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ISSUE 45



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TSAC RESEARCH REVIEW

This article is the ninth in 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.

WILDLAND FIREFIGHTER'S YEARS OF SERVICE AND HEALTH

In a recently conducted survey of 499 United States wildland firefighters, Erin Semmens and colleagues examined the links between years of service as a wildland firefighter and the likelihood of being diagnosed with a range of health conditions or requiring orthopaedic surgery (11). Citing statistics from the United States Centers for Disease Control, Semmens and colleagues noted as background information that the overall prevalence of high blood pressure and heart arrhythmias was lower or similar (respectively) in the wildland firefighters they surveyed when compared to the prevalence reported for the general United States adult population (11). They attributed this finding to the fact that, although the surveyed firefighters were drawn from the United States adult population, they were also particularly fit due to their occupational demands (11).

Additionally, Semmens and colleagues found an increasing prevalence of several health conditions and cardiovascular risk factors in those wildland firefighters with greater years of service (11). After controlling for age, sex, race, and household income, the odds of wildland firefighters having been diagnosed with high blood pressure were 4.2 times greater in those with 10 – 20 years of service than in those with less than 10 years of service, and five times greater in those with more than 20 years of service (11). Similarly, the odds of those firefighters with 10 – 20 years of service or more than 20 years of service having elevated cholesterol levels were, respectively, 2.3 and 3.4 times greater than for those with less than 10 years of service (11). The prevalence of heart arrhythmias followed a similar trend across the years-of-service groups in the surveyed wildland firefighters, and so did the prevalence of having wrist/hand or knee surgery (11). In contrast, the prevalence of hearing loss, asthma, non-rheumatoid arthritis, spinal surgery, ankle/foot surgery, and depression did not vary significantly across years-of-service groups in the surveyed wildland firefighters (11). While it would have provided valuable additional information, Semmens and colleagues did not compare the prevalence of these latter conditions in the wildland firefighter population with the general population (11).

For the tactical facilitator, these findings suggest that wildland firefighters may benefit from physical conditioning and dietary advice that addresses the health conditions which become more prevalent with increasing years of firefighting service—particularly as they advance in years of service. Regular aerobic exercise,

reduction of time spent each day in sedentary activities, and dietary habits that promote heart health are all well-known and widely promoted to reduce cardiovascular risk factors and risk of adverse cardiovascular events, including heart attacks and strokes (3). However, these recommendations can be challenging to consistently implement in daily (3). Nevertheless, the tactical facilitator has much to offer in regards to physical conditioning and can also encourage firefighters to seek dietary advice from an appropriately qualified health professional or, if specifically qualified in this area, provide such advice. It is also possible that strengthening of the muscles of the wrist/hand and those that surround the knee, along with proprioceptive and balance training, may help to make the wrist/hand and knee more resistant to injury and reduce the need for surgery to these joints following years of arduous wildland firefighting (1,5). Additional, more rigorous research is needed to test these preventive interventions in the wildland firefighter population, specifically, and to confirm the findings of the survey conducted by Semmens and colleagues (11). However, this need for further research should not delay efforts to implement the most current knowledge into practice to address the health issues that appear to be associated with increasing years of wildland firefighting experience.

MALE AND FEMALE OPERATIONAL SOLDIERS OF SIMILAR AGE, FITNESS, AND BODY FAT LEVELS HAVE SIMILAR INJURY RATES

It is well known that, at a cohort level, women tend to be injured at significantly greater rates than men during basic army combat training and that much of this difference between the sexes in injury rates can be attributed to differences between the sexes in average fitness levels (5). Following from this, in the basic combat training context, women and men of similar fitness levels have fairly similar injury rates (1). However, little has been previously known about the relative injury rates of men and women in operational army units, since no research on this topic has previously been published (1). To fill this gap in knowledge, Anderson and colleagues reported a survey involving 4,384 male and 363 female soldiers from United States light infantry brigades (1). The survey collected information on each soldier's recent (within the previous 12 months) injuries, gender, age, body fat, tobacco use, Army Physical Fitness Test results, and occupational physical demands (1).

The rates of new injury occurrence in the male and female operational soldier cohorts were 42% and 53%, respectively, over a 12-month period (1). However, the difference in injury rates between the sexes was fully explained by differences between the male and female operational soldier cohorts in average age and relative body fat aerobic fitness and muscular endurance. Similar to the basic combat training context, the best predictor of injury

rates in soldiers from these operational light infantry brigades was aerobic fitness levels (1). Male and female soldiers of similar age and with similar fitness and body fat levels had very similar injury rates (1). Once these other factors were taken into account, women were no more likely than men to suffer an injury (1).

These findings add valuable information to the current knowledgebase about individual factors that predict injury risk in the basic combat training context and advance the findings within the operational Army context. In both contexts, it is clear that any predictions of risk of injury to the individual soldier during Army service should be based primarily on assessed levels of physical fitness rather than considering the sex of the soldier. Furthermore, if levels of physical fitness, muscular endurance, and body fat are the best predictors of injury risk in soldiers in operational units, regardless of sex, then it is quite possible that well-designed physical conditioning programs that improve these factors without causing injury or ill-health themselves may help to reduce injury rates. While further research designed to rigorously test and refine such interventions is currently lacking and much needed, the tactical facilitator has an important role to play in this area.

FEMALE AND MALE SOLDIERS EXPERIENCE SIMILAR RATES AND PATTERNS OF INJURIES DUE TO LOAD CARRIAGE TASKS

Load carriage is a regular requirement for soldiers, both male and female. It is increasingly so for female soldiers, as historical restrictions on service of women in combat arms roles are removed in various armed forces, internationally (7). With this in mind, Orr and Pope recently conducted a study to examine the relative rates of injuries arising from load carriage in male and female soldiers (7). Injury incident records representing all injuries reported by male and female Australian soldiers over a two-year period were extracted from the Australian Army's work health and safety incident reporting system. Injuries arising from load carriage tasks were identified for both male and female soldiers and the numbers of male and female soldiers in the Army in each of the two years was ascertained.

From these records, Orr and Pope were able to ascertain that female and male soldiers experienced almost identical overall rates of injuries arising from load carriage tasks in the two-year period observed (these rates were calculated as the average number of injuries experienced by each soldier, each year), with a calculated injury rate ratio of 1.02 (7). However, when the small number of more serious types of injury arising from load carriage were extracted and assessed separately, it was apparent that female soldiers reported more than twice as many serious injuries than their male counterparts (serious personal injury risk ratio 2.4) (7). In addition, both male and female soldiers reported load carriage injuries to the back more often than any other body site, with back injuries accounting for around one quarter of all reported load-carriage injuries (7).

Importantly, although both male and female soldiers were observed for the same time period (two years), it is uncertain whether they were exposed to the same volume of load carriage or to equivalent loads during this time period, and the results obtained in this study might be different if loads and load carriage volumes had been equal for all soldiers, regardless of sex (7). Further research is needed to more rigorously assess the relative load carriage demands of female and male soldiers, to better inform the assessment of relative load carriage injury rates. Nevertheless, at this point in time, there is no evidence to suggest that female soldiers are injured at higher rates than male soldiers during load carriage tasks, which is consistent with the above findings of Anderson and colleagues (1). However, there is evidence from the Pope and Orr investigation that female soldiers may experience serious load carriage injury types more often than their male counterparts (7). This finding warrants both further research and consideration by tactical facilitators "on the ground," as there may be potential contributors to this increased risk of more serious injuries in female soldiers undertaking load carriage tasks that are obvious to those observing the tasks being undertaken. For example, ill-fitting or poorly-configured packs or equipment for the particular individual (whether male or female), or inadequate load sharing within a section to take account of differences between section members (whether male or female) in stature and roles. If tactical facilitators can identify any such potential contributors to the greater proportion of load carriage injuries that are serious in female soldiers, this information can usefully inform both future research and efforts to effectively manage the risks of load carriage (7).

LONG PERIODS OF TIME WITHOUT ORGANIZED PHYSICAL TRAINING ADVERSELY IMPACTS POLICE CADET BMI AND PHYSICAL CAPACITY

Mitrović and colleagues conducted a study of 137 entry-level police academy students (67 male and 70 female students; mean age 18 years) in which they measured the students' height, weight, muscle strength, and muscular endurance at enlistment and then again following an initial eight-month period of academic work, during which the students received no organized physical training (4). All students passed the entry-level physical performance testing (which included sit-ups, push-ups, standing long jump, vertical jump, and isometric deadlift [males] or hand grip strength [females]) at a level required to enlist (4). Across the eight-month period of academic study, without any organized physical training, the students' body mass index (BMI) increased significantly (4.0% in female students and 2.5% in male students) (4). Standing long jump distance and vertical jump height also reduced (4.6% and 7.3 %, respectively, in female students and 2.8% and 4.23%, respectively, in male students) (4). In female students, hand grip strength reduced 7% as well, but this was not measured in male students (4). The authors conclude that a long period of academic training without organized physical training is detrimental to police cadet morphology and physical performance (4).

While the study did not involve a control group and did not report the levels of physical activity undertaken by the police students in informal or unorganized sessions on their own initiative, the results are nevertheless a useful reminder of the perils of filling the time of tactical personnel with academic activities and other sedentary duties that impede their engagement in regular physical training (4). For example, vertical jump height is a useful predictor of police cadet illness and injury risk (8). Deterioration in these measures is likely to increase risks in later training and possibly in later service. Regular physical activity is vital if tactical personnel are to remain physically fit for their occupational role and, as this study suggests, organized physical training sessions may assist personnel to achieve the required levels of physical activity.

PHYSICAL FITNESS OF POLICE ACADEMY CADETS IMPROVES WITH PHYSICAL TRAINING CONDUCTED THREE DAYS PER WEEK FOR ONE HOUR

In contrast to the aforementioned study by Mitrović and colleagues, a recent study by Crawley and colleagues investigated the extent to which regular, organized physical training embedded with academy training improved the physical fitness of police academy cadets (2,4). In this study, organized physical training was conducted for police academy cadets in one-hour sessions, three times per week for 16 weeks (2). Baseline fitness data were collected, along with follow-up fitness data at eight weeks and 16 weeks, for 55 cadets. The fitness tests at each time point included grip strength, arm crank, 30-s Wingate Anaerobic Test, sum of skinfolds, percentage body fat, 40-yard dash, one repetition maximum (1RM) bench press, T-test (agility), sit-and-reach, push-ups, sit-ups, and half-mile shuttle run (2). The one-hour physical training sessions included aerobic training, plyometric training, bodyweight training, and resistance training exercises (2).

The researchers reported significant, measured improvements in agility, upper-body and lower-body peak power, sit-ups and push-ups across the first eight weeks of the academy training program (2). In the full 16-week program, the researchers found improvements in agility, lower-body peak power, sit-ups, push-ups, and half-mile shuttle run performance (2). However, no significant improvements in any of the fitness measures occurred between the eight-week and 16-week time points, suggesting that cadets were not physically challenged in the last eight weeks of the program, and the researchers recommended that consideration be given to modifying the physical training occurring in the final eight weeks of the program to increase program effectiveness (2). The authors also noted that previous research has shown that new and relatively untrained recruits often respond quite dramatically to physical training in the first 6 – 8 weeks, and this phenomenon might also have influenced the difference in observed fitness outcomes for the two eight-week periods (2). Further details of their specific recommendations can be found in the full article and are quite informative for tactical facilitators providing support to police academy training (2). Valuably, these results

provide a reminder that regular assessment of fitness gains is important in tactical physical training programs to inform training progression, ensure training goals are being achieved, and identify opportunities to enhance the training outcomes by program modification, where needed. The results also contrast sharply with those reported by Mitrović and colleagues, with the two studies together reinforcing the vital role that adequate physical training throughout police academy training programs plays in the physical development of police cadets and in ensuring they do not lose critical physical fitness before entering the police force (4).

