>
</tr>
<tr>
<td></td>
<td>Location of agency or department?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Equipment availability?</td>
<td>Assignments: unpredictable duration and level of exertion</td>
</tr>
<tr>
<td></td>
<td>Season length?</td>
<td>Difficult to design consistent training program:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Exercise (other than occupational tasks) is non-existent “in-field”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Rest is a high priority when not on assignment</td>
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<tr>
<td></td>
<td></td>
<td>• Season length often influenced by geographical region; may vary for different firefighters given duration of employment and responsibilities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wildland firefighter-specific nutritional programs have been developed (7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exercise facility (albeit usually small) is on base; often mountainous regions and summer season make exercising outside an option (need to account for heat, humidity, and altitude)</td>
</tr>
</tbody>
</table>
### TABLE 2. EXAMPLES OF PERSONAL, ENVIRONMENTAL, CULTURAL, AND ORGANIZATIONAL CONSIDERATIONS (CONTINUED)

<table>
<thead>
<tr>
<th>CONSIDERATIONS</th>
<th>POSSIBLE QUESTIONS</th>
<th>EXAMPLES OF SPECIFIC WILDLAND FIREFIGHTER APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural and Organizational</td>
<td>Is there any financial support?</td>
<td>Funding is not typically available as a line item for fitness equipment or training; may have to rely on minimal equipment and be prepared to use whatever apparatus is available</td>
</tr>
<tr>
<td></td>
<td>Is there endorsement or involvement in training program from hierarchy?</td>
<td>Support for physical conditioning and training from leadership is varied or inconsistent across agencies and departments (trying to get “buy-in” from leadership is important)</td>
</tr>
<tr>
<td></td>
<td>Are there credentialed/competent training personnel available?</td>
<td>Given the seasonal nature or seasonal shifts inherent in wildland firefighting, absenteeism is not typically an issue, however, there may be some resistance in reporting injuries or signs and symptoms of illness</td>
</tr>
<tr>
<td></td>
<td>Are there any departmental trends concerning injury consistent throughout department?</td>
<td>Knowledge of training program development, exercise selection may be varied</td>
</tr>
<tr>
<td></td>
<td>Is there ongoing clearance to exercise through the fire season?</td>
<td>Tactical facilitator needs to be open to different approaches given contraindications to exercise that may arise during season, understand how to motivate the firefighters (promote a positive atmosphere toward physical conditioning), and know when group, buddy, or individual approaches may be useful</td>
</tr>
<tr>
<td></td>
<td>Do the firefighters have any hesitation to report injuries (major or minor)?</td>
<td>Overuse injury risk is high, but acute injuries from slips, trips, and falls are also common</td>
</tr>
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This article is the fourth of a continuing series of tactical strength and conditioning (TSAC) research reviews. It is designed to bring awareness to new research findings of relevance to tactical strength and conditioning communities.

SOLDIER LOAD CARRIAGE, FATIGUE AND IMMEDIATE COGNITIVE PERFORMANCE IN DETECTING AND RESPONDING TO THREATS

Mariana Eddy and colleagues from the United States Army Natick Soldier Research, Development, and Engineering Center and Tufts University recently reported a sophisticated repeated measures study examining the impacts of load carriage and associated fatigue on immediate cognitive performance of soldiers in aurally and visually detecting and responding to threats (1). The authors provide a valuable overview of relevant literature before proceeding to report and discuss the findings of their own study, which addresses important gaps in previous knowledge. Eddy et al. noted that a range of research has previously been conducted on the effects of exercise on cognitive performance. Most of this research has examined the effects of short-duration exercise and has limited relevance to sustained tactical tasks like load carriage (1). In addition, much of the previously reported research has involved assessment of cognitive performance following exercise rather than during exercise, and the specific measures of cognitive performance that have been examined have also usually been of limited relevance to the tactical athlete. The authors conclude that, for all of these reasons and more, the results of previous research have often been contradictory and indicating both improvements and degradation in cognitive performance associated with exercise.

To address these deficiencies in the bank of previous research, Eddy et al. examined soldier performance in identifying and responding to sounds of friendly gunfire (M4) versus enemy gunfire (AK47) and in visually detecting enemy personnel, both while walking for two hours with a 40 kg-load comprised of standard issue Army items and walking for two hours with no load except a simulated rifle (6 kg-load) (1,2). Concurrently, they monitored levels of soldier oxygen consumption as an indicator of workload and fatigue to examine whether soldier performance on these cognitive tasks changed when they worked harder and became fatigued. Each of 10 soldiers who participated in the study attended the research facility on four separate days, and walked on a treadmill at 4.8 km/hr for two hours. The load and gradient conditions differed between the days, such that they walked unloaded on two days and loaded on two days. On each day, they walked for the first hour on a fixed uphill gradient of +4%, but then in the second hour they either walked on a fixed downhill gradient of -8% or a variable gradient alternating every 10 min between -8%, 0%, and +4%. Each soldier experienced all of the possible load/gradient combinations once, each on a separate day of attendance and with the order of these combinations systematically varied by the researchers to ensure randomization.

From a tactical perspective, it is important to note that the findings of this study by Eddy et al. demonstrate the impact that load carriage and fatigue can have on the task performance during an actual load carriage or unloaded patrolling activity (1). Implications of the research findings become immediately apparent when the results are considered in this light. Soldiers moved into the fatigue zone of their oxygen consumption levels (specified by the authors to be above 50% of VO₂max) when carrying a 40 kg-load on the 4% uphill gradient, and moved close to this fatigue zone when carrying a 40 kg-load on a level surface. When walking unloaded and when walking with a 40 kg-load on the 8% downhill gradient, oxygen consumption stayed below the fatigue zone. The rate of false alarms in identifying and responding to simulated enemy gunfire was higher (19%) in the loaded condition than in the unloaded walking condition (10%). The rate of false alarms in identifying and responding to simulated enemy gunfire increased to 18% in the second hour of each walking period, when compared to soon after walking commenced (10%). Reaction times in identifying and responding to simulated enemy gunfire were 50 – 70 milliseconds (9 – 13%) slower when carrying a 40 kg-load than when walking unloaded. Reaction times in visually detecting enemy personnel targets slowed by 56 milliseconds (7%) as the duration of walking increased across the two-hour testing period. Reaction times in visually detecting enemy personnel targets were also 4% slower when carrying a 40 kg-load than when walking unloaded, though this finding did not quite reach statistical significance.

Clearly, the existence and magnitude of these effects of fatigue and load carriage on reaction times and accuracy in identifying and responding to an enemy threat have serious tactical implications, potentially meaning the difference between life and death or between mission success and failure. Eddy et al. noted that fatigue will rapidly occur when tactical personnel operate in a sustained fashion at greater than 50% of their individual VO₂max. They also suggest that one other contributor to the observed impairments in cognitive performance during load carriage may be the requirement for dual-tasking during load carriage (e.g., having to focus on the cognitive motor control demands of load carriage while also attending to the enemy threat). These two considerations indicate two potential avenues for enhancing cognitive performance, and specifically improving reaction times and responses to threats, during load carriage. First, for those tactical personnel who have the capacity to further increase their VO₂max through focused physical conditioning activities, the tactical facilitator can assist them in achieving this goal, in
order to delay the onset of fatigue and thus delay the associated
degradation in cognitive performance. Second, regular load
 carriage training in realistic contexts and with loads and session
durations relevant to operational requirements is likely to assist
tactical personnel in automating load carriage as an agile and
adaptive skill set, thus reducing the cognitive demands of motor
control for this task and thereby reducing the impact of dual-
tasking on cognitive functioning. This sort of skill automation
would allow personnel to devote more of their cognitive capacity
to identifying and responding to threats in hostile environments,
and less to controlling their body motion for load carriage. Specific
guidelines for load carriage conditioning have been provided by
Orr et al., (2).

KEEPING FIREFIGHTERS FIT AND WELL: KEY ELEMENTS OF A DEMONSTRATED EFFECTIVE WELLNESS PROGRAM

One of the persistent difficulties for tactical facilitators and health practitioners trying to address and reduce occupational health risks is knowing what will really work and how to implement it during practice. Faced with this dilemma after being approached by a local fire department chief seeking assistance in improving the health and wellness of the department’s firefighters, Suzanne McDonough and colleagues from Mississippi College considered previous research and relevant guidelines and then designed, implemented, and evaluated a tailored wellness program (3). The wellness program, FIT Firefighter program, was demonstrated to be effective, and constitutes a useful example that may also work in enhancing the health and wellbeing of other fire departments.

The FIT Firefighter program was provided for an eight-week period to 29 firefighters. The design of this program was guided by recommendations of the International Association of Fire Fighters (IAFF), the American College of Sports Medicine (ACSM), the general theory of motivation developed by Ryan and Deci, as well as the broader body of research evidence (3,4). Evaluation of the program included review of changes experienced by the firefighters across the eight-week program period, in key fitness and health measures. All of the fitness and health measures that were monitored showed improvement at the end of the eight-week period when compared to initial measurements (3). Blood pressure, both systolic and diastolic, and resting heart rate each reduced by an average of 3%. Body fat percentage (measured with a three-site skinfold assessment) and waist circumference each reduced by an average of 8%. Scores improved by 6 cm on the sit-and-reach test, though this was not specified. Aerobic fitness improved by an average of 1.6%, biceps strength by 5%, and reduced bodyweight and body mass index (BMI) by 1% each.