COMPREHENSIVE FITNESS SCORES PREDICT INJURY RISK IN METROPOLITAN FIREFIGHTERS

In a recent study, Poplin and colleagues examined the utility of a comprehensive fitness score for predicting injury risk in firefighters (10). The comprehensive fitness score was generated by summing the levels of fitness (1, 2, or 3) that the individual firefighter demonstrated across seven tests, with level 1 representing high fitness, level 2 representing medium fitness, and level 3 representing low fitness. The seven tests included a submaximal assessment of VO_2max , resting heart rate, total grip strength, flexibility (sit and reach test), percent body fat (bioimpedance), sit-ups, and push-ups. The authors found that firefighters who were deemed to be “less fit,” or level 3 based on the comprehensive fitness score, were nearly twice as likely to report an injury within a given time period as those in the “high fit,” or level 1 category (10). When sprains and strains were examined separately, the difference in injury rates between “less fit” and “high fit” categories of firefighters increased nearly threefold (10). These findings support the utility of comprehensive fitness batteries for identifying those firefighters who may benefit from targeted interventions and from support to build their level of physical conditioning to sufficient levels to reduce their injury risk.

Also of interest, Poplin and colleagues highlighted deficiencies in some of the fitness tests, which reduced the reliability of the tests in their study (10). In particular, the use of a submaximal assessment of VO_2max and having caps on the number of sit-ups and push-ups that firefighters were required to achieve reduced the reliability of these tests (10). In addition, the periods of time over which reliability of these tests were assessed (full years) could be criticized for being too long (since studies of the effects of bed rest, for example, indicate that fitness levels can vary substantially within an individual in days or weeks), it is nevertheless valuable to consider this issue of reliability in fitness testing (9,10). As they indicate, reliability can be improved by selection of reliable tests in the first place, carefully standardizing the testing procedures to maximize repeatability and precision, and using a test battery rather than relying on results of a solitary test as an indicator of fitness (10). Each of these considerations will provide valuable good information for the tactical facilitator as they decide on the best ways to assess and monitor the physical fitness of firefighters they support.

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BOOTS ON THE GROUND

PURPOSE AND EFFICACY OF UNITED STATES ARMY OCCUPATIONAL PHYSICAL ASSESSMENT TEST

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The United States Army recently introduced the Occupational Physical Assessment Test (OPAT) in order to test soldiers' physical readiness for physically demanding Military Occupational Specialties (MOS). As with any change, the OPAT has been received by the force with mixed opinions ranging from those who see it as long overdue to those who view it as unnecessary. There are also many who see its value but question the veracity of the exercises selected and the established standards.

Until 2015, there was no physical fitness evaluation performed prior to enlistment to screen an individual for their ability to succeed in their assigned specialty in the United States Army. Provided a recruit met the associated Armed Services Vocational Aptitude Battery (ASVAB) standard, a male recruit could contract for any entry-level MOS that had a vacancy. A female recruit could do the same with the caveat that they were precluded by law from enlisting into certain Combat Arms MOS. These included, among others: Special Forces, Infantry, Artillery and Armor (tank crew) positions.

The 2016 decision to allow women to enlist into Combat Arms specialties is not the subject of this article and will not be addressed. However, this decision was critical to the development of the OPAT. Most importantly, with gender no longer a consideration in MOS selection, the Army now needed a physical assessment test that measured the recruit or soldier's occupational fitness, which is absolute in nature (i.e., same task regardless of gender and age) instead of the health-related age and gender-scaled tests which is relative in nature (i.e., accounts for the age and gender of the soldier). In essence, the OPAT helps prevent the placement of recruits into positions where they are physically unprepared to perform to standard.

Recruiting and training a soldier is expensive. A physically unprepared recruit will have difficulty keeping up with his or her peers in demanding training programs and may develop otherwise

preventable chronic and acute injuries that can ultimately result in separation from the Army. During recruitment, these costs include items such as marketing efforts, administrative costs, physical examinations, and transporting them to basic training. Once at training, the government is responsible for feeding them, paying their cadre, providing medical and pharmaceutical treatment while injured, and then potentially transporting them back home after a medical separation. Compound this by the steep expense of possibly remunerating them for life with a Veterans Administration (VA) disability claim. It becomes evident that the total cost is nothing short of colossal. Multiply this cost by tens of thousands of personnel annually and the astronomical financial burden set in motion by placing the wrong candidate into the wrong career field is clear. This is why the OPAT is so important and valuable.

Through the OPAT, the Army now has a screening tool to train the right soldier for the right job, mitigate wasted resources, and ultimately improve force readiness.

The OPAT consists of four events, each with a different purpose or intent. They are:

1. Standing Long Jump

The standing long jump (SLJ) is considered a test of "lower body power" but more specifically is an excellent indicator of explosive horizontal displacement. Subjects stand at a take-off or starting line and jump forward, exploding with both legs as far as possible. There are strong biomechanical similarities between the muscles and energy system used in an SLJ and those utilized by a track sprinter coming out of the starting blocks. One could even argue that the SLJ is a better indicator of explosive acceleration because the hip extension of both legs are utilized rather than just the dominant or favored leg of a track athlete. In short, it's a practical and easily administered means of testing a recruit's first step quickness.

2. Seated Power Throw

The seated power test is intended to be a measure of "upper body power." In effect, a basketball chest pass from the subject in a seated position against a wall where the recruit explosively tosses a 4.4-lb (2 kg) medicine

PURPOSE AND EFFICACY OF UNITED STATES ARMY OCCUPATIONAL PHYSICAL ASSESSMENT TEST

ball as far as possible. Correlations are many in this event, from general upper body strength and power to pushing, punching, and lifting capability. It may seem to lack sport specificity because a soldier is seldom working from a seated position. However, this position removes the core assistance, thus isolating the upper body and giving a truly valid assessment of the power produced by the arms, chest and shoulders.

3. Strength Deadlift

Often unofficially referred to in the force as the “squat lift,” this event is nothing more than a standard hex-bar deadlift. Individuals attempt each of eight ascending levels of resistance ranging from 120 – 220 lb until they are unable to lift the weight with correct mechanical form. This event is intended to measure lower body strength, but also is an excellent indicator of trunk strength.

4. Interval Aerobic Run

The interval aerobic run is based on the 20-m Progressive Shuttle Run Test or “Beep Test” and is an easily administered test of aerobic capacity. Personnel performing this event begin on a starting line and run forward to a parallel line 20 meters away on command. A loud audible beep will direct them to return to the starting line. These beeps continue, with gradually less and less time between intervals. An individual’s test is terminated when they fail to touch the 20-meter line before the “beep” three times in a row.

There has been discussion in online forums, social media and elsewhere that the standards required in the OPAT for various career fields do not reflect the norms in a combat unit. It should be noted that the OPAT is not designed or intended to replace the Army Physical Fitness Test (APFT) performed by the Army at large, nor is it to identify people as battle-ready. Just as the ASVAB test is designed to assess the aptitude of an incoming recruit to be successful in a given career field, so too is the OPAT intended to serve as an assessment of one’s physical acumen and help prevent placing personnel in an MOS where they may not succeed.

A young freshman football recruit entering a major university is often red-shirted his first year in order to provide him with an additional year in which to develop. Certainly it can be argued that the average college athletics recruit is at least as fit as the average incoming trainee in the military and yet no mechanism exists in which to physically assimilate the entry-level soldier into his or her new vocation. Indeed, the slow and easy approach to physical preparation is not particularly practical when associated with the needs of our nation’s defense. As such, a comprehensive but realistic battery of tests can serve to expose those who are sufficiently fit and athletic enough to immediately assimilate into

training with the least possible likelihood of failure or injury. The OPAT was designed to identify those individuals and screen out those who require further physical development.

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HEART RATE VARIABILITY USEFUL IN MONITORING FITNESS AND TRAINING RESPONSES IN TACTICAL ATHLETES

Active-duty military personnel are required to maintain a certain level of physical preparedness relative to their job duties and standards set forth by governing bodies. Additionally, there is a concerted effort in maintaining balance between physical readiness and increased injury risk. As such, the United States Army has implemented strategic physical readiness training programs to physically prepare soldiers to perform military operations (14). Emerging techniques and technologies that monitor exercise, fitness changes, and physiological stress provide information aimed to improve training outcomes while potentially minimizing risk of injuries. One such tool that is growing in popularity is heart rate variability (HRV). HRV is thought to provide objective insight into understanding fatigue, “trainability,” and “readiness” to perform in athletic populations. Due to the intensity of tactical performance, training needs, and physical fitness requirements, strength and conditioning programs of military personnel can be analogous to those of athletes. Furthermore, technology intended to capture physiologically-relevant variables is quickly developing. As such, several devices and specialized software can be used to capture and analyze HRV data. Evolving access to data may enhance the understanding of individualized fitness and training responses in tactical athletes.

HRV BASIC INTRODUCTION

HRV is a non-invasive measure of cardiovascular-autonomic control (2). In short, the autonomic nervous system (ANS) has two branches that influence several of the body's systems. The sympathetic branch provides the “fight or flight” responses, while the parasympathetic branch elicits “rest and digest” actions (15). With respect to the cardiovascular system, HRV provides some insight into the balance between one's sympathetic influences versus parasympathetic tone (2). Common HRV measures analyze the time between consecutive heart beats to calculate a variety of scores (17). Practitioners can use the scores to monitor the current state of, or changes in, autonomic control for any individual of interest. By recording daily or semi-regular HRV measures, comparisons can be made between current scores and one's baseline average or recent HRV trends. While the HRV measure will have small fluctuations each day, on an individual level, norms and trends in HRV can be monitored over time for irregularities. Generally, a higher HRV score is more favorable than a lower one, although there are several nuances that must be considered when interpreting data (e.g., sleep, non-training stress, anticipation, etc.) (2). HRV scores are best utilized within the context of an individual's data.

HRV RELATIONSHIP WITH TRAINING AND PERFORMANCE

HRV is correlated to cardiovascular fitness ($r = 0.49$, $p < 0.001$), a major component of several tactical applications including combat readiness and the United States Army Physical Fitness Test (APFT) (10,11,14). Additionally, researchers utilizing HRV-guided aerobic training sessions have produced several promising results regarding aerobic training fitness outcomes (5,11,12,13). HRV-guided training uses an athlete's HRV score to dictate daily or weekly training loads. For example, if an athlete reports a low, repeatedly-low, or highly variable HRV score over a period of time, this could be evidence of a lack of recovery (5,11,12,13). Consequently, the training load or intensity can be adjusted individually to provide adequate recovery time. Alternatively, the opposite can be true, with high HRV scores training load or intensity can be increased to maximize adaptation. In several studies, the HRV-guided aerobic training outperformed or matched training outcomes with that of the normally scheduled training groups, even though the HRV-guided groups used less training volume or sessions (5,12,13,16). Kiviniemi et al. found that over a four- or eight-week aerobic training program in moderately fit young adults, HRV-guided and pre-determined training programs both improved $\text{VO}_{2\text{peak}}$. However, the HRV-groups completed about equal to one less high-intensity training session per week (12,13). This highlights how training via HRV-guided programs may potentially lower the time spent training, and thus optimize individual training adaptations while minimizing injury risk.

Additionally, advances in technology have allowed HRV to be successfully used as part of a system to monitor athlete training and recovery in team sport settings (3,4,7). For instance, in female soccer players, the players' HRV response to early training session was related to eventual training outcomes in the yo-yo test (7). In other words, the players who responded well early ended up having the best training outcomes. Recently, smartphone applications have been developed for convenient, in-home measures of the common HRV measure, $\ln\text{RMSSD}$, the log-transformed root mean square of successive R-R intervals (8,9). $\ln\text{RMSSD}$ is suggested to be the preferred HRV marker for field-based monitoring (2). The smartphone applications utilize ultra-short-term stabilization and recording durations of approximately one minute each, which has been shown to be valid compared to traditional, lengthy recordings under laboratory-controlled conditions (8). These advancements provide an opportunity to implement HRV monitoring in tactical training applications.

HEART RATE VARIABILITY USEFUL IN MONITORING FITNESS AND TRAINING RESPONSES IN TACTICAL ATHLETES

TABLE 1. BASELINE HRV MEASURES (TIME-DOMAIN MEASURE, INRMSSD) WERE CORRELATED TO SOME APFT PERFORMANCE TESTS (E.G., SIT-UP AND 2-MILE RUN) BUT NOT PUSH-UPS. * = P-VALUE < 0.05 (1)

HRV (INRMSSD)	PUSH-UP (REPS)	SIT-UP (REPS)	2-MILE RUN (MINS)
86.5 ± 9.4	56 ± 21	71 ± 9	16.0 ± 2.9
Person Product r	0.49	0.67	-0.64
p-value	0.09	0.01*	0.02*

The use of HRV in specifically guiding resistance training programs is less explored (6). One study provided evidence that HRV is lower after a difficult/overreaching resistance training session in trained powerlifters. Additionally, the study monitored time-course recovery of weightlifting performance, HRV, and muscle damage markers in the blood over a 72-hr recovery period (6). Twenty-four hours after the training session, HRV and weightlifting performance were down, while blood markers of muscle damage were up (6). However, all trended back towards baseline at the 48-hr and 72-hr marks (6). In other words, HRV scores did decrease after a bout of training, and these changes were indicative of how the individual responded to the training stimulus, as well as their recovery status in the following days after the training stimulus. However, more research is needed to evaluate if responses to aerobic, anaerobic, and combined training can be directly related to the changes seen in HRV scores in tactical populations. More specifically, research conducted in the field and more-controlled lab settings are needed to help inform how practitioners can monitor and interpret these interactions of HRV, recovery status, and performance.

RELATIONSHIP TO FITNESS IN TACTICAL ROTC ATHLETES

In a recent study, HRV was evaluated before Reserve Officer Training Corps (ROTC) cadets performed their routine APFT (1). To establish a baseline, HRV was recorded for each of the cadets three days prior to testing. This three-day period was a good indication of how the cadets' ANS was responding to normal stimuli encountered in the days prior to the APFT (1). Baseline HRV was then used to determine relationships between the different portions of the APFT (push-ups, sit-ups, and two-mile run) which can be found in Table 1 (1). The study found that baseline HRV had high and moderate correlations ($r = 0.67$, $p = 0.01$; $r = -0.64$, $p = 0.02$) to performance on the 2-min maximum sit-up test and the two-mile run (1). The correlation to push-up performance was slightly lower ($r = 0.49$, $p = 0.09$) and did not reach the typically accepted $p \leq 0.05$ threshold (1). However, taken as a whole, one can conclude that HRV is positively related to fitness test scores in this population. HRV scores vary between individuals; therefore, it is important to monitor individuals closely to see if changes are due to the training stimuli.

CONCLUSION

Implementing HRV monitoring into tactical athlete applications has promising potential. Because HRV is thought to represent an overall index of how one is handling stress, these data can help monitor and guide training and recovery sessions at the individual level. Using this objective, non-invasive tool, tactical facilitators can create monitoring protocols specific to their needs that maximize favorable adaptations and performance while minimizing risks.

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PHYSICAL EMPLOYMENT STANDARDS— IS “LEGALLY DEFENSIBLE” THE SAME AS “MORALLY DEFENSIBLE?”

In the modern firefighting workplace, where increasing diversity of workforces is an all-consuming goal, any potential barriers to maximizing participation are subject to ongoing scrutiny and change. In these populations, the greatest barrier to increasing diversity, whether real or perceived, continues to be the requirement to meet predetermined physical standards. This focus on critically examining and defining the inherent physical requirements of physical work tasks has spawned a field of research, which is known as physical employment standards (PES), which addresses the dual goals of recruiting a resilient and effective workforce, while also minimizing possible barriers to increasing the workforce participation of previously underrepresented demographics. In many fire services, diversity often means actively increasing the proportion of women in the workforce. For example, in the Australian fire services, this goal has taken the form of “50/50 quotas” for positions in recruit colleges, a strategy meeting with varying levels of success. While the focus is on developing modern PES, reflective of the work tasks of 21st century tactical personnel, the all-consuming drive to increase diversity can conflict with accurately defining the needs of the workplace (6).

In Australian fire services, a career may last more than 30 years, with many individuals remaining operational as a firefighter throughout. This need to remain operational is partly due to a lack of opportunity for promotion, but also due to a genuine desire to remain “on the tools.” Traditionally, retirement ages were in the mid-50s, but reduced government revenue has increased the age of access to retirement benefits to over 60 years of age in Australia, and many other jurisdictions have now become the norm.

The goal of any recruitment process must be to select those most likely to succeed in their new career, acknowledging that individuals will be required to work for extended periods of time. Therefore, it is intuitive to expect that some level of “future proofing” of an individual’s physical abilities should be a consideration in the physical abilities testing (PAT) during recruitment.

For firefighters, recruitment standards are generally based on a minimum VO_2max of about $42 \text{ ml.kg}^{-1}.\text{min}^{-1}$ where firefighters are asked to work at up to 80% of this VO_2max and 94% of their maximal heart rate (4,5,11). But those who meet the minimum level of fitness are only being able to sustain this high intensity anaerobic work for no more than 90 s (3). Furthermore, previous research has shown that firefighters demonstrating the minimum

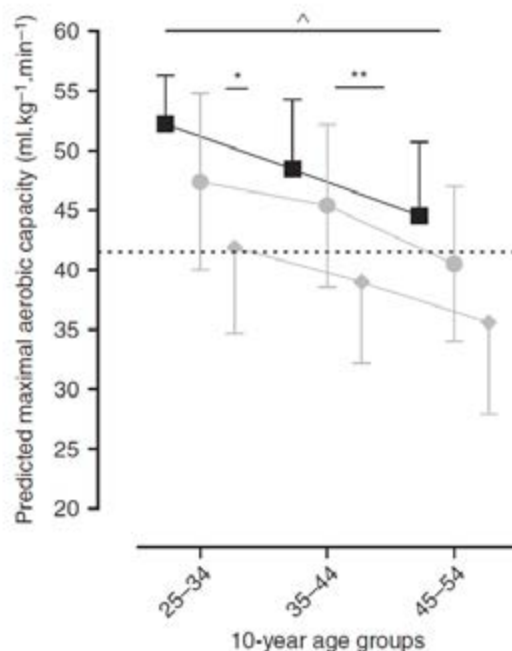
level of fitness only ($< 43 \text{ ml.kg}^{-1}.\text{min}^{-1}$) are more than twice as likely to be injured in emergency responses than those who are fitter ($> 48 \text{ ml.kg}^{-1}.\text{min}^{-1}$) (9). Additionally those with higher fitness levels have been shown that they can safely sustain much higher core temperatures when working in the heat than those who are less fit (1). Therefore, to remain safe while completing emergency firefighting tasks, it is intuitive to expect that recruitment standards reflect a need for individuals to perform at this higher level throughout their career.

While the magnitude of declines in an individual’s strength may be less clear, it is well established that the maximum aerobic power (VO_2max) declines in the order of 0.2 to $0.5 \text{ ml.kg}^{-1}.\text{min}^{-1}$ per year after the age of 30 (7). This means that in a 30-year career, the VO_2max of an individual can be reduced by as much as $15 \text{ ml.kg}^{-1}.\text{min}^{-1}$, meaning an individual who demonstrates only the minimum aerobic power (in conjunction with strength) at recruitment is likely to not be able to perform their role safely within a short period without some level of intervention. Of course, proper physical conditioning programs at work can ameliorate many of these declines, but these generally are not employed in fire services and no requirement is made for professional firefighters in Australia post-recruitment (12). In fact, in the United States fire services, less than 30% of firefighters are exposed to workplace health programs (10). Thus, in a climate where ongoing monitoring and intervention in the physical strength and conditioning of firefighters does not occur, having recruiting set to a bare minimum standards appears risky if not completely inappropriate.

To potentially meet the dual needs of “legal” and “moral” responsibility, it is proposed that a system of age-based recruitment standards be employed to allow for the natural physical decline of firefighters to help ensure their safe and effective workplace participation (12). However, this continually meets with resistance from those pushing for “legal defensibility” at all costs with statements such as: “The implications of recent recommendations in this regard for ageing firefighters are disturbing, for they could potentially translate into a workforce that contains individuals, or units, no longer capable of performing their jobs,” (2). Within this statement is the argument that this article seeks to address. However, while acknowledging that “inflated entry requirements, for the purpose of attenuating the effect of ageing on work performance, would be very contentious in some jurisdictions, and cannot be recommended,” the same authors acknowledge that, “the latter recommendations may well alleviate some of the concerns with ageing employees,” (8).

PHYSICAL EMPLOYMENT STANDARDS— IS “LEGALLY DEFENSIBLE” THE SAME AS “MORALLY DEFENSIBLE?”

TABLE 1. DECLINE IN AEROBIC POWER BETWEEN A FIREFIGHTING POPULATION AND GENERAL POPULATION DATA (REPRODUCED WITH PERMISSION FROM WALKER ET AL., 2014)



Age-based decline in predicted maximal aerobic capacity of ■ participants compared with • active and ♦ sedentary populations (Herdy and Uhlendorf 2011). The dashed line denotes the minimum recommended maximal aerobic capacity value of 42 ml kg⁻¹ min⁻¹ (IAFC 2013; NFPA 2011). ^ represents significant difference between 25–34 and 45–54 year age groups ($p < 0.001$). * Represents significant differences between 25–34 and 35–44 year age groups ($p = 0.027$) and ** between 35–44 and 45–54 year age groups ($p = 0.039$).