While the evaluation design in this study is limited, the general principles are evident and the reported results are promising. Further information about the program can be found at www.mc.edu/news/kinesiology-department-mississippi-college-assists-clinton-firefighters/ and https://www.clintonms.org/about/get-acquainted/annual-reports/annual-report-2013/annual-report-clinton-fire-department/.

BACK INJURIES IN ELITE TASK FORCE POLICE OFFICERS: DO FITNESS AND QUALITY OF MOVEMENT AFFECT RISK?

A recent “holy grail” sought by many strength and conditioning professionals has been the identification of accurate predictors of injuries, and even specific injury types, in individuals engaged in particular sports or occupations. The anticipated benefit
of success in this quest is the ability to select persons for the sport or occupation who will be at low or no risk of injury, and the ability to intervene to prevent or treat the injury. A recent study that has sought to find a way to predict and prevent back injuries in elite law enforcement officers is a study by Stuart McGill and colleagues (5). In this longitudinal study, McGill et al. collected data on 39 demographic, fitness, hip range of motion, and movement competency variables for each of the 53 participating elite task force police officers. They then followed these officers for a period of five years and recorded all back injuries they suffered—14 in total.

Following a multistage analysis of the data that involved several tests of statistical significance, McGill et al. arrived at a regression equation that incorporated seven of the measured variables, which together best predicted the occurrence of back injuries in this population. These predictors included static sit-up posture endurance time, Biering-Sorensen extension endurance time, the ratio of the static sit-up posture time to the Biering-Sorensen extension time, right side-plank endurance time, hip extension range of motion with knee flexed, hip extension range of motion with knee extended, and pelvis rock movement competency score.

Differences among the elite police officers in scores from this regression equation (each score reflecting individual injury risk) explained an estimated 58% of the variation in injury risk across the individuals comprising this elite police officer population. Using scores from the regression equation, McGill et al. reported that they were able to predict 64% of those officers who were eventually injured and 95% of those who were not injured, meaning that overall the scores could be used to accurately predict 87% of the injury or non-injury outcomes across the 53 participating officers (5). They note that this level of predictive accuracy is one of the highest reported in the research literature for predicting back injury risk over a five-year period. The authors also emphasized that the results of their study demonstrate that causes of back injuries in this population are complex and multifaceted, and that the regression equation they have derived and the associated predictors within it still leave around 40% of the individual variation in back injury risk unexplained.

However, caution is advised when looking at the results of this study; especially given the large number of statistical analyses used to arrive at the final predictive regression equation and the relatively small numbers of officers and injuries that were observed. It is necessary for the performance of this predictive equation and the individual predictor measures within it to be retested and validated in a separate sample before final conclusions are drawn regarding their value for predicting back injuries in police populations (6). Frequently, when re-examined in a different sample of people drawn from the same or a similar population, predictive equations like this and their constituent predictor variables do not perform consistently well in predicting future outcomes (6). In addition, just because a particular demographic or functional measure is a predictor of injury, does not necessarily mean that it can be remediated by some sort of intervention (e.g., age or height of a person cannot be changed by intervention), or that remediation, where feasible, will result in a significant change in level of injury risk (e.g., a measure of aerobic fitness might usefully predict risk of stress fractures, but improving aerobic fitness alone may not reduce the risk of stress fractures if the initial level of aerobic fitness is really just a predictor of stress fracture risk because it is well correlated with more crucial underlying factors like bone mineral density and strength of the bone structures, both developed through a strong adolescent exercise history).

Finally, it is important to recognize that the measures assessed by McGill et al. and used to predict back injury in elite police officers are all intrinsic risk factors for injury. A major limitation in the quest to find predictors of injury risk and injury mitigation is a frequent underlying assumption that there exists an ideal body that can safely withstand the forces that will be exerted upon it by the respective occupation. This assumption often fails to acknowledge that extrinsic risk factors and causes of injury also play a role in injury causation. Sometimes, no matter how strong, flexible, fit, fast, and cognitively adept the individual might be, the human body simply cannot withstand the injuring agents to which it is exposed, which are exerted upon it during the tasks, or by the environments in which these tasks are undertaken. For example, extreme heat can cause soft-tissue damage, brain damage, and even death if protective devices or apparel are inadequately used. Regardless of how strong the police officer may be, jumping down from a height in pursuit of a suspect may generate forces on bones and soft tissues that these structures cannot withstand, leading to sprains, fractures, or worse. Carriage of heavy loads in tactical contexts can cause acute or cumulative damage to bones, joints, and soft tissues of the spine despite high levels of strength and fitness if the limits of the capacities of these structures to withstand the loads imposed upon them are exceeded. Therefore, prediction and prevention of injuries in tactical populations require consideration of not only intrinsic but also extrinsic risk factors, with the latter often being more extreme, unpredictable, and difficult to avoid in tactical contexts than in other occupations and in sports.

In conclusion, the research of McGill et al. and other similar research can provide useful indications of intrinsic risk factors for injury which may be able to be addressed through well-designed tactical conditioning programs. However, it will always be wise to ensure that the same intrinsic risk factors have been shown time and again, in different studies, to play a role in injury causation, before too much emphasis is put on addressing them through physical conditioning. In addition, it is critical that the “victim” of an injury knows that they should not be “blamed” for injuries that occur. Rather they should know that injuries are never solely caused by functional deficiencies or other characteristics of the
individual; they are typically caused by a complex interaction between intrinsic and extrinsic risk factors and causes. While it is important to make the tactical athlete as resistant to injury as possible via adequate conditioning, protective equipment, and similar individual interventions, it is also important to consider the extrinsic causes of injury and to address those as much as possible in the tactical context. The “holy grail” of total injury prediction and prevention based on intrinsic risk factors alone will never be achieved in tactical populations. However, knowledge of both intrinsic and extrinsic factors that contribute to injury will assist the tactical facilitator in protecting tactical athletes from harm as much as possible, while simultaneously enabling them to perform to required levels.

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Rod Pope is currently an Associate Professor of Physiotherapy and co-leads the Tactical Research Unit at Bond University in Australia. Pope provided clinical physiotherapy, rehabilitation, and injury prevention services at the Australian Army Recruit Training Centre before establishing and leading the Australian Defense Injury Prevention Program, at the request of the Defense Health Service Branch. In this role, he worked closely with senior military physical training instructors to optimize physical training practices. As part of this work and more recently in his university roles, Pope has conducted and supervised wide-ranging research and consultancy projects on preventing injuries and enhancing performance during physical activity in tactical training and operational contexts. Very much a practitioner researcher, Pope’s research invariably stems from questions about practice in the field and aims to usefully inform this practice.
This the final part of a four-part series on proper movement as it pertains to Marines. The previous article discussed the current topics commonly found in the United States Marine Corps including assessment protocols for Marines.

United States Marine Corps officers receive 40 hr of marksmanship instruction before firing a rifle in boot camp and again before each annual requalification (2). However, despite movement under load being fundamental to everything that Marines do, they never receive any formal movement instruction. Studies conducted on soccer players, firefighters, and United States Army recruits all demonstrated that by educating participants on how to move functionally and create stable positions, injury rates can be decreased by up to 75% (8,13,19). In addition, a study of Army soldiers conducting a functional training program also found that teaching the participants how to properly stabilize under load and on the importance of mobility in both performance and injury prevention was critical to adopting functional movement patterns (9). During that study, active duty Army soldiers were taught the foundational movement step that the Marine Corps misses, and as a result mobility and stability increased, performance metrics across the board increased, and participants frequently stated that they “felt less pain in their lower back when wearing protective gear,” (9).

The Marine Corps has Primary Marksmanship Instructors, Rifle Range Coaches, Marine Corps Martial Arts Program (MCMAP) Instructors, and Marine Corps Water Survival Instructors, yet they do not have fitness or movement instructors. Marine Corps Order 6100.13 identifies the need for commanders to assign a Combat Conditioning Instructor and/or a Command Physical Training Representative (4). While this individual is “responsible to the commander/officer-in-charge for development, implementation, management, and supervision of the organizational combat conditioning program (CCP),” their primary duties focus on ensuring that the semiannual Physical Fitness Tests (PFT) and Combat Fitness Tests (CFT) are conducted in accordance with the order (4). Both the Marine Corps Order 6100.13 and Marine Corps Reference Publication (MCRP) 3-02A repeatedly refer to the importance of fitness for combat; however, no formal combat conditioning instructor training is outlined and neither publication discusses the importance of executing fitness programs with quality movement (4). In the absence of formally trained physical fitness experts within a unit, some Marines may be forced to rely on personal experience and what was passed down to them from leaders during Physical Training (PT). For example, movement under load is inherent to most job tasks of a rifleman, yet the Marine Corps does not teach this foundational step.

The official Marine Corps Fitness Readiness Guide website also does an excellent job of explaining the role of core strength and mobility and provides demonstration videos for almost all 500 exercises that the HITT program incorporates. However, both resources fail to explain how to properly hinge at the hip, which is an essential movement component, especially when lifting weight off the ground (12). The video shows a Marine execute a deadlift with perfect form; however, it never discusses the need to properly hinge at the hip (loading the hamstrings) which is a critical component to performing a deadlift correctly (16). This is one example of the Marine Corps not teaching the foundational step of proper movement mechanics. Deadlifting is a critical skill for Marines that can transfer to multiple combat related tasks such as picking up ammunition cans, picking up water jugs, or picking up a wounded comrade. A Marine cannot be expected to execute any of these tactical tasks with proper technique while also wearing 60 lb of personal protective gear if they cannot first do it correctly in training. Therefore, educating Marines on the foundational movement steps for this exercise is critical. It is essential to educate Marines on the very basics of movement prior to teaching them more advanced exercises. Failure to do so may result in unnecessary injuries and decreased operational readiness.