Thus, it is recommended that a system be put into place based on all recruits meeting the most basic standards only, which would create precisely the workforce proposed by Fullagar et al. (2). If a 20-year old is recruited at 42 ml.kg⁻¹.min⁻¹, they will likely only be capable of producing a VO₂max of 27 at age 50, which is well below the safe working threshold and therefore unfairly setting that individual up for a reduced working lifespan. Table 1 provides data on the age-based decline in aerobic power in firefighters.

CONCLUSION

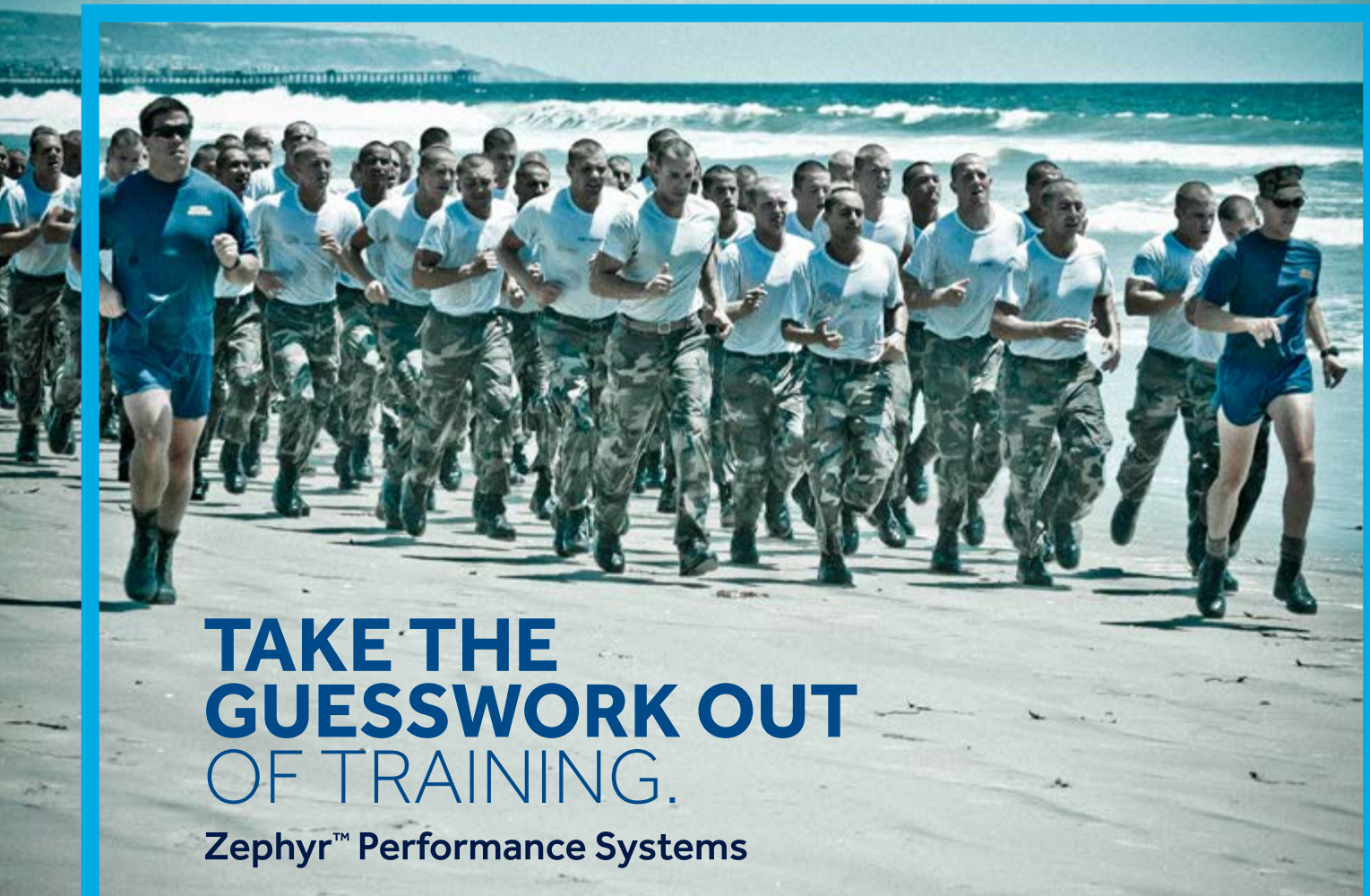
While no recruitment process will ever be perfect, it is time to address the “legal defensibility” of PES as the primary consideration in developing recruitment standards that are concurrently designed to increase workplace diversity. To recruit a person, knowing that they will be unable to complete a 20, 30, or even 40-year career due to a highly predicted decline in their physical ability could be considered “morally indefensible.” Furthermore, the legal argument or what is “defensible” is something not yet tested in any Australian jurisdiction to date. The conversation surrounding defining recruitment standards should continue. Of course, should fire services and the unions actually act to deliver evidence-based, effective, and monitored workplace strength and conditioning programs, then the argument for using legal defensibility may be more likely valid in the modern workplace.

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THE DIFFERENCE BETWEEN TACTICAL STRENGTH AND CONDITIONING AND TRADITIONAL TRAINING

Tactical strength and conditioning has gained popularity over the last 10 years as a method of improving job-related performance and offers the potential to help in saving lives (4). Traditional training, on the other hand, improves overall health, how one looks and feels, or alters specific components of fitness, which may or may not be related to occupation. Tactical strength and conditioning refers to training in a way that increases occupational preparedness, or the ability to perform job-related tasks (3). These tasks are often done under stress and usually involve lifting and/or carrying loads.

STRONGMAN TRAINING FOR TACTICAL FITNESS

Strongman training and common movement patterns seen in the tactical environment have many similarities, for example, the requirement to lift a heavy, awkward object and then carry it a distance. As a bit of background, strongman training involves using nontraditional equipment for lifting, carrying, pushing, pulling, and gripping. In the tactical environment, these movements are often critical for the safety of people and the transport of equipment/gear. In strongman training, these lifts, carries, pushes, pulls, and gripping tasks are performed either as separate movements or in medleys. Medleys can also improve the tactical requirement of speed, endurance, and muscle endurance. A list of tactical movement requirements and the accompanying strongman implement are shown in Table 1 (5,6).

TABLE 1. LIST OF STRONGMAN IMPLEMENTS/EXERCISES TO ACHIEVE TACTICAL FITNESS (5,6)

TACTICAL MOVEMENT REQUIREMENT	STRONGMAN IMPLEMENT	SAMPLE PROGRAM IMPLEMENTATION
Lifting	Sandbags, stones, deadlift	Bodyweight stone over shoulder
Carrying	Sandbags, kegs	Carry 200-lb sandbag 60 ft
Pushing	Sled, car, tire flip	Push 180-lb sled in the grass
Pulling	Sled, car	Pull 170-lb sled arm-over-arm
Gripping	Farmer’s walk, deadlift	Hold bodyweight in each hand for as long as possible

TABLE 2. CONSIDERATIONS FOR SUBSTITUTE EQUIPMENT FOR STRONGMAN IMPLEMENTS/EXERCISES

INSTEAD OF	CONSIDER ANYTHING...
Atlas stone	That requires holding large, heavy, hard-to-grasp objects close to the body
Car	Heavy that moves but does not move freely (no inertia or forward momentum involved)
Circus dumbbell	Imperfectly shaped and bulky that can be gripped and controlled overhead
Deadlift	That can be kept close to the body from the ground to an erect position
Farmer’s hold/walk	That has varying grips and sizes that is either heavy or can be loaded to become heavier
Sandbag/kegs	That employs imperfection training to have an oddly weighted implement (handles are okay, but no handles are better)
Sled	That can be pushed and provides some degree of forward momentum
Tire	That involves triple extension while moving up and forward simultaneously
Yoke	That can be evenly or unevenly weighted across the shoulders, with the weight displaced inferior to the center of gravity

SUBSTITUTIONS FOR STRONGMAN IMPLEMENTS WHEN NONE ARE AVAILABLE

In many instances, strongman implements may not be available. When deciding what to substitute, it is important to consider the biomechanics of the movement, the weight and imbalance of the implement, and the physiological demand. Table 2 provides possible implements that can be used instead of the traditional strongman training implements.

PROGRAMMING STRONGMAN FOR TACTICAL FITNESS

All strength and conditioning programs should follow the appropriate dose response for the level of the trainee. Generally, a beginning weight trainee at a training age of zero would use 1 – 2 sets of relatively light weight (67% of one repetition maximum [1RM]), whereas an experienced trainee would benefit from heavier weight (85% of 1RM twice per week using eight sets per body part) (2). Dose-response strongman training can be introduced as part of the overall strength and conditioning program during the general physical preparation phase of a periodized plan, and tactical personnel will most likely focus

on strongman-type training, preparing for the specific job requirements that may occur during the task-specific phase of training (3). Strongman training should be considered a single component of an overarching tactical strength and conditioning plan. It offers flexibility of training and biomechanically and physiologically similar movements that can mimic the tactical environment. Many of the implements used in strongman training can be modified for tactical strength and conditioning. For example, movements such as farmer's walks and farmer's holds develop the necessary core stabilization, movement under control with weight, and grip strength necessary for tactical performance (1). Table 3 provides sample workouts for advanced tactical athletes who have strongman implements readily available.

For the tactical athlete to improve tactical performance and reduce the risk of injury, it is also helpful to understand the correct technique for strongman lifts within each tactical fitness category, as well as positive cues that prompt proper movement mechanics. Table 4 provides exercises descriptions and common coaching cues for performing strongman exercises.

TABLE 3. SAMPLE STRONGMAN WORKOUTS FOR ADVANCED TACTICAL ATHLETE EXERCISE DESCRIPTIONS

TACTICAL FITNESS REQUIREMENT	SAMPLE WORKOUT 1	SAMPLE WORKOUT 2	SAMPLE WORKOUT 3
Warm-Up	Light sled drag 60 ft	Light arm-over-arm sled drag	Light yoke front press
Power	Stone to platform x 3	Keg toss x 3 kegs	Circus dumbbell x 5
Strength	Deadlift fat grip x 5, 5, 3, and 3 repetitions at 80 – 85% of 1RM with 2 – 5 min rest between sets	Sandbag carry 60 ft 0.75 x bodyweight (BW), 1.25 x BW	Yoke walk 2 x bodyweight 60 ft drop and return 1 min
Metabolic Conditioning	Medley: arm-over-arm, tire flip, and sandbag carry 60 ft each	Stone over shoulder x as many repetitions as possible	Sled drag and car push 180 ft each
Feat of Strength	Farmer's hold for time	Stone over bar MAX	Yoke back squat from parallel depth
Cool-Down	Light sled drag 60 ft	Light arm-over-arm sled drag 60 ft	Light yoke front press

TABLE 4. EXERCISE DESCRIPTIONS AND PERFORMANCE STANDARDS FOR STRONGMAN IMPLEMENTS

TACTICAL FITNESS REQUIREMENT	IMPLEMENT/ TACTICAL SUBSTITUTE	PERFORMANCE STANDARD	COACHING CUES
LIFT			
	Circus dumbbell	Angle dumbbell on shoulder Keep shoulder blade back Use powerful countermovement Forcefully exhale, driving the hips up and extending the arm	Dumbbell will rise with stabilization Swing up and back to load, then lock, dip, and explode
	Keg toss	Check clearance over bar Grab keg either by handles or long ways Flex hips and knees, bringing keg between legs Explode upward and toss keg back over head and over bar	Get the hop to drive to the top Position to the line to be consistent and over every time Powerful triple extension
	Stone over bar	Keep arms straight Grip stone underneath Hinge hips to lift stone to lap Reset hands to “10 and 2,” high on chest Triple extend stone over bar	Set hands and use the hips to lift to lap Reset hands/triple extension over bar
	Stone over shoulder	Keep arms straight Grip stone underneath Hinge hips to lift stone to lap Reset hands to “10 and 2,” high on chest Triple extend stone over one shoulder Repeat over the other shoulder	Set hands and use the hips to lift to lap Reset hands/triple extension over shoulder
	Stone to platform	Keep arms straight Grip stone underneath Hinge hips to lift stone Hold stone at “10 and 2,” high on chest Triple extend stone onto platform	Set hands and use the hips to lift to lap Reset hands/triple extension onto platform
	Tire flip	Use traditional or sumo deadlift stance with arms straight and palms up under the tire Chest to top of tire while looking ahead Triple extend forward and up Flip tire either by resting it on one leg and then pushing it, or by powerfully driving and switching hands to overhand position	“45 and drive” (45 degrees to the tire and push with the chest) Explode and reload

STRONGMAN-STYLED TRAINING FOR THE TACTICAL ATHLETE

TABLE 4. EXERCISE DESCRIPTIONS AND PERFORMANCE STANDARDS FOR STRONGMAN IMPLEMENTS (CONTINUED)

TACTICAL FITNESS REQUIREMENT	IMPLEMENT/ TACTICAL SUBSTITUTE	PERFORMANCE STANDARD	COACHING CUES
LIFT			
	Yoke front press	Position height of yoke to top of armpits from the front Stand evenly in front of yoke and grip yoke with pronated grip Press overhead under control	Clear the head
	Yoke back squat	Position height of yoke to top of armpits from the front Stand evenly in front of yoke and dip under yoke into back squat position Grip yoke with pronated grip either on the top bar or along the side bars Brace the core and extend the hips and knees until standing Slowly lower to the starting position	Brace, set, and drive
CARRY			
	Keg carry	Start with keg in upright position Use non-dominant hand to push keg over to the non-dominant side, then hold the handle towards the ground Grab bottom of keg with dominant hand on top of the bottom edge of the keg Use triple extension to lift keg off ground while pulling the keg to torso	Quick rotation of hands on keg Triple extension Shoulders back Chest up
	Sandbag carry	Either stand the sandbag upright and squat down to lift, or lay the sandbag on the side and grip from the sides to lift the bag with the hips	Squeeze the shoulders back Keep bag close to the body
	Yoke walk	Position height of yoke to top of armpits from the front Stand evenly in front of yoke and dip under yoke into back squat position Grip yoke with pronated grip either on the top bar or along the side bars Brace the core and extend the hips and knees until standing Take slow even steps from hips to maintain control of the yoke Reset at each turning point	Brace for the race Stand tall and take small steps

TABLE 4. EXERCISE DESCRIPTIONS AND PERFORMANCE STANDARDS FOR STRONGMAN IMPLEMENTS (CONTINUED)

TACTICAL FITNESS REQUIREMENT	IMPLEMENT/ TACTICAL SUBSTITUTE	PERFORMANCE STANDARD	COACHING CUES
PUSH			
	Car push	Start with small steps Push evenly with hands Keep low profile	Dig and drive
PULL			
	Sled drag	Athletic stance Lean back slightly Chest proud Shoulder blades back and down Arms straight Quick and short steps	Fast feet, eyes to the skies, and drive Body straight and tight with a lean Drive with fast feet like a machine
	Arm-over-arm sled drag	Athletic stance Lean back slightly Chest proud Shoulder blades back and down Arms straight Watch grip while pulling the sled arm-over-arm	Pull and squeeze
GRIP			
	Deadlift fat grip	Deadlift either traditional or sumo-style, using fat and pronated grips	Squeeze with the thumbs
	Farmer's hold for time	Set farmer's implements close to sides to grip in line with ankles and hips Hold farmer's implement close to the body and hip hinge to a standing position Keep farmer's implements even and at the sides, with a tight grip	Eyes to the skies and squeeze to the sides

STRONGMAN-STYLED TRAINING FOR THE TACTICAL ATHLETE



FIGURE 1. ATLAS STONE



FIGURE 2. ATLAS STONE



FIGURE 3. ATLAS STONE



FIGURE 4. ATLAS STONE



FIGURE 5. ATLAS STONE



FIGURE 6. ATLAS STONE

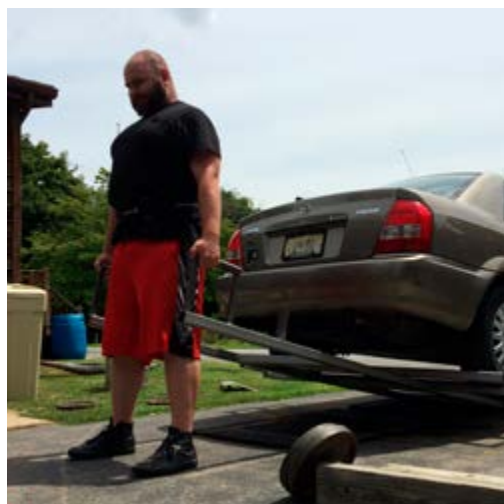


FIGURE 7. CAR LIFT



FIGURE 8. CAR PULL

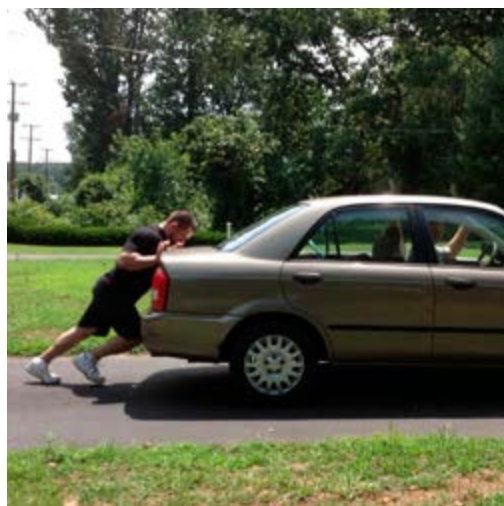


FIGURE 9. CAR PUSH



FIGURE 10. FARMER'S CARRY



FIGURE 11. KEG CARRY



FIGURE 12. TIRE FLIP

A TACTICAL APPROACH

Tactical athletes must consider the job requirements (e.g., lifting, carrying, pushing, pulling, and gripping) and match those requirements to the strength and conditioning variables (e.g., power, strength, muscular endurance) and the various implements available to meet the tactical requirements (6). Strongman implements and their functional nature of strength-in-motion types of lifts incorporate tactical movement requirements in a challenging, nontraditional manner. Strongman training is a novel way to develop the fitness necessary for tactical athletes, who must be ready to demonstrate their abilities every day (5).

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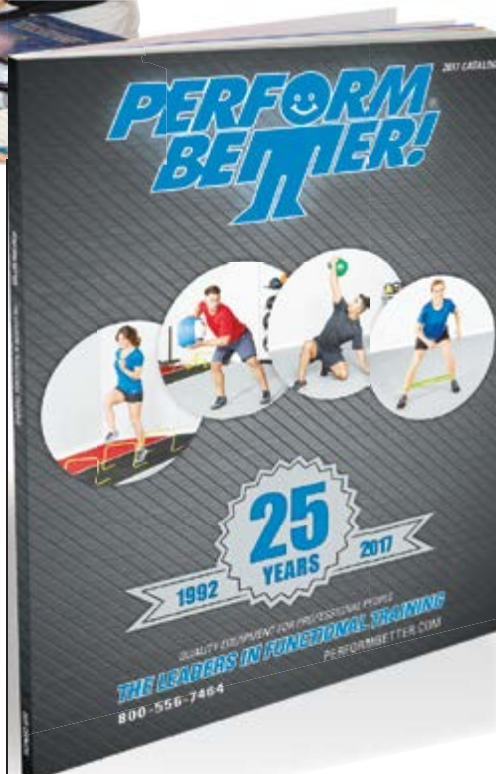
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INJURY RISK REDUCTION PROGRAMS FOR FIREFIGHTERS—A CASE EXAMPLE

Injury prevention, or more specifically, musculoskeletal injury (MSI) prevention is often a topic of discussion for senior command in professional fire departments, and with good reason. MSI can account for 57% of all injuries suffered by firefighter personnel, on and off the fireground (9). Furthermore, MSI can affect the personnel pool, burdening the fiscal solvency of a department, which must either backfill these positions or send crews out at dangerously low staffing levels (8). In the example used for this article, from 2013 – 2015, the Fairfax County Fire and Rescue Department (FCFRD) spent over 19 million dollars on MSI treatment, rehabilitation, and backfill.

Given these costs, it should come as no surprise that there is enormous pressure on occupational medicine professionals serving tactical populations to come up with injury prevention solutions and in doing so, show a cost-saving benefit to justify their funding. Consequently, the efficacy of occupational medicine providers, such as Tactical Strength and Conditioning Facilitators® (TSAC-F®), Certified Strength and Conditioning Specialists® (CSCS®), physical therapists, and exercise physiologists, is judged heavily on their ability to affect change in this arena. To this end, tactical facilitators are faced with two challenges: 1) come up with a solution to identify MSI risk and 2) show the efficacy of injury risk-reduction programs.

These MSI interventional efforts are traditionally called “injury prevention programs.” It is suggested, however, that approaching this problem with the mindset of preventing MSI is a bit of a fool’s errand. This is an assertion confirmed by the statistical premise that is inordinately difficult to prove prevention—the causation versus correlation premise (11). Moreover, the phrase “injury prevention” has become the de facto title of occupational medicine efforts to this end, and predisposes any such program to “prove prevention” in order to confirm efficacy and justify funding. Therefore, it is imperative to adopt both a mindset and a vernacular that emphasizes “risk reduction,” and in fact, that is precisely what these programs are attempting to do. Furthermore, taking a risk-reduction approach can produce quantifiable metrics where tracked injury rates indicate a reduction in injury rates, near misses, and exposure due to a specific intervention program.

The responsibility to meet the challenge of curbing MSI in the fire/rescue service has been addressed by the program implemented by FCFRD’s Wellfit Division, the department’s in-house fitness and rehabilitation center. Wellfit is led by a CPT II and staffed with a Peer Fitness Trainer Coordinator (PFTC), a director of strength and conditioning, a physical therapists, and a team of Peer Fitness Trainers (PFT). It was agreed that the first steps involved a closer examination of injury data (e.g., nature, body part involved,

mechanism) and the development of a strategy to identify at-risk personnel. Analysis of injury data revealed several key components of the personnel’s MSI profile that needed consideration. First of these was that the overwhelming majority of MSIs were to the lower back, shoulder, and knee (Table 1). Low back injuries are the most common MSI in the fire service, and account for the largest percentage of MSI expenditure (12). As the FCFRD processed their injury data in greater detail, it became abundantly clear that the predominant mechanism of injury for low-back injuries was lifting (Table 2). The next step was to determine the best way to identify those personnel who might be predisposed to injury.