Potentially, a formally trained Combat Conditioning Instructor would function similar to a MCMAP instructor to help fulfill this step. They would advise the commander on combat conditioning, build an appropriate training plan, and ensure that movement assessment is properly conducted. The MCMAP and Army Master Fitness Trainer program can serve as models for a Combat Conditioning Instructor Trainer program. For the MCMAP, participants undergo intensive 4 – 7 weeks of schooling. Upon completion, the Marine then returns to their unit where they are now responsible for allocating resources and overseeing the MCMAP within their unit (3). Commanders rely on their MCMAP instructors to conduct training and ensure Marines are qualified to the appropriate level. If teaching movement were given the same attention and resources as teaching MCMAP, musculoskeletal injuries in the Marine Corps could possibly decrease, leading to reduced training time loss and increased operational readiness.

The Army Master Fitness Trainer program works similar to the MCMAP instructor program. Participants undergo an intensive four-week course where they learn about proper movement, kinesiology, basic exercise science, and nutrition (17). They are then assigned a supplemental military occupational specialty (MOS) and return to their units. The current Army guidance is to assign one Army Master Fitness Trainer per company and that soldier is an advisor to the commander on fitness and combat.
conditioning related issues. The Army Master Fitness Trainer is directly responsible for designing a PT program that is tailored to that specific unit’s mission and the associated required tactical tasks (10). Due to competing priorities, the Army canceled the Master Fitness Trainer program in 2001. However, it was brought back in 2012 in order to improve performance, decrease injuries, and make the Army an overall healthier organization (10). Educating Combat Conditioning Instructors in a similar manner and assigning one per company could significantly enhance the physical readiness and operational effectiveness of any Marine Corps unit.

The facilities and resources to formally train Combat Conditioning Instructors in a manner similar to the MCMAP program or the Army Master Fitness Trainer program already exist through the High Intensity Tactical Training (HITT) program. Formally introduced in 2012, “the HITT program is a comprehensive combat-specific strength and conditioning program that is essential to a Marine’s physical development, combat readiness, and resiliency,” (11). Regarding the HITT’s program methodology:

“As the worldwide authority on strength and conditioning, the National Strength and Conditioning Association’s (NSCA) Tactical Strength and Conditioning (TSAC) Department supports that the HITT program methodology offers a comprehensive and balanced strength and conditioning approach specific for combat readiness and physical resiliency. The HITT program is aligned with the NSCA’s national standards and guidelines and provides research-based knowledge/curriculum along with practical application to improve athletic performance specific to today’s warrior athlete,” (11).

The HITT methodology has already proved effective at the Infantry Training Battalion, School of Infantry East, where over the course of six different classes CFT scores consistently increased from the beginning of the course to the end of the course using the HITT program as the primary combat conditioning tool (15). To this end, there could be a HITT facility on every major Marine Corps installation with each teaching a one-week Level I HITT Instructor Course, which would potentially certify Marines in Functional Movement Screen (FMS), TSAC-F, and United States of America Weightlifting (USAW).

The infrastructure and plan to make Combat Conditioning Instructors formally trained experts already exists. The only remaining step is formalizing the process and mandating that units train and employ them using a methodology aligned with or similar to HITT training. Directing commanders to use the HIT methodology is not mandating that daily PT will be the same throughout the Marine Corps. Daily PT sessions will be developed by each unit’s Combat Conditioning Instructor as part of a long-term periodized training plan for that particular unit designed to have Marines’ conditioning levels peak when they deploy. Fully embracing the HITT program may help to integrate FMS screening throughout the Marine Corps because all Combat Conditioning Instructors that have completed the requisite training would be qualified to conduct FMS screening.

Educating commanders on movement and defining the Combat Conditioning Instructor’s role are essential in order to achieve full leadership buy-in. Commanders must understand the current musculoskeletal problems faced by many Marines, and must understand why they are being given a requirement to have Marines trained by Combat Conditioning Instructors. If commanders are simply told to have a set number of Combat Conditioning Instructors, but their benefit and the value they add are not explained, it is unlikely that the commanders will be advocates for the program and give it the diligence that it deserves. While some commanders may be reluctant to have one more training requirement, they might be more likely to embrace a requirement that enhances combat readiness since poorly planned and improperly executed workouts from uneducated Marines may be a likely contributor to musculoskeletal injuries in the Marine Corps.

Executing both physical training exercises and tactical combat tasks with good movement needs to be continually emphasized. The Marine Corps Recruit Depot, Parris Island has attempted to increase education regarding movement through their male and female Recruit Physical Training Playbook. These books serve as a guide to the entire recruit training staff and provide detailed guidance on the execution of PT while emphasizing the need for mobility and stability (5).

In conjunction with establishing an evidence-based movement assessment and developing formally trained Combat Conditioning Instructors, the Marine Corps needs to begin a paradigm shift towards balancing intensity with quality movement. From the moment a recruit begins their Marine career, the need to move with intensity is continually emphasized. This repeated emphasis on intensity may lead recruits to push themselves harder than they have ever before. Unfortunately, without an emphasis on quality movement patterns, the movements may be dysfunctional. Despite compromising stability, the human body is able to compensate and find ways to move under duress when necessary (6). It is important to teach new recruits proper movements right off the bat because in many cases the movement patterns established in boot camp will remain with Marines throughout their career (7). If the movement patterns that they learned are dysfunctional, eventually this dysfunctional movement may catch up to the Marine and lead to a musculoskeletal injury later on (16). For example, if a recruit does thousands of push-ups with their scapulae protracted and hips sagging during recruit training, they are likely to continue to do push-ups in this incorrect manner until new movement patterns are ingrained in their neuromuscular system.
With the comprehensive program described here, recruits would begin their recruit training having already achieved a proficient score in the FMS. The recruit training environment could then be used to instill functional movement patterns into recruits. For example, if a recruit is ordered to pick up an object and the recruit does not properly stabilize their torso, that action could warrant some form of correction from their instructor. By firmly and fairly correcting a recruit for dysfunctional movement, the drill instructor can assist in instilling functional movement patterns while also instilling discipline and an instantaneous obedience to orders. In order to effectively do this, the drill instructor must be educated on proper movement and be able to identify dysfunctional movement, which all ties back in to the need to improve movement education throughout the entire Marine Corps. The Marine Corps should develop a balance with physical training intensity and functional movement patterns in order to effectively teach Marines how to properly move, ultimately helping to prevent unnecessary musculoskeletal injuries and increase combat effectiveness.

**IMPLEMENTATION OBSTACLES**

There are three primary anticipated counterarguments or obstacles to implementing the plan described in this article. First, that the current injury rate is simply the cost of doing business and is a way of life in the Marine Corps. Combat is inherently dangerous and there will always be casualties associated with it. However, the Marine Corps’ current musculoskeletal injury rate, combined with the knowledge that these injuries can be relatively predictable, indicates that it is possible that more can be done to prevent injuries in training. If Marines are consistently suffering avoidable musculoskeletal injuries, then something is not working correctly. Assessing and correcting movement patterns prior to moving to performance exercises, educating Marines about movement’s role in accomplishing combat related tasks, and modifying current PFT and CFT standards to require more mobility and stability may help in reducing the common sprains and strains suffered by Marines and make them more effective warfighters.

The second major counterargument is that during these fiscally austere times it will cost too much to implement the proposed changes. Regarding the PFT and CFT movement standard modifications, this will be cost neutral as no new equipment, people, or resources are required. With respect to enhancing the Marine Combat Conditioning Instructor education, by using the HITT program for example, all required facilities and instructors are already in place. In addition, with every installation having a HITT facility, units will not have to use funds to send Marines to a new location for the training. The major obstacle with the education and HITT program is that Marine Corps Community Services (MCCS) currently oversees the HITT, not Training and Education Command (TECOM). This means that a comprehensive combat conditioning program is overseen by an organization that offers a wide variety of recreation and fitness programs to provide Marines and their families with resources to lead active healthy lives; the Semper Fit division of MCCS is immediately responsible for the HITT program and they claim that active duty Marines are their priority. However, they are also responsible for providing health promotion and fitness programs for dependents and retirees. Each local HITT facility is controlled by the local MCCS fitness center and the local HITT director reports to the fitness director or fitness coordinator, not the combat fitness program manager who oversees the entire HITT program. Therefore, if the local fitness director or fitness coordinator prioritizes commercial group exercise classes over the HITT program, the HITT program will likely not receive the attention it requires. In order to effectively implement the HITT program, TECOM needs direct authority over it. Making the HITT program directive in nature through the TECOM Physical Fitness Division will ensure quality control and that commanders are implementing it effectively. Implementing FMS as an evidence-based movement assessment is a measure that will cost money. Training screeners is currently incorporated in the proposed HITT curriculum. Purchasing screening kits is the only other cost associated with the FMS. However, through using the screening methods for large groups laid out in the Tactical FMS program, a battalion would only need to purchase 10 kits for a total of approximately $1,000. This is a one-time expense that could directly contribute to reducing the approximately 27 million dollars currently spent on musculoskeletal injuries (12,18).

The largest and final obstacle will be getting the leadership of the Marine Corps to accept the change, and enforce it down the line. Some may argue that the Marine Corps has survived 238 years without doing this and follow the “why fix something that is not broken” philosophy. Sending Combat Conditioning Instructors through the multilevel HITT education program represents one more requirement for commanders to balance. Learning to move correctly during PT with a well-designed combat conditioning program will facilitate Marines finding the most advantageous position possible when they are wearing 60 lb of equipment and running through a dynamic combat environment.

Implementing change and adjusting the way people think, especially in regards to human movement, is not easy and will require steadfast leadership to implement properly. The Navy Sports Medicine and Reconditioning Team Centers, developed in 2002, have decreased time lost to musculoskeletal injuries throughout the Marine Corps (1). Through increased use of professional athletic trainers and building state of the art physical therapy rehabilitation centers, the Marine Corps has made tremendous strides over the past 12 years in identifying and effectively treating musculoskeletal injuries. However, the fact is that the avoidable injuries are still occurring and these programs deal with quickly diagnosing and rehabilitating injured Marines. Physical fitness is something about which the Marine Corps takes great pride. The foundational step to performing well at any type of combat conditioning related task is quality movement and
in the Marine Corps’ pursuit of excellence through intensity and mental fortitude, this critical step is frequently overlooked.

CONCLUSION

The comprehensive solutions proposed in this article are synergistic. Implementing FMS as an evidence-based movement assessment will not be effective if the force is not educated on movement’s role in accomplishing combat tasks. Likewise, if there is no method to identify and subsequently hold Marines accountable for improved movement, the education provided will go to waste. Training and implementing Combat Conditioning Instructors will facilitate implementing FMS and the proposed PFT and CFT movement standard modifications. Implementing FMS; modifying the pull-up, crunch, and ammunition lift; and improving movement education throughout the Marine Corps are deeply intertwined with each other and may be effective strategies to reduce the problem.

Knowing that injuries may be predictable based on individual’s movement patterns, it is advised that the Marine Corps not allow Marines to participate in any type of fitness or combat conditioning program without first screening their movement quality and then educating them on how to move correctly. Movement is fundamental to everything Marines do in combat. However, assessing and teaching that foundational step is continuously skipped. An evidence-based movement assessment that prevents Marines with limited range of motion and poor stability from taking the PFT or CFT, improved Combat Conditioning Instructor training through the HIT program and modifying the movement standards to the current pull-up, crunch, and ammunition lift may help bring the necessary focus to the foundational movement step and subsequently reduce musculoskeletal injuries. By focusing on the foundational step of movement, the Marine Corps should find itself with more physically capable warfighters and more operationally ready than ever before.

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Matt Zummo is currently the Executive Officer for 2d Tank Battalion, 2d Marine Division. He has over 15 years of experience as an active duty Marine Corps officer with multiple combat deployments. Having served as a platoon commander, company commander, battalion operations officer, and at the Marine Corps Recruit Depot San Diego and Officer Candidate School, he has trained thousands of Marines in various environments to include during austere combat deployments. He has a Bachelor of Science degree in Business Administration from the University of Colorado, a Master’s degree in Military Studies from the Marine Corps University, and is a Level 1 Functional Movement Systems (FMS), Level 1 United States of America Weightlifting (USAW) Sport Performance Coach, and CrossFit Level 1 coach.
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OBSTACLE COURSE TRAINING TO ENHANCE ARMY PHYSICAL READINESS

The United States Army has been engaged in large-scale combat operations for over a decade. The years of combat deployments and increased operational tempo highlights the importance of fit and resilient soldiers. For soldiers to be ready to meet the physical demands of combat, it is vital for the U.S. Army to physically train and maintain fitness levels in soldiers properly. The fitness program of the Army has evolved as understanding of the physical challenges of contemporary warfare has increased. Specifically, the Army philosophy changed from conducting physical training to prepare for the three-event Army Physical Fitness Test (APFT) to engaging in a physical readiness training (PRT) program to better prepare soldiers to execute their unit missions. As the focus of PRT changed, so too did the guidance on how PRT was to be conducted. The current Army Regulation 350-1 stresses that improved strength, endurance, and mobility as a result of PRT is paramount to enhance combat readiness and leadership effectiveness (1). Similarly, the Field Manual: Army Physical Readiness Training reinforces that the “fitness trinity” consists of strength, endurance, and mobility (3). Past U.S. Army fitness training guidance focused primarily on strength and endurance; however, the current publications now give mobility equal importance to endurance and strength during PRT. Following this direction, leaders must consider methods to train all three of these fitness components effectively. As such, unit fitness trainers should consider the advantages of obstacle course training as a method for PRT. Obstacle course training may enhance Army PRT by providing an avenue to train mobility while also serving as a creative option to train endurance and muscular strength.

The primary benefit of obstacle course training is the ability to specifically target and train mobility. Mobility is described as the sum of several qualitative factors (agility, balance, coordination, flexibility, posture, stability, speed, and power) that provide the movement proficiency linked to Army warrior training performance and mission requirements (1). Simply stated, mobility enables the “functional application of strength and endurance,” (3). Yet, it is often an overlooked aspect of a unit fitness plan. Understanding the linkage between mobility and its support to functional movements (i.e., the movements required to execute soldier skills in combat) further highlights the need to train this fitness component. Through mobility training, soldiers can improve their proficiency to execute military physical skills such as running, jumping, climbing, and carrying (3). Obstacle courses can be designed with the specificity to enhance physical movement patterns required for mission tasks, yet still service the subcomponents of mobility to execute the unknown movement demands of combat. This reinforces that mobility training should be central to PRT, and that obstacle course training can be an effective means to train and develop mobility.

The second potential advantage of obstacle course training, as it relates to the Army PRT fitness components, is that strength and endurance may be developed through a well-constructed and properly designed obstacle course. For instance, an obstacle course developed with a series of circuit stations (e.g., rope climbs, pull-ups, drags, etc.) and muscular strength tasks (e.g., tire flips, buddy carries, etc.) may adequately develop muscular fitness and strength while simultaneously training mobility. Likewise, a longer obstacle course requiring significant aerobic work (e.g., Tough Mudder, Warrior Dash, etc.), or repetitively running the same course for a set amount of time (e.g., endurance obstacle course circuit, obstacle course intervals, etc.), stresses endurance while concurrently executing a number of mobility qualitative factors while fatigued. This idea of combining multiple fitness components is already being executed by the United States Marines Corps, when they created an obstacle course type assessment known as the Combat Fitness Test (CFT). The CFT is an annual test that compliments their three-event physical fitness test (PFT), and is designed “to evaluate strength, stamina, agility, coordination, as well as overall anaerobic capacity,” (4). The Marine Corps clearly acknowledges the link between mobility, strength, and endurance.

Implementing obstacle course training into PRT sessions can be easy and a great way to provide variety to a unit fitness plan. Appendix E of the Field Manual: Army Physical Readiness Training provides the basic information on the movements and skills that soldiers should perform during PRT. The appendix states that “soldiers must be able to crawl, creep, climb, walk, run, and jump in order to accomplish certain missions,” (3). It also describes a number of possible obstacles and the basic steps to negotiate the named obstacle. An analysis of the unit’s mission movement requirements enables the PRT leader to quickly determine what obstacles would develop the mobility necessary to enhance physical readiness. Basic obstacle courses can then be created to develop mobility as well as strength, endurance, or both.

Figure 1 demonstrates a basic obstacle course developed at Kirtland Air Force Base, NM. Very little resources were required as the organization took advantage of park amenities such as pull-up bars, park benches, and some logs within a children’s playground. Everyone who participated in the training was first trained on each individual obstacle prior to performing the course in its entirety. Obstacle skills included pull-ups, climbing over a tall bar (7 ft), low crawl, balance logs, jumping over and through obstacles, a combat roll, and running (both forward and backward). Individually, these
obstacles were relatively simple, but when linked together the course became incredibly challenging. This simple design clearly demonstrates the effectiveness and advantages of periodically including obstacle courses into Army PRT.

At the United States Military Academy at West Point, obstacle course performance is considered the most relevant fitness task for assessing a cadet’s physical readiness. In fact, cadets at West Point are required to run the Indoor Obstacle Course Test (IOCT) annually. This test is a grueling 11-event obstacle course (Figure 2) consisting of “a timed sequence of obstacles which include the low crawl, tire run, two-handed vault, shelf mount, balance walk across horizontal bars, hanging tire, balance beam walk, vertical wall, horizontal ladder, rope climb, and running 2 ¾ laps on the track,” (2). The IOCT is designed to test “a cadet’s coordination, balance, agility, muscular strength and endurance, cardiovascular capability, and ability to perform a series of basic movement skills under pressure,” (2). The IOCT is deemed so significant that successful completion of this test is a mandatory graduation requirement. Achievement on the IOCT ensures the Army has fit leaders capable of performing the physical tasks expect of the soldiers they will be leading, while failure to demonstrate the fitness to pass the IOCT prevents a cadet from commissioning as an officer in the Army. West Point’s commitment to the IOCT, and obstacle course training in general, provides a roadmap for the rest of the Army to follow to achieve mobility, strength, and endurance.

With the increased popularity of obstacle-style races and televised events (e.g., American Ninja Warrior, BattleFrog Obstacle Race Series, etc.), it is the perfect time to introduce soldiers to obstacle course training. Obstacle course training can offer variety to any physical readiness training program. Also, properly conducted obstacle course training may be a useful method to train strength, endurance, and mobility simultaneously.