MOVEMENT SCREEN CONSIDERATIONS

Movement screens have been used in various forms to identify movement/mobility dysfunction with varying degrees of success. Among established movement examinations, the Functional Movement Screen™ (FMS™) may be the most widely employed. Consisting of seven movement demands, the FMS is intended to provide an assessment tool for ascertaining the competence of an individual’s movement (5). The FMS has been shown to be an apt tool for performing gross movement screening on the general population and for eliciting a positive change in movement patterns (5). However, it has been demonstrated that there are components of the FMS that can potentially invite inaccurate assessments of movement proficiency, especially in tactical populations as it relates to movement proficiency in a high-stress environment (4). The most notable of these components, as they relate to tactical populations, are the absence of exertional factors (e.g., load, speed, fatigue) and the equivocal nature of quantifying movements of varied complexity with a limited ordinal system (1,2,4,6,7,10).

Returning to the example program implemented by the FCFRD, there were several challenges in constructing a screen for the department. The screening events needed to be specific to fireground activities but also mimic typical functional movements, create a positive attitude towards the screening, select appropriate movement demands, take time-constraints into consideration, and incorporate both load and fatigue. Given that the intention was to reduce the risk for lower back, knee, and shoulder injuries, movements needed to be selected so that they might help to rule out dysfunction for the lumbo-pelvic system, the lower extremity, and the shoulder girdle, respectively. The input of the PFTs was invaluable during this process. Another consideration was the desire to move away from the nomenclature and mindset of “screening,” to something more supportive and constructive. A “workshop” seemed to be the perfect solution and was selected as the designation for this department’s “screening” process—the FCFRD’s Functional Movement Workshop (FMW).

INJURY RISK REDUCTION PROGRAMS FOR FIREFIGHTERS— A CASE EXAMPLE

TABLE 1. DISTRIBUTION OF MSI SITE OF INJURY WITHIN FCFRD

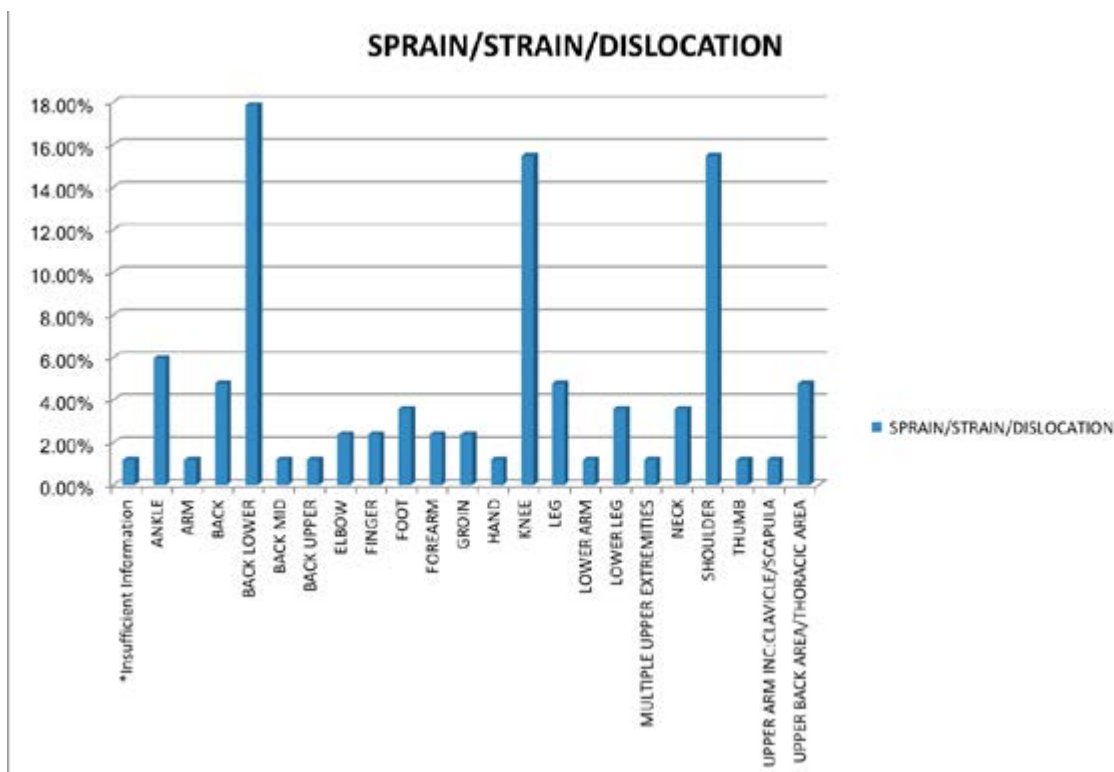
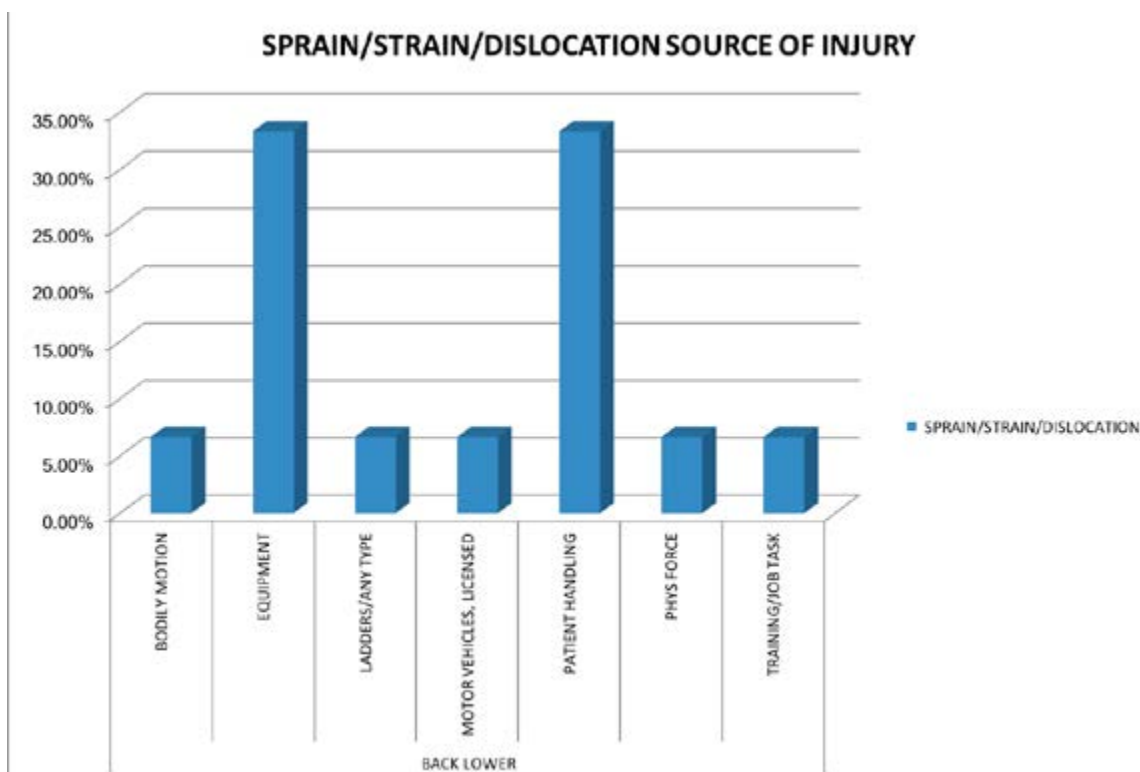


TABLE 2. MECHANISMS OF LOWER BACK INJURIES



The movements selected to populate a three-event format were the deadlift, in-line lunge (ILL), and overhead press (OHP). Although the initial movements are described as “unloaded,” it was decided that incorporating a baseline load on the deadlift and overhead press was necessary to create realistic mechanical demand and a degree of perceived risk. To justify the loads prescribed, a functional justification, or “tactical link,” had to be established. This was necessary to validate the magnitude of the load and address the need for parity of effort across the department’s population. Time constraints were another issue, as obtaining out-of-service time on an already engorged master calendar can be next to impossible. The solution was a format that required only 30 min of out-of-service time and also afforded one-on-one interaction between the staff and each firefighter. Lastly, the program needed to incorporate load and fatigue. This was accomplished by inserting a short but intense session consisting of exercises performed with as many repetitions as possible (AMRAP). Afterwards, the firefighters donned a self-contained breathing apparatus (SCBA) and repeated the screening events (Table 3).

THE WORKSHOP FORMAT

In the example of the FCFRD program, a staff of 4 – 5 (2 – 3 PFTs, the strength and conditioning director, and the PFTC) set up in the bay of the predesignated station. Crews were scheduled through the battalion to rotate through every 30 min. Incoming crews filled out the FMW worksheet information section which included

their MSI history, were briefed by the PFT coordinator, and then assigned to an individual PFT. The workshop then proceeded with detailed instruction and a demonstration of what was expected for each particular movement, including a comprehensive explanation of the screening criteria. Some argue against this method purporting that it cues the participant too much and possibly white-washes existing movement dysfunction (3). The goal was to raise awareness, coach, and educate the individuals involved in the program, so the FCFRD set out to give the firefighters every possible advantage to realize improved biomechanics.

The active portion of the workshop followed the instruction. The firefighters performed the prescribed movement while unloaded and unfatigued. The PFT paired with each firefighter observed them from multiple angles, annotated the workshop sheet, and used the workshop guide as a resource/reference for coaching the movements (Tables 4 – 6). At the completion of the third event, the overhead press, the PFT took each firefighter through five minutes of the AMRAP session. While this was done in a self-paced fashion, the firefighters were encouraged to work as hard as possible. This also provided an invaluable coaching opportunity and another platform for raising awareness. Form and movement decrements were documented on the workshop sheet (Table 7). At the immediate conclusion of the AMRAP session, the firefighters donned the SCBA and repeated the events. The PFT observed the firefighters again and annotated movement and postural anomalies.

TABLE 3. AMRAP SESSION

FUNCTIONAL MOVEMENT WORKSHOP INTERVAL CALISTHENICS—5 MINUTES	
	10 free-standing squats
	30 jumping jacks
	10 down-ups/burpees—to standing only (no jump)
	10 counter-movement jumps
	10 push-ups (hands or knees)
	10 alternate forward lunges (5 each leg)

TABLE 4. DEADLIFT COACHING GUIDELINES

Deadlift:

Address

- a. **Bar Position** – Barbell should be close to the tibia/shin to facilitate keeping the load nearest the center of gravity.
- b. **Foot/hand placement**
 - i. Feet – should be positioned under the shoulders and aligned so that the axis of knee flexion/extension is parallel to the line of the foot and femur
 - ii. Hands – Generally positioned on the bar under the shoulders. Grip can be traditional or off-set.
 - iii. Shoulders – should be just anterior to the bar
- c. **Joint Stack** – From the floor up, the knee, hip, and shoulder should be positioned in order, respectively. i.e. the hip should not be at the level of, or below, the knee and the shoulder should not be at the level of, or below, the hip.

Spine

- d. **Curvatures** – As observed in standing posture, curvatures of the spine should be maintained from address to completion and back to the floor. i.e. the gentle extension curves of the Lumbar and Cervical spine, and the moderate flexion curve of the Thoracic spine.