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ABOUT THE AUTHOR
Russ Nowels is an active duty United States Army Major serving as the Deputy Director for the Department of Physical Education at the United States Military Academy in West Point, NY. At West Point, he teaches military movement (gymnastics), combatives, and unit fitness development, as well as supervising the Competitive Club Athletics Program consisting of numerous collegiate club sports teams. Nowels holds a Master of Science degree from Indiana University in Kinesiology. He is a Tactical Strength and Conditioning Facilitator® (TSAC-F®) as well as a certified Army Master Fitness Trainer, Modern Army Combatives Level II Instructor, United States of America Track and Field (USATF) Level I Coach, CrossFit Level I Coach, and a National Association of Intercollegiate Athletics (NAIA) Champions of Character Coach.
FIGURE 1. SHORT OBSTACLE COURSE

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>TASK</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Five pull-ups and climb over bar</td>
<td>Five dead hang pull-ups, then climb over the bar and drop on opposite side</td>
</tr>
<tr>
<td>2</td>
<td>Low crawl</td>
<td>Low crawl between start cone and finish cone</td>
</tr>
<tr>
<td>3</td>
<td>Sidewalk jump</td>
<td>With a running approach, jump over the running trail without touching the asphalt</td>
</tr>
<tr>
<td>4</td>
<td>Vault park bench</td>
<td>Vault or hurdle the park bench while maintaining balance (falling down the back of the obstacle results in a restart of the obstacle)</td>
</tr>
<tr>
<td>5</td>
<td>Balance logs</td>
<td>Walk across the balance logs and jump from one log to the next without falling off (any step not on the log results in a restart of the obstacle)</td>
</tr>
<tr>
<td>6</td>
<td>Tire broad jumps</td>
<td>Two-foot hop/jump through the large tires (falling in tire or single-step results in a restart of the obstacle)</td>
</tr>
<tr>
<td>7</td>
<td>Forward roll</td>
<td>Complete a forward or combat roll</td>
</tr>
<tr>
<td>8</td>
<td>Cone run</td>
<td>Run in a zig-zag pattern through the cones</td>
</tr>
<tr>
<td>9</td>
<td>Backwards run</td>
<td>Run backwards to the finish line</td>
</tr>
</tbody>
</table>
OBSTACLE COURSE TRAINING TO ENHANCE ARMY PHYSICAL READINESS

FIGURE 2. INDOOR OBSTACLE COURSE TEST
FIGURE 3. TIRE JUMP

FIGURE 4. Z RUN

FIGURE 5. PULL-UP BAR CLIMB

FIGURE 6. BALANCE BEAM RUN
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Proper hydration is one of the most fundamental tenets of performance nutrition. For tactical athletes training in extreme environments, proper hydration can be the difference between life and death. Understanding fluid needs and what increases or decreases these needs can help tactical athletes avoid potentially dangerous extremes in terms of hydration.

**FLUID NEEDS**
The first step in any type of hydration assessment is to determine baseline hydration needs, or how much fluid an athlete needs without training. The Institute of Medicine estimates that average adult women need 2.7 L and men need 3.7 L a day, which includes fluid from food (5). The difference in fluid needs for men and women is based largely on average body size and caloric needs. With equal size and physical fitness level, fluid needs do not differ much between men and women. Women sweat less but have similar heat tolerance to men when exercising at equivalent relative aerobic intensities (6). Most men and women can adapt to the heat equally.

Interestingly, age is not a factor with regard to fluid needs or heat adaptation as long as physical fitness levels are maintained (6). There is no specific age when a person’s ability to thermoregulate decreases and they require more fluid; however, after age 65 there may be a decline in renal function, which would reduce the body’s ability to retain water and sodium.

Given these average requirement guidelines, fluid needs for tactical athletes can be much higher depending on body size, strenuous physical activity, and environmental factors. In addition, uniforms worn by tactical athletes may increase sweat rate. For example, heavy protective uniforms can induce a sweat rate of 1 – 2 L per hour (6). Apart from using average requirements, another way to determine fluid needs is to use ½ – 1 oz per lb of bodyweight, which accounts for additional fluid for training and exercise. This formula may better prepare a tactical athlete to meet their fluid requirements. For example, a 180-lb tactical athlete needs 90 – 180 oz (11 – 23 cups or 3 – 6 L) of fluid daily.

**ENVIRONMENT**
Understanding how an environment affects fluid losses can help the tactical athlete prepare for activities in that environment. There are two types of heat: wet and dry. Wet heat, or humidity, is generally at locations closer to sea level, while dry heat is normally at higher elevations. Given equal temperatures, the body is apt to sweat more in dry climates and have a more difficult time cooling down in humid climates. The human body can lose up to 1 – 2 L per hr in hot climates, regardless of whether it is a wet or dry climate (6). However, be aware that during physical exertion, the primary mechanism of heat loss is through evaporation (8). In humid environments, the increased water vapor content in the air alters the concentration gradient and reduces the air’s ability to accept more water vapor molecules through evaporation, so the body becomes less efficient at cooling itself and core temperature can rise dramatically (8).

Elevation affects fluid needs significantly. Regardless of temperature, individuals at elevations over 5,000 ft will require an additional 1 – 2 L of fluid a day, largely due to physical changes in respiration and urination due to acclimatization (7). Additionally, the more acclimatized a person is, the less electrolytes they will lose in their sweat (7). Increasing fluid intake may help prevent acute mountain sickness and dehydration.

Cold temperatures are often overlooked, but tactical athletes can lose up to 3 – 4 L per day from breathing in extremely cold environments (7). The body is able to thermoregulate using respiration in cold temperatures. Therefore, inadequate hydration in cold temperatures can put tactical athletes at a higher risk for hypothermia.

**REPLENISHING ELECTROLYTES**
After determining estimated fluid requirements, tactical athletes must decide what to drink. The selection process for a sport drink can be quite overwhelming, and the added ingredients in many sport drinks can be confusing. A sport drink label should not look like a multivitamin label. Some tactical athletes take multivitamins already and it is possible to get too much of certain vitamins and minerals, which can have negative effects. Sport drinks should not contain caffeine unless the tactical athlete is intentionally using it as a stimulant.

Supplementing sport drinks with 3 – 4 daily meals and snacks can be an effective way to replace the main electrolytes lost in sweat (sodium and potassium) and should provide a small amount of carbohydrates to aid in absorption. For example, if a tactical athlete training in harsh environments requires 5,000 mg of sodium, it can be estimated that approximately 3,000 mg of sodium can be consumed through 3 – 4 meals and snacks throughout the day. This means that approximately 2,000 mg of sodium can be taken in 1 – 2 L of a sport drink. A tactical athlete training in a temperate environment or performing an easy training day may only require 2,000 – 3,000 mg of sodium, which might be adequately consumed in their normal diet, or with the addition of a small amount of sport drink. While sweating usually also results in a loss of magnesium, iron, zinc, manganese, and calcium, most diets suffice to compensate for these losses (6).
HYDRATION AND ELECTROLYTE CONSIDERATIONS FOR TACTICAL ATHLETES

SWEAT RATES
The goal is simple—replace the fluids and electrolytes that were lost. The amount is not the same for everyone but it is not difficult to estimate. Change in bodyweight is an easy way to determine the amount of fluid lost: one pound equals two cups of fluid. One way to determine sweat rates is to weigh the tactical athlete before and after short bouts of training and gradually apply this to longer durations. Different types of activities will produce different sweat rates. For instance, an hour of road marching may produce 1 – 1.5 L of sweat compared to an hour of running, which may produce 0.5 – 1.8 L (6,10). Intensity, clothing, and load carried are all factors that can make a difference when it comes to sweat rates. A general recommendation for tactical athletes is to aim to stay within 2 – 3% of normal bodyweight to remain adequately hydrated and not see a drop in performance (4,9). For a 180-lb tactical athlete, this is about 4 – 5 lb. Dark urine, strong smelling urine, or not urinating at all may be indicators of inadequate hydration. If a tactical athlete is drinking what seems to be sufficient or perhaps excess amounts of water, yet feels bloated, cramped, or has not urinated in a few hours, this may indicate hyponatremia and medical attention may be necessary (4). Hyponatremia, or electrolyte “wash out,” can occur with excessive water consumption, especially when dietary intake is limited (1,3,8). Sodium and chloride are the primary electrolytes lost in sweat; therefore, as the body sweats, sodium and chloride are lost (3). If water is continually replaced in the absence of sodium (e.g., food deprivation exercise or simply limited food intake), the body’s sodium concentrations will be diluted and can lead to an electrolyte imbalance and possible illness (1,8).

CONCLUSION
It is important for tactical athletes to be aware of their fluid intake and hydration status when training for or performing job duties. Tactical athletes can do this by monitoring their urine color, odor, and frequency; understanding environmental factors; and estimating and tracking their sweat rates. In general, it is recommended to replace about 75% of the fluid lost from exercise immediately and replenish the rest afterward (up to 125 – 150%). Forcing hydration is not always the best strategy; rather, listening to the body and drinking before the feeling of thirst may be the best guideline for tactical athletes to stay in a healthy range when it comes to hydration.

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ABOUT THE AUTHOR

Trisha Stavinoha’s United States Army and dietetic career began in 1998 after earning her Bachelor of Science degree in Nutrition from Texas State University and being accepted into the United States Army’s dietetic internship program. Stavinoha earned her Master of Science degree in Sport Nutrition from Long Island University while concurrently competing on their track and field and cross-country teams. She has been a credentialed sport dietitian and strength and conditioning coach since 2008. Her credibility in sport nutrition comes from being a soldier, scholar, and athlete. Stavinoha’s experience with athletes includes a wide range of Olympic hopefuls in the Army’s esteemed World Class Athlete Program, high school and collegiate cross country runners, triathlon and endurance athletes, tactical soldiers, Wounded Warriors, and overweight service members trying to pass body fat and physical fitness standards.

<table>
<thead>
<tr>
<th>ELECTROLYTE</th>
<th>CONCENTRATION IN SWEAT</th>
<th>AMOUNT IN MOST SPORT DRINKS</th>
<th>ADEQUATE INTAKE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>460 – 1,840 mg/L</td>
<td>400 – 1,000 mg/L</td>
<td>1,300 mg/day</td>
</tr>
<tr>
<td>Chloride</td>
<td>710 – 2,840 mg/L</td>
<td>300 – 1,000 mg/L</td>
<td>1,300 mg/day</td>
</tr>
<tr>
<td>Potassium</td>
<td>160 – 390 mg/L</td>
<td>100 – 800 mg/L</td>
<td>4,700 mg/day</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0 – 36 mg/L</td>
<td>0 – 160 mg/L</td>
<td>240 – 420 mg/day</td>
</tr>
<tr>
<td>Calcium</td>
<td>0 – 3 mg/L</td>
<td>0 – 25 mg/L</td>
<td>1,000 – 1,300 mg/day</td>
</tr>
</tbody>
</table>
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The American College of Sports Medicine (ACSM) 62nd Annual Meeting was held in San Diego, CA, May 27 – 30, 2015. The number of tactical sessions was greater than the two previous years, when the Federal Government sequester severely affected attendance. Holding the conference in San Diego, a city with a strong military presence, may have been another factor in improving the number of tactical attendees and sessions. Another sign of an increased military component of the meeting was that the Military Sports Medicine Special Interest Group (SIG) met for the first time in three years.

Several sessions examined various aspects of tactical performance. One paper created a Soldier Physical Performance Index (SPPI) which consisted of a sum of six components that was hypothesized to be a less confusing alternative to the traditional military fitness tests currently in place (2). The six components included five-second cadence pull-ups, a 155/80-lb gender specific bench press, a 65-lb bench press, 45-lb dumbbell squat, a two mile run, and a 300-m forward-backward run. A total of 110 subjects (73 males and 15 females) participated in the study. The results from the SPPI were correlated with the current Army Physical Fitness Test (APFT), which consists of two minute push-ups, two minute sit-ups, and a two-mile run. When compared, the correlation between the SPPI and the APFT was weak ($r = 0.25$). The SPPI removed the effect of body mass from performance in males, but not in females. This may have been due to the much smaller female sample size. Because strength and mobility are not included in the APFT, but are in the SPPI, the SPPI “may assist commanders in rank ordering military members on important physical readiness parameters,” (2).

Another session looked at whether chronic hypergravity training (CHT) would improve anaerobic performance in tactical athletes (12). Nine trained men completed three weeks of CHT. This training consisted of wearing a weighted vest equal to approximately 11, 13, and 16% of body mass for the first three weeks. The vests were worn at least four days per week for eight or more hours per day, but not during physical training. The anaerobic tasks in the test battery consisted of a 53-step stair climb, 44-m zig-zag sprint, 2 x 25-m casualty drag, and 8 x 25-yard shuttle run. The subjects practiced the events twice before the experimental trials. A three week control trial was conducted after the CHT trial. The results indicated significant improvements in trial performance after CHT, and a modest decline in performance during the three-week post-trial period. The authors concluded “these results suggest the addition of CHT provides greater enhancement of occupational anaerobic task performances for tactical athletes than traditional training alone,” (12).

One session reported on the effects of load carriage on multiple aspects of tactical performance and another on load wearing. The first session examined whether rucksack load, heart rate (HR), and marching distance would impact soldier shooting performance (17). Twelve soldiers performed two 11.8-km marches in wooded terrain; one march included the use of protective armor and armaments and the other included a 22.4-kg rucksack load. Soldiers performed live-fire shooting tasks prior to, in the middle of, and at the end of the marches. Heart rate was collected with a chest strap monitor. Interestingly, the results showed that shooting while carrying the rucksack resulted in significant improvements in targeting accuracy, relative to wearing protective armor and carrying armaments. In addition, a 20 beats per minute (bpm) reduction in HR also significantly improved the odds of hitting the target. The second session looked at muscle damage, inflammation, and performance responses to load wearing (9). Forty young adults participated by performing a 90-min submaximal cycle ergometry bout, with and without a 24.3-kg load. In general, muscle damage, inflammation, and soreness responses were different (and usually greater for the group with the added load).

Another session looked at whether critical velocity (CV) was related to various combat performance measures in a Special Forces unit (8). Eighteen male soldiers from the Israel Defense Forces volunteered for the study. The subject completed a 3-min all out run, plus a battery of combat specific tasks, including a 2.5-km run, 50-m casualty carry, and 30-min repeated sprints with “rush” shooting (RPTDS). Estimates of CV were calculated from a portable Global Positioning System unit worn by the subjects. The results showed a significant negative correlation between CV, the 2.5-km run, and the RPTDS; however, there were not significant correlations for the casualty carry.

One session discussed factors related to lumbar strength extension gains in soldiers (14). A total of 584 active duty United States Army Soldiers were randomized into two groups for an 11-week study. They were separated into a high-intensity progressive resistance exercise group ($n = 298$) and a core stabilization group ($n = 284$). The results indicated that baseline lumbar extension strength was negatively correlated with lumbar strength gain, with a mean improvement of 14.6%. No relationships were found between lumbar extension strength gain, sex, low back pain history, physical activity history, smoking, bodyweight, body height, or the number of completed exercise sessions.
Another session looked at the effects of age and years of service on strength and physiological characteristics in 253 United States Army Soldiers (14). The results concluded that younger soldiers had higher levels of aerobic fitness and strength, as well as lower body fat percentage than older soldiers. A similar result was observed when years of service were compared. However, some of these differences, such as aerobic fitness, could be confounded by differences in body mass between subject groups. Adjusting the results to account for body mass differences may have led to somewhat different conclusions.

Several sessions on nutritional interventions were also presented. Two of these from the same research group examined whether consumption of beetroot juice would reduce the risk of thermal injury during performance of military tasks (5,11). For one of the studies, ten male subjects completed three 45-min simulated battle marches with full combat gear, boots, body armor, and a loaded rucksack (5). The first march was carried out in thermoneutral conditions, while the second and third marches took place in an environment that mimicked a dry desert. One desert trial included ingesting beetroot juice and the other ingested placebos. The second study was similar, except simulated hypoxia was included in the experimental conditions (11). The results revealed that beetroot juice did not reduce, and may have actually increased, thermal stress. Possible mechanisms for these results included increased core temperature, skin temperature, and heart rate.

Another session looked at the effects of dehydration on cognitive motor skills (16). Four subjects (two males and two females) participated. The exercise sessions consisted of three hour walk/rest sessions in a hot environment. One trial required the subjects to perform the walk/rest in a dehydrated state, normal hydration level state (control), and hydrated state. Comparison of brain activity under all three conditions found the dehydrated subjects displayed significant elevations in brain activation relative to the other two conditions. According to the researchers, “this suggests neural inefficiencies due to dehydration present in low level cognitive motor tasks are not isolated to higher level executive function tasks,” (16).

The nutritional habits associated with Special Operations Forces (SOF) officers formed the basis of another session (1). A total of 595 SOF officers were surveyed. Nutrition habits were correlated with various physiological and strength testing, such as isokinetic knee strength, torso and shoulder rotation, VO2 max, and anaerobic power and capacity. The results indicate that the SOF officers who performed best on the tests typically consumed diets higher in carbohydrates and seafood- or plant-based proteins than those who did not score as well.

A session investigated patterns of dietary supplement (DS) use in Navy Sea, Air, and Land (SEAL) Qualification Training (SQT) and Crewman Qualification Training (CQT) students (6). The use of DS in both groups were high: 88.7% of SQT students and 80.2% of CQT students regularly used DS. Higher DS use was associated with smokeless tobacco use, strength training volume, and caffeine intake. The researchers noted that “combining DS use with consuming caffeine and smokeless tobacco increases potential adverse reactions to DS, especially DS with proprietary blend ingredients,” (6).

One session looked at whether consumption of the supplement beta-alanine (BA) would affect combat-specific performance in tactical athletes (7). Eighteen soldiers from an elite combat unit were randomly assigned to either the beta-alanine group or the placebo group. Beta-alanine and the placebo were supplemented for 30 days prior to the testing period. The tasks included a 2.5-km run, a one-min sprint, 50-m casualty carry, repeated 30-m sprints with target shooting, and a test of cognitive function. Significant increases in muscle carnosine were observed in the subjects consuming BA, but no changes in brain carnosine were observed. Following supplementation, those subjects who consumed BA showed significant improvements in the casualty carry and cognitive function tests compared to the placebo group. No other performance differences between the groups were observed. The improvement in cognitive function, despite no changes in brain carnosine levels, suggests the mechanism by which BA improves cognition remains to be understood.