Lift Mechanics

- e. **Up (knee ext; hip ext)**
 - i. From the floor, the bar should be accelerated by knee extension until the bar reaches the knee joint. This can be observed by gauging the rate at which the hip and shoulder rise – this pace should be symmetrical.
 - ii. Once the bar reaches the knee, the hip should begin to “un-hinge” – hip extension as the knee continues to extend. At the finish, the shoulders should be vertically loaded just slightly posterior to the hip. The hip should be loaded directly over the knee. The knee should be slightly flexed or “soft” (**Never** “locked” when loaded)
- f. **Down (hip flex; knee flex)**
 - i. The initial lowering action should be a hinging of the hip joint, with the soft knee position remaining largely static. This causes the hip to move posteriorly and shoulder to move anteriorly as the lifter maintains the center of mass over the center of gravity.
 - ii. When the Barbell is at the knee, the knee should begin to flex and hip flexion (hinging) essentially stops. A rigid trunk and hip maintains stability while the flexing knee lowers the barbell to the floor.

TABLE 5. IN-LINE LUNGE COACHING GUIDELINES

In-Line Lunge

Trunk/Dowel

- a. **Hip/shldr velocity equal** – Do the hip and shoulder move in unison (at the same speed). This is especially important as the participant returns to standing from the lunge. Asymmetrical trunk/hip velocity can indicate one of two deficiencies:
 - i. **Weak/inactive trunk extensors (glutes, erector spinae, et al)**. The hip will move with more velocity than the trunk and the spine will tend to collapse into flexion and lag the pace of the lower body. The trunk “catch up” to the hip very gradually throughout the return phase of the lunge.
 - ii. **Weak knee extensors/arthritis or degenerative changes in the knee**. The knee extensor mechanism cannot generate enough force (or the pain is prohibitive) to overcome the moment-arm of the trunk as it accelerates with the center of mass, the trunk will flex; decreasing the moment arm and allowing the knee extensor to elevate the body’s center of mass. The knee and hip then briefly act isometrically and the trunk will “whip” into extension; overcoming the inertia of the moment arm and gaining the momentum necessary for the participant to return to standing.
- b. **Remains vertical**– The dowel should remain vertical in both the sagittal and frontal plane throughout.
- c. **Maintains Contact**- The participant should be able to maintain contact with both hands (behind head and against the lumbar spine) throughout the movement,

Knee Joint

- a. **Alignment** – As the participant lunges, the knee should flex along a line that is parallel to the centerline of the foot.
- b. **Touches Beam** – the participant should have a level of overall strength and mobility that permits them to lunge deeply enough to touch the beam with the trailing knee.

TABLE 6. OVERHEAD PRESS COACHING GUIDELINES

Overhead Press

A-P View

- a. **Symmetry** – Each upper extremity should move in unison; same angles, same pace. In the finish position, the shoulder girdle should be level.
- b. **Load Alignment** – During the press, the DB should generally stay positioned directly above the elbow. At the finish position, there should be a relatively straight line from the DB, through the shoulder, to the floor.

Lateral View

- c. **Load Alignment** - During the press, the DB should generally stay positioned directly above the elbow. At the finish position, there should be a relatively straight line from the DB, through the shoulder, to the floor.
- d. **Posture** – The participant’s posture should remain in a relatively neutral position; with a plumb line from the DB through the shoulder, hip, knee, and ankle.

TABLE 7. FMW COACHING WORKSHEET

FCFRD Well-Fit Functional Movement Workshop														
Name:		Age:		Gender (1= M 2=F):		Date of Workshop:								
Prior Musculoskeletal Injury (y or n):		Location of Injury:				Surgical/ Medical History:								
Station or work locale/Shift:		Yrs of Service:												
Initial														
Deadlift					In-Line lunge					Overhead Press				
Address					Trunk/Dowel					A-P View				
Criteria	Optimal	Non-opt	Corrected		Criteria	RIGHT LEG FORWARD	Optimal	Non-opt	Corrected	LEFT LEG FORWARD	Optimal	Non-opt	Corrected	
Bar position														
Feet/Hands/shoulders														
Joint "Stack"														
Spine					Knee Joint					Lateral View				
Criteria	Optimal	Non-opt	Corrected		Criteria	RIGHT LEG FORWARD	Optimal	Non-opt	Corrected	LEFT LEG FORWARD	Optimal	Non-opt	Corrected	
Curvatures														
Lift Mechanics														
Criteria	Optimal	Non-opt	Corrected		Criteria	RIGHT LEG FORWARD	Optimal	Non-opt	Corrected	LEFT LEG FORWARD	Optimal	Non-opt	Corrected	
Up (knee ext; hip ext)														
On (hip flex; knee flex)														
Exertion Session Observations:														
Fatigued/Loaded														
Deadlift					In-Line lunge					Overhead Press				
Address					Trunk/Dowel					A-P View				
Criteria	Optimal	Non-opt			Criteria	RIGHT LEG FORWARD	Optimal	Non-opt	Corrected	LEFT LEG FORWARD	Optimal	Non-opt	Corrected	
Bar Position														
Feet/Hands/shoulders														
Joint "Stack"														
Spine					Knee Joint					Lateral View				
Criteria	Optimal	Non-opt			Criteria	RIGHT LEG FORWARD	Optimal	Non-opt	Corrected	LEFT LEG FORWARD	Optimal	Non-opt	Corrected	
Curvatures														
Lift Mechanics														
Criteria	Optimal	Non-opt			Criteria	RIGHT LEG FORWARD	Optimal	Non-opt	Corrected	LEFT LEG FORWARD	Optimal	Non-opt	Corrected	
Up (knee ext; hip ext)														
On (hip flex; knee flex)														
Additional Notes:														
PFT NAME														

A critical piece of this process was video capture. The PFTs were supplied with tablets and software that allowed them to record the firefighters as they completed the workshop. The software was performance coaching software that allowed slow-motion replay and stop-action video replay. PFTs used this video capture technology to create visual feedback for the firefighters (e.g., including graphics and lines to demonstrate joint/segment angles, postural alignment, rates of change, and positional changes). It would be difficult to overstate the impact that this has on increasing awareness and improving the coaching experience for all concerned (Figures 1 and 2).

MOVEMENTS

DEADLIFT

Observation of the deadlift can reveal a host of sub-optimal components as they relate to a firefighter's lifting technique, such as the position of the load in relation to the firefighter, position and posture of the firefighter as they address the load, sequencing of movement systems, and lumbo-pelvic stability and posture. Another consideration included in the performance of the deadlift is the weight of the 24-ft ladder, which measured 73 lb in the FCFRD facility. Therefore, the load applied to the deadlift movement was 70 lb, which consisted of an Olympic bar and 2 x 15 lb bumper plates.

After instruction and demonstration, the firefighters performed the movement. The PFT had complete autonomy and allowed the firefighters to perform several repetitions if necessary (Figure 3). In the second round, after the AMRAP session, the firefighters

repeated the deadlift wearing the SCBA (Figure 4). During both evolutions, movement deficiencies were noted on the worksheet and they coincided with the coaching guidelines established by the facility.

IN-LINE LUNGE

The set-up for the ILL was essentially identical to the FMS format (Figure 5). During the ILL, the PFT assessed the firefighter's balance, lower extremity strength, knee frontal-plane stability, and lower extremity mechanics. Additionally, the PFT grossly assessed upper extremity range of motion by observing the firefighter's ability to hold the dowel rod correctly. Because assuming, and returning from, a kneeling position is a common requirement in tactical populations, the ILL was utilized because it mimicked lower extremity movement patterns commensurate with ingress/egress of apparatus, ladder and stair climbing, and many other tactical demands.

The firefighters received instruction and a demonstration of the movement (Figure 6). After the tibial measurement was performed, the firefighters were instructed to assume the correct stance on the beam and perform the ILL with the dowel rod held vertically behind their trunk (as in the traditional FMS format). The FMS balance beam was used for the initial event. Again, the PFT observed the firefighters from multiple angles and was free to coach and mentor the firefighters at their discretion after the initial assessment was completed. In the post-exertion phase, the dowel rod was removed and the firefighters were required to perform lunges wearing the SCBA (Figure 7).