New research on musculoskeletal injuries were also the focus of several sessions. One session examined injury patterns in United States Air Force Special Tactics (ST) (15). A total of 95 ST operators enrolled in the study. Self-reported injury history was collected by a Certified Athletic Trainer for one year. Of the total injuries, musculoskeletal injuries accounted for 33.7% per year and preventable injuries accounted for 15.8% per year. The upper extremity was the most frequently injured site, followed by the spine and lower extremity. Physical training was the greatest cause of injury, with 76.5% reported as preventable. One session compared the ability of three different screening batteries to predict injuries (3). The three batteries were the Functional Movement Screen (FMS), the Y Balance Test Anterior Reach (YBT-A), and the Landing Error Scoring System (LESS). A total of 257 United States Marines performed the screening tests. The overall results indicated that 72% of the tested cohort was deemed high risk on at least one screen, while 4.3% were high risk on all three screens. Significant differences in the proportion of Marines categorized as high risk when the FMS and LESS results were compared (13.2% were high risk with both screens). There were also significant differences in injury risk prediction when the YBT-A and LESS were compared. By contrast, no significant differences in predicted injury risk were seen when the FMS and YBT-A results were compared. Another session investigated the 10-year incidence rate of shoulder dislocations in United States Army Soldiers (10). Medical encounters from 2002 – 2011 were the
source of the study data. A total of 15,471 dislocation injuries were
reviewed. Soldiers who were 30 years of age or less had a higher
risk of injury than soldiers who were 40 years of age or older.
Males had a higher risk of injury than females. A recurrent injury
occurred in 32.1% of cases. Soldiers 30 years of age or less with
concurrent peripheral nerve injury exhibited the highest risk of
injury recurrence.

Research presented at national conferences held by esteemed
organizations such as ACSM and the National Strength and
Conditioning Association (NSCA) provide the scientific
foundation for evidence-based training of tactical athletes (4).
This is important when determining whether novel training
techniques are safe and effective alternatives to more traditional
fitness training.

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BALANCING HIGH OPERATIONAL LOAD WHILE SUSTAINING CONDITIONING FOR LAW ENFORCEMENT OFFICERS

The drain on domestic tactical police units is as high as it ever has been given the heightened threat environment of the past 15 years. Specialist law enforcement resources are under constant strain to maintain operational and organizational outcomes. The high operational tempo has a cumulative effect that disturbs many functions including skill enhancement, officer personal development, work/life balance, and optimal time for physical conditioning maintenance or improvement.

OPERATIONAL CAPACITY VERSUS CAPABILITY
Capacity refers to the specialist resources, manpower, and operational tools required to complete a successful resolution. Capability is how the essential “human capacity” is utilized. For example, it may take 15 highly trained tactical response operators to safely execute a high risk warrant. If those members have been engaged in other operational activities previously, or on-call, then the overall unit capability is affected as a direct result of reduced capacity. In other words, if those 15 tactical response operators worked all night while dressed in heavy load bearing personal protective equipment (PPE), then fatigue may become an issue if they are not provided enough time to rest (1,2). If the team is recalled to duty the next day, optimum performance can be affected if they are not adequately rested and recovered; therefore, the end state capability is effected by the diminished capacity. This balance of operational needs and maintaining optimum human output-capacity is a constant juggling act for law enforcement officers. Research and recent literature has explored the effects of fatigue and stress on law enforcement officers and the ability to make time-critical decisions (5).

Research supports the supposition that law enforcement officers are affected by stress (5). Other supporting evidence suggests physical performance is affected by altered sleep patterns and stress (3). The same applies to specialist tactical response officers; they should not be expected to be able to perform any physical conditioning program with any level of success, especially involving strength and power, while in a fatigued state. This then raises the question, what is the best way to manage and sustain physical conditioning performance in a high stressed workforce that relies on physically performing at an optimal level every day of the year?

DISCUSSION
Recently, interagency discussions and observations have occurred in relation to human performance and how specialist law enforcement officers handle the continuous rigor of long reinforcement training cycles, particularly including close quarter battle (CQB). To this end, the following situational example from personal observation provides some insight on the physical stress of training and CQB. The example focuses on the tangible performance of law enforcement officers during an intense protracted period of complex skill development. The performance activities observed during this period of interest were tactical shooting and building clearance scenarios while wearing full PPE. It was noted that at the end of the training week, the officers’ scores plateaued and in some instances decreased, despite them being able to absorb more experience and undertake further development. After several weeks of observation, an anecdotal performance bell curve was noticed. The directional staff stepped back from the program delivery and looked at not only the curriculum delivery and duration, but also the additional physical stressors of Physical Training (PT) conducted in the mornings on top of the already robust 10-hr days of CQB. Due to regulations, details of this sample could not be provided but it seems evident that after weeks of high-intensity physical activity plus PT every morning, these officers were suffering from physical and cognitive fatigue.

Upon recognizing this, the directional staff immediately halted the PT in the mornings and reduced the length of physical activity. Further, they provided the officers more rest time at key breaks during the day. Complementing this additional rest, the staff took the officers through mobility, foam rolling, and sports massage sessions. They also had the officers undertake beginning yoga classes and learn relaxation breathing techniques. The tangible effects of this sample were again anecdotal, however, a recognizable improvement in performance was observed.

Sometimes changing a schedule or roster, or altering the focus can allow for recovery, stress reduction, and a refreshing view for law enforcement officers. Dealing with the actual immediate needs, and in some instances, giving officers time off to enhance recovery, is often forgone until paperwork is completed or physical training is undertaken even in a fatigued state. Most law enforcement officers are affected by stress (5).
enforcement officers want to physically train as often as they can, even at the risk of overtraining or inducing fatigue. A respected and credentialed tactical facilitator can have a strong influence on team leaders and decision makers by closely monitoring law enforcement officers’ workload and performance indicators. Mobility and exercise therapy may assist in recovery and managing law enforcement officers’ ability to return to a normal routine after being adequately rested (2).

Some strategies to manage workforce fatigue and optimize physical performance include:

• Managing the roster: Do all of the officers need to be back on deck first thing the next morning after a strenuous night? Can a flexible work model be introduced to allow supervisors to grant officers time off to recover if needed?

• Rather than trying to do everything, prioritize the immediate needs: A reduced capacity through trying to achieve too much directly impacts capability. For instance, if the officer is overreached due to poor sleep patterns or protracted periods of high tempo physical work, their capability will be reduced.

• Looking at the overall roster and upcoming team activity: If there are periods of high complex skill development, formal training courses, or planned operational activity, adjust the PT program to accommodate for heavy workloads. Additionally, plan on maintenance and sustainment rather than a period of focused physical improvement.

• Mitigating organizational stressors: Internal structure changes, policies, and practices can have a large effect on officers (4). Mitigate these stressors by taking action on whatever change is required quickly without lament. It is important to deal with the immediate situation efficiently so less time is given to workplace stress and more time is placed on improvement.

**CONCLUSION**

Research on workplace-induced law enforcement officer fatigue and the physical impacts of operational workload show that any ability to reduce workload and improve recovery will result in an improved and more balanced work force (1,5). This precarious balance, while very difficult to achieve, must always be the focus of tactical facilitators. Every opportunity to enhance the ability for law enforcement officers to physically perform at their very best is crucial and should not be ignored.

**REFERENCES**


**ABOUT THE AUTHOR**

Shane Irving is currently serving as a tactical law enforcement officer in Australia. He has over 20 years of experience working domestically and internationally as a member of the Australian Police Tactical Groups and Special Operations community. Irving has an undergraduate degree in Exercise Science and supervises the physical conditioning of tactical officers in his current occupational role. He has also represented Australia as an elite athlete in track and field and triathlon. Irving is commencing his post graduate studies at Bond University as part of the Health Sciences and Medicine Faculty.
EXERCISE TECHNIQUE—A SIMPLE APPROACH TO TEACHING THE POWER CLEAN IN A GROUP ENVIRONMENT

In the years that I have been coaching athletes, one of the hardest lifting concepts to teach has always been the Olympic-style lift progressions. I recall as a young coach, I would call upon the more experienced coaches I was working with to assist in teaching these complex lifts. It was not until I obtained my certification and began practicing the techniques that I was able to truly appreciate the benefit of the lifts and the complexities involved in teaching them.

These complexities extend beyond the strength and conditioning professional’s knowledge of the lift; they include the limitations of the lifter with regard to kinesthetic awareness, mobility, and neuromuscular coordination, to mention a few. Many strength and conditioning professionals encounter scenarios where they have to teach a group the clean progression or other variations. This can be a problematic situation because each individual in the group will have a unique set of physical constraints. For example, one may not appreciate what it means to arch their back, another might not be able to keep their shoulders retracted, etc. Typically, the time strength and conditioning professionals have with their lifters is limited, but yet they have to properly teach them the first pull, transition, second pull, catch, and the appropriate progressions. Oftentimes this will result in the strength and conditioning professional running out of time or rushing through the steps so quickly that the lifters do not learn or consolidate the movements thoroughly.

Often strength and conditioning professionals are taught the science and major teaching points of the Olympic-style lifting progressions but the art of teaching said progressions is neglected. The art of coaching is what happens when you have the right mentor, enough personal experience, and creativity to accomplish a task. Over the years, I have been fortunate enough to have several colleagues that have cared enough to provide me with some great feedback that has influenced and helped me to develop and refine the art of my coaching style. The following is my way (albeit not the only way) to accomplish teaching the power clean progression and some coaching cues that can be used to teach sport athletes or the tactical athletes in a group setting.

BACKGROUND INSTRUCTION

In order to do this successfully, the strength and conditioning professional must first provide some background information to cultivate understanding of the lifts. I begin by answering the following questions:

Why Perform the Olympic-Style Lift Progression? In order to increase power, or the rate of force development, for single effort or multiple effort bouts. Also, to increase strength and the ability to do more work over a given period of time. Becoming proficient at these lifts can help to maximize the integration of multi-joint movements into the programming and maximize the amount of time spent in the weight room, especially when under a time constraint.