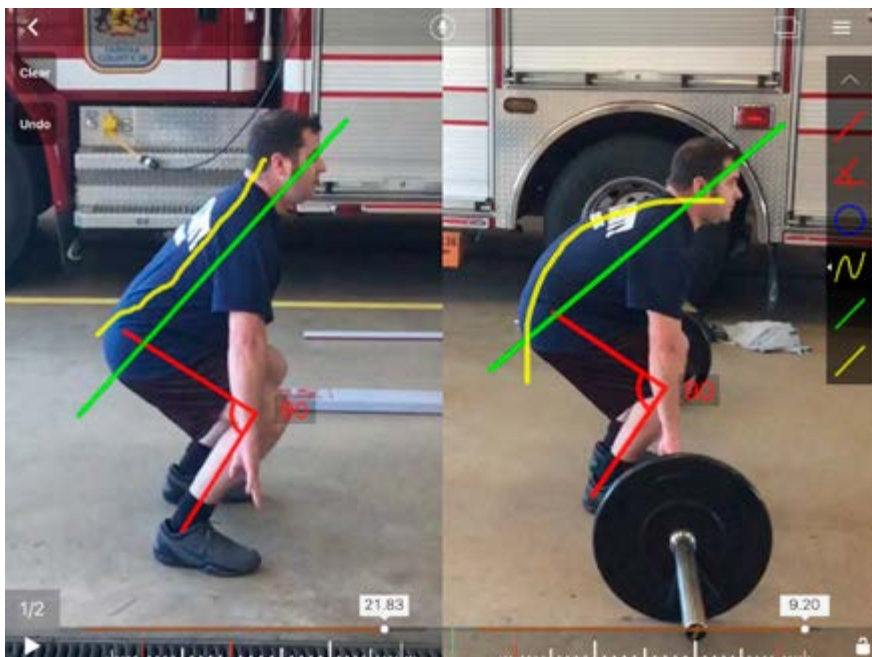


FIGURE 1. AFTER AND BEFORE COMPARISON OF DEADLIFT MECHANICS

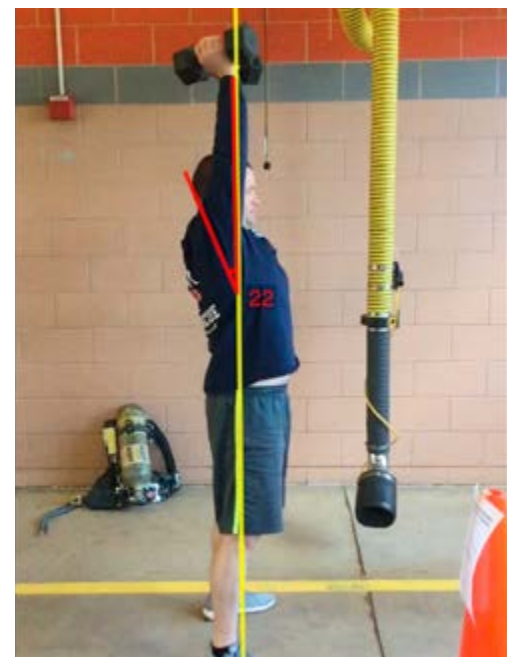


FIGURE 2. OVERHEAD PRESS WITH OVERLAY OF ANGLE OF THORACIC EXTENSION

INJURY RISK REDUCTION PROGRAMS FOR FIREFIGHTERS— A CASE EXAMPLE

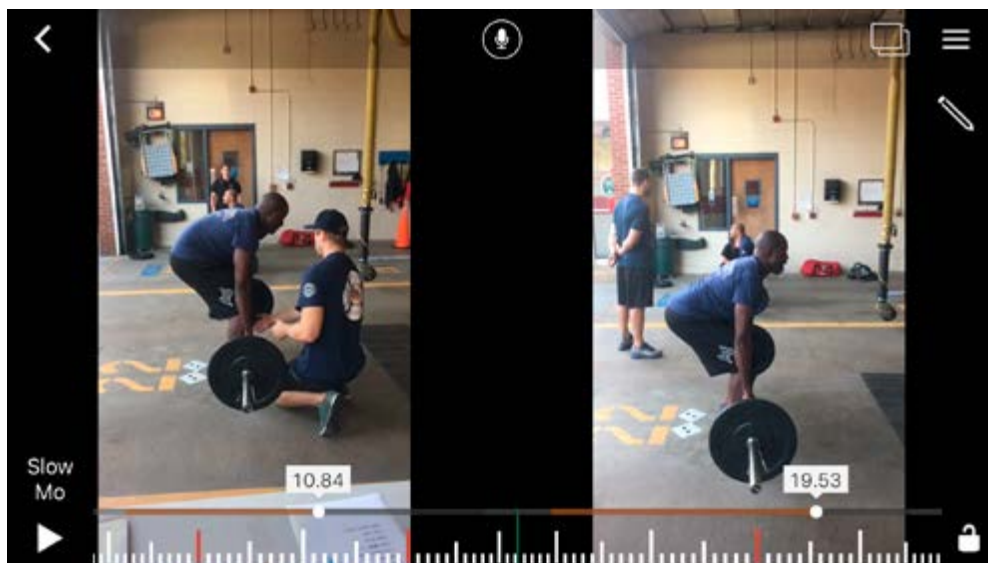


FIGURE 3. REPEATED ATTEMPTS AND RESULTS OF COACHING CORRECTIONS



FIGURE 4. DEADLIFT AFTER AMRAP
SESSION WITH SCBA



FIGURE 5. ILL WITH IMPLEMENTS



FIGURE 6. COACHING ILL TECHNIQUE

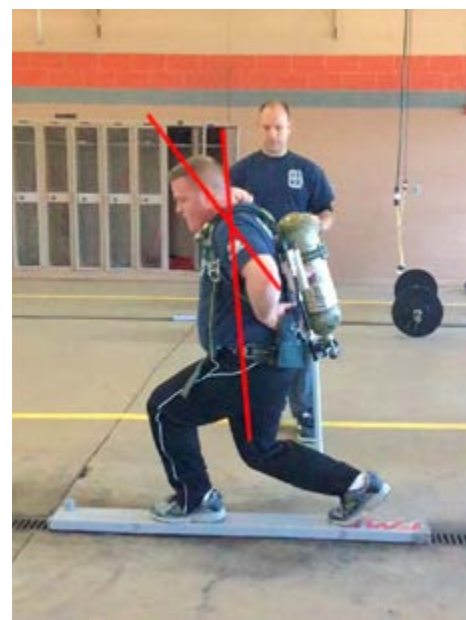


FIGURE 7. ILL AFTER AMRAP WITH SCBA
AND SPINE ANGLES

OVERHEAD PRESS

The issue of how to approach screening for shoulder injury risk is a difficult one. The approach of thoroughly examining the mechanical integrity of the shoulder is as complex as the joint itself. In order to maintain the efficiency of the workshop and stay within the scope of practice for the staff, it was decided that the overhead press was suitable for the purposes of the program. A load of 30 lb (two 15-lb dumbbells) was selected, as this is approximately the force needed in order to raise one end of the 24-foot ladder, as measured in the FCFRD facility with a force dynamometer. Being that there are innumerable overhead activities required in tactical operations with varied loads and velocities, an effort was made to maintain the integrity of the intent, which was to assess the upper extremities in terms of identifying injury risk and not to assess absolute upper extremity strength.

After instruction and demonstration, the firefighters stood with a dumbbell in each hand with their elbows flexed, and positioned the dumbbells at shoulder height (Figure 8). Then they pressed the dumbbells upward until their elbows were fully extended. The PFT observed the load placement, trunk posture/stability, and upper extremity positioning/stability. After the initial observation, the PFT was free to make adjustments and provide coaching and observations relative to posture and upper extremity alignment and axial loading.



FIGURE 8. STARTING POSITION FOR OVERHEAD PRESS

EVALUATION AND FOLLOW-UP

The PFTs utilized the workshop worksheet to guide their observations and evaluate the firefighters. Instead of an ordinal system, a nominal system of optimal/non-optimal assessment was used and applied to key movement features. These movement features became the driving force behind the evaluation format. Deviations from ideal movement patterns were noted as “non-optimal” and corrective actions were taken in the worksheet to address these issues. If the firefighter was able to correct the movement deficiency in the workshop, that component was noted as “corrected.”

The greatest number of movement deficiencies observed occurred during the deadlift movement. They include positioning issues (e.g., the firefighter taking their stance too far from the load), mechanical issues (e.g., inefficient sequencing of hip/knee flexion/extension, spinal control), and mobility issues (e.g., excessive posterior pelvic tilt/lumbar flexion). Thus, the deadlift becomes an extremely effective vehicle for increasing awareness of movement dysfunction and allowed for an accepting environment for introducing corrective/protective exercises to improve firefighter performance and reduce their risk of injury (Figure 9).



FIGURE 9. COACHING DEADLIFT TECHNIQUE

INJURY RISK REDUCTION PROGRAMS FOR FIREFIGHTERS— A CASE EXAMPLE

The ILL revealed dramatic changes in gross motor control after the AMRAP session, which resulted in losing balance. Apart from identifying dynamic internal rotation of the femur and early indications of limited shoulder range of motion, this significant decrease in balance was used to educate firefighters on the effect of fatigue as it related to their overall stability and balance. Postural issues and shoulder girdle range of motion limitations were the predominant non-optimal findings of the OHP. The OHP allowed the PFTs to observe upper extremity mechanics, axial loading of the shoulder, and the firefighter's dynamic posture.

CONCLUSION

The program implemented by the FCFRD is an example of how a department can attempt to address and potentially prevent MSI in firefighters and similar tactical populations. This process includes the use of movement screens, active workshops, and various modes of feedback based on the evaluation of movement and the specific needs of the population.

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SLEEP HYGIENE STRATEGIES FOR TACTICAL ATHLETES

Sleep is one of the most important aspects of recovery and has the potential to influence optimal workplace performance. Tactical athletes, due to the nature of their jobs, may have sleeping problems such as falling asleep and/or staying asleep, which is indicative of poor sleep quality (3,11). For tactical athletes who are transitioning from deployment to garrison duties, getting quality sleep can seem almost impossible. Police officers, firefighters, and first responders who have shift schedules that rotate frequently may feel like they can never get into a regular sleep schedule. In addition, organizations that are short on personnel often require tactical athletes to work additional shifts or be on-call 24 hr a day, making eight hours of sleep per night very difficult to attain. The intent of this article is to help educate these groups in developing proper sleep hygiene programs for tactical athletes.

Work tasks, whether military missions, fighting wildland fires, or responding to an incidence where a person has barricaded themselves in a building, often require tactical athletes to perform job duties for long periods of time. In some instances, they may even go multiple days with little sleep and in order to continue to perform in these instances, some tactical athletes may consume energy drinks or coffee to stay awake. In some cases, tactical athletes may consume multiple energy drinks or cups of coffee to continue to perform. Consuming multiple energy drinks or cups of coffee may disrupt the body's day/night or circadian cycle, which is important because it is the cycle that governs when a person becomes sleepy, falls asleep, and how they sleep (3).

The variability in tactical tasks may sometimes cause tactical athletes to have trouble falling asleep and/or staying asleep. Working night shifts is part of the job for many tactical athletes and these nightly events can disrupt circadian rhythms, which help to regulate day/night cycles in the body (3).

Police officers, firefighters, and Special Weapons and Tactics (SWAT) teams may have atypical work schedules that may lead to sleep problems. Some may have shift work that changes every week, others may be permanently scheduled for the night shifts. In some departments, SWAT members also work in other divisions, such as traffic.

Tactical athletes may use technology that has screens, such as computer screens. These screens produce blue light which blunts the melatonin response in the user. Cajochen et al. stated, "our data indicate that the spectral profile of light emitted by computer screens impacts on circadian physiology, alertness, and cognitive performance levels," (4). Cajochen et al. also stated, "exposure to monochromatic blue light in the evening lengthens sleep latency," (4). Melatonin is the hormone that the body produces that makes the body sleepy. Using technology that blunts melatonin response may make it harder to fall asleep after a shift (6).

It is important to teach all tactical athletes about sleep hygiene. Some tactical athletes may not allow themselves to recover from deployment or after an extended period of work. If they do not engage in a sleep hygiene program, they may not recover, which may affect training for the next deployment or future job performance. It is also important for them to stop any habits started during extended periods of work (e.g., additional shift work, deployments, etc.) such as consuming multiple cups of coffee or energy drinks in one day, that while potentially necessary during these extended periods may negatively impact their sleep quality during more regular duties.

Commanders should teach all subordinates about sleep hygiene programs and then provide continuous training to maintain the habit. It is important that tactical athletes understand the importance of sleep and the impact it has on their physical and mental wellbeing. Lack of sleep results in fatigue, sleepiness, and decreases in alertness, vigilance, working memory, concentration, and problem-solving ability (8). In summary, poor sleep quality can lead to poor decisions on the job (8). Not all tactical athletes are affected the same way. Plumb et al. stated, "sleep problems were more severe among service members with less education, from lower ranks, with greater combat exposure, and greater depression, anxiety, and PTSD symptoms," (10).

SLEEP HYGIENE PROGRAMS

Sleep hygiene training should be taught to the tactical athlete and their family. It should be taught multiple times per year and as part of a dedicated sleep hygiene program. During the beginning of a sleep hygiene program, educational classes should be conducted more frequently so that the information is reinforced. Throughout the year, additional training should be provided and where possible, the hygiene programs should be tailored to the individual group.

The following are suggested guidelines for a sleep hygiene protocol that can form part of an educational program to be used by tactical personnel.

1. Turn off all screens an hour and a half before going to sleep
 - a. If allowed by the department, turn off the computer screen on the way back home or to the station
2. When possible, go to bed and wake up at the same time every day, even on the weekends
3. Do not hit the snooze button in the morning, get up when the alarm goes off
4. Exercise regularly every week
5. Develop a pre-bed ritual and do it daily (examples could include reading a book or meditating)
6. Do not eat a heavy meal, consume alcohol, or drink a lot of liquids before going to sleep
7. Avoid napping during the day
8. Some tactical athletes have to be in touch 24 hours, seven days a week, 365 days a year; if a phone has to be on, put it in a place where it can be heard but not seen
9. Do not do anything else in bed other than sleep

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