What are the Benefits of the Olympic-Style Lift Progression? Of course, the obvious benefits from becoming proficient in these lifts is power and strength, however, mobility, stability, and core strength can also be developed. The bottom line is that in order to become proficient in these lifts, the entire spectrum of performance should be addressed, not just picking up a weight and putting it down. The ability to get into the proper position, activate the right muscles, and coordinate the movement of multiple joints to get from initiation to completion will be determined by the amount of mobility and stability in the ankles, hips, torso, and shoulders.

How to Get There? The body can be broken into three major checkpoints: the base, hips, and torso. This can be useful for lifters to be able to make a quick reference to parts of the body and ensure proper alignment. The feet are considered the base since they are in contact with the ground.
TEACHING THE OLYMPIC-STYLE LIFTS

POWER BASE AND STRENGTH BASE (FIGURES 1 AND 2)

There are two types of bases to consider when executing the power clean: the initial base is the power base and the completion base is the strength base. In the power base, the feet should be positioned hip-width apart to optimally produce maximal force vertically. For example, a basketball player would never spread their legs to go for a rebound, and this is because joint position dictates muscle recruitment. The right alignment will allow the basketball player to maximize their vertical displacement.

The strength base is a natural defensive position or a position ideal for stabilizing a large load imposed on the body. For example, a wrestler assumes a defensive posture when sprawling their legs to avoid a takedown by the opponent. The strength base is typically used during the catch phase of the power clean.

The strength base should consist of feet being shoulder-width apart or slightly wider. The hips should be slightly above the knees and the lower back should be flat or slightly concave. The big takeaway for this checkpoint is to understand why the hip position is so important. The position of the hip will dictate the order of recruitment for the three major muscles performing the first pull: the glutes, hamstrings, and quadriceps. There are different schools of thought on this point of performance; however, what I have found is that before starting to make adjustments for the limitations of the lifters, it is beneficial to try to achieve performance based on biomechanical principles first. It goes back to joint position dictating muscle recruitment, such that the height of the hips will determine if all three muscles will work synergistically or as part of a segmented effort. If they work synergistically, then maximal force production from three different sources at the same time can be attained. Conversely, if they work in a segmented fashion, then the potential for maximal force production is lost because they are not working together. Additionally, keep in mind that the weight distribution into the base in the triple flexed position should be equally distributed on the back ¼ of the foot to facilitate the hips and shoulders moving as a unit.
HIPS PARALLEL VERSUS HIPS ABOVE THE KNEES (FIGURES 3 AND 4)

The torso is composed of four sub-checkpoints: the head, lats, arms, and hands. The head should be positioned looking straight ahead or neutral. The lats should be “set.” A good way to think of the lats is as the winch housing the line between two cars where one is being towed. Before the car in front can begin towing the other car, there must be tension in the line to allow the force to be transferred through the line. If there is slack in the line there will be an interruption of force transfer, but if the line is tight then the force will transfer immediately and both cars will move in accord. The same holds true for the bar and the body. When the lats are activated, they set the conditions for the transfer of force from the hips to occur between the body and the bar. When the lats are deactivated, there is a delay in the transfer of force from the hips to the bar. This can lead to a number of errors such as shooting the hips, rounding the back, or swinging the bar forward, all of which have a negative effect on the execution of the lift.

The arms work in conjunction with the lats to transfer the force being produced by the hips onto the bar. The arms should remain fully extended and the elbows should be pointed out. This will influence the bar to move towards the body as the hips and shoulders rise or as the lifter pushes off the ground. A useful coaching cue is that “the bar is a magnet for the body,” which reinforces that the closer the bar is to the source of power, the easier it will be to lift the load. Finally, the hands also play a critical role in the execution of the lift and the bar path. The hands should be curled towards the body so as to keep bar from swinging away from the body and crashing down onto the lifters shoulders.

TORSO (FIGURES 5 AND 6)

FIGURE 3. HIPS PARALLEL

FIGURE 4. HIPS ABOVE KNEES

FIGURE 5. LATS ENGAGED
EXERCISE TECHNIQUE—A SIMPLE APPROACH TO TEACHING THE POWER CLEAN IN A GROUP ENVIRONMENT

STARTING POSITION (FIGURES 7 – 10)
The starting position for the power clean is very important. Note that the starting position does not always have to be from the ground; depending on the lifter’s hip mobility, a strength and conditioning professional may consider teaching the lift from the “top down” versus from the “bottom up.” If performing a “top down” power clean, position one would be from the top of the thigh, position two would be from the mid-thigh, position three would be from below the knee or top of the knee, and position four would be from the ground.
WHOLE-PART-WHOLE METHOD
Executing this in a large group setting can be much easier once the lifters have learned quick references, allowing them to make adjustments. This part of the instruction usually takes around 20 min, which allows the rest of the time (preferably an hour) to be spent on executing the progressions. The method I use with my lifters is the whole-part-whole method. While this is not a new approach by any means, there is something to be said about knowing how to apply this technique in different settings and finding ways to achieve various outcomes.

Assuming that there are somewhat limited resources available, a sample progression includes:

- Clean pull to knees (Figures 11 and 12)
- Deadlift
- Clean pull (Figures 13 and 14)
- Clean high pull (Figure 15)
- Power clean (Figure 16)
- Front squat (Figures 17 and 18)
EXERCISE TECHNIQUE—A SIMPLE APPROACH TO TEACHING THE POWER CLEAN IN A GROUP ENVIRONMENT

FIGURE 15. CLEAN HIGH PULL – FINISH

FIGURE 16. POWER CLEAN – FINISH

FIGURE 17. FRONT SQUAT – FRONTAL VIEW

FIGURE 18. FRONT SQUAT – LATERAL VIEW
SCARECROW CLEAN (FIGURES 19 AND 20)
It is important to note that after teaching the high pull, strength and conditioning professionals may have to demonstrate a supplemental progression that is not part of the actual sequence. Catalyst Athletics refers to this progression as the “scarecrow clean,” (1). This progression will allow the lifter to visually see the barbell’s spinning characteristics and how this will allow them to pull their body under the bar when executing the catch.

CRAWL, WALK, RUN METHOD
Begin by setting up six barbells in a row. Ideally, there should be no more than three lifters for each barbell, which will reduce the amount of time the lifters have to waiting for their turn. With a group going through the class for the first time, I am a bit more conservative and usually have each lifter perform three rotations of three repetitions. After teaching in this format a few times, the strength and conditioning professional can be as creative as they want to be in the execution. Keep in mind that the more barbells in use, the greater potential for throughput; however, as throughput increases, it may become necessary to increase the amount of strength and conditioning professionals.

Having an Army background, I use the “crawl, walk, run” method as a teaching progression. During the crawl phase, start with one group of three at each barbell. They will execute each progression in accordance with the specified repetition scheme using the waterfall start (one operator executes while the other two observe, provide feedback, and wait for their turn). The initial load will be light to facilitate learning the movement pattern and making kinesthetic adjustments easier (even if some lifters claim that adding more weight will help technique). If all the points of performance are being properly met, the lifter can transition from the crawl phase to the walk phase by increasing the weight and/or tempo, depending on their needs.

The run phase is executed similarly to a complex routine. Now that the lifter has completed a decent amount of repetitions and has a fundamental understanding of the lift, they can be transition to a faster pace, a greater load, or both if their movement is proficient. During the run phase, a strength and conditioning professional can choose to execute all of the progressions in the complex or any variations that may better benefit the group. A sample complex routine could include:

- Clean pulls (3 x 3)
- Clean high pulls (3 x 3)
- Power cleans (3 x 3)

The lifter will execute three repetitions of each progression to complete one set. The rest ratio would be 2:1 since each lifter would have to wait for their turn. The intent behind the run phase is twofold: to validate the principles that were learned from the instructions, and to show the group how challenging the progressions can be to execute. Once each lifter has completed the prescribed number of sets and repetitions, the strength and conditioning professional can conduct a final review of the material covered to conclude the session.
CONCLUSION
This is one of many ways to organize a block of instruction in a group setting to teach Olympic-style lifts, each strength and conditioning professional should find what works best for them. There may be situations where part of the group is executing the progressions from the top down and the other half is doing it from the bottom up. This is where the art of coaching and knowing a variety of technical models comes in handy. Just remember to keep it simple, use brief coaching cues that stick, and be flexible with the various learning abilities of the group.

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Joe Cruz currently serves as the Head Strength and Conditioning Coach for Naval Special Warfare-Special Boat Team 20 in Virginia Beach. He has over 12 years of experience in coaching athletes to improve their strength, power, speed, and agility across a wide spectrum of sports and civil service jobs. Prior to taking the position with Naval Special Warfare, he worked as a Sports Performance Director with Velocity Sports Performance and the Parisi Speed School. He is an Infantry Officer in the Virginia Army National Guard and has over 21 years of combined officer and enlisted service. He served a tour in Afghanistan in support of Operation Enduring Freedom as a Combat Advisor in 2008. He completed his undergraduate degree in Biology at City University of New York-Hunter College and his Master’s degree in Exercise Science and Health Promotion through the California University of Pennsylvania. He is a Certified Strength and Conditioning Specialist® (CSCS®) through the National Strength and Conditioning Association (NSCA), United States of America Weightlifting (USAW) Level I Weightlifting Coach, National Academy of Sports Medicine (NASM) Performance Enhancement Specialist (PES), and Functional Movement System (FMS) certified.