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NICK BARRINGER, CSCS, ERIK SERRANO, AND JOSEPH KARDOUNI, PHD, DPT

GRAVITATIONAL RUNNING AND THE TACTICAL ATHLETE

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INTRODUCTION

For tactical athletes, maintaining a peak level of physical fitness at all times is essential to mission completion and survival. They must be prepared to deploy to any environment at all times, and seek training methods to gain an edge over enemies on the battlefield. The military places particular emphasis on minimizing injury risk while optimizing running performance, given the need to develop and maintain cardiovascular fitness, speed, and endurance. This sometimes leads to adopting alternative or untested training methods and products. The Pose Method® and ChiRunning® are two commercial running techniques that have become increasingly popular among United States military personnel (5,9,11,12). These techniques promote a Running Pose or slight forward lean, which enables gravity to propel the runner forward for improved performance and reduced injury risk (16,19). The purpose of this article is to review these gravitational running (GR) techniques from an evidence-based approach, then recommend whether to include GR techniques in the training of tactical athletes.

BACKGROUND

GR techniques promote a decrease in stride length and vertical displacement of the center of mass, with an increase in stride frequency and ankle movement, and a midfoot to forefoot strike pattern (12). The foremost element of these techniques is the assertion that a slight lean forward creates the potential energy for forward movement. Forward lean is followed by a passive falling motion using gravitational torque to produce forward movement and minimize stress on lower extremity muscular and tendinous structures by requiring less muscular effort (10). GR running instruction methods also promote a reduction in ground reaction force, which accompanies shorter strides and forefoot strike patterns (10). The major GR programs both claim to improve efficiency, speed, and prevent injuries (16,19). The Pose Method webpage states "the end result is faster race times, freer running and no more injuries!" (16). The ChiRunning website states: "regardless of your experience, ChiRunning will help you: "set yourself up for a lifetime of injury-free running… go farther or faster with less effort… lower impact to your joints," (19). Given these claims, we assessed the evidence related to the three major claims of improving running efficiency, speed, and reducing injuries.

RUNNING EFFICIENCY

GR practitioners advocate that it improves running efficiency but the evidence used to suggest that these techniques improve economy appear to be inconsistent and suggests this technique provides no mechanical advantage (10,14,17). In a comparison of GR technique with a control group using their typical running techniques, Dallam et al. found that the GR group experienced a significant increase in submaximal absolute oxygen (3.28±0.36 1 x min-1 to 3.53±0.43 x min-1; $p<0.01$) cost after 12 weeks of instruction, where the control group did not (7). Fletcher and colleagues found a week of GR (Pose Method) training had no significant impact on oxygen consumption or 2,400-m run time performance (10). While not statistically significant, the GR group improved its 2,400-m run time by a mean of 24.7 s, compared to the control group running three seconds slower. The standard deviation was much greater in the control group run times both pre- and post-test (63.5 and 62.2 s, respectively) compared to the GR group (10.1 and 7.1 s, respectively); this indicates more variability among the runners in the control group even before the study began (10). It seems that there may have been influential data points that affected the outcome of the analysis. Craighead et al. found no difference in running economy after eight weeks of GR instruction in the experimental versus control groups (6). It is important to note that all studies demonstrated a significant change in kinematic variables, such as a decreased stride length (137.25± 7.63 cm to 129.19± 7.43 cm; $p<0.05$), so it appears it is not a case of the participants not executing the technique, but rather the technique not improving running economy. The findings of Dallam, Fletcher, and Craighead are in agreement with previous work that has demonstrated a freely chosen stride frequency and length is most associated with optimal running economy (4). Given the above evidence, we find the claim that GR makes the runner more efficient is not supported by research.

SPEED

It is well established that sprint speed is the product of stride length and stride frequency. However, after initial acceleration of 0 – 10 m, it has been demonstrated in athletes that stride length is the main driving factor for maximal velocity rather than stride frequency (8). In a study involving 109 male and 79 female elite sprinters, Paruzel-Dyja et al. reported stride length as the most important parameter for males, while stride frequency was the most important ($r=-0.39$; $p\leq0.01$) parameter for females. They also correlated increasing body mass and body height with greater stride length and lesser stride frequency (15). This work by Paruzel-Dyja demonstrated that a "one-size-fits-all" running

approach is inappropriate when attempting to maximize speed. The GR practice of shortening SL could hinder maximal sprint velocity for taller/heavier tactical athletes. Another principle of GR is the passive nature of the running technique aimed at minimizing ground reaction forces experienced by the runner. Researchers demonstrated that "exerting a large propulsive force during the entire acceleration phase, suppressing braking force when approaching maximal speed, and producing a large vertical force during the maximal speed phase are essential for achieving greater acceleration and maintaining higher maximal speed, respectively," (16). Thus, the practice of passively running and deliberately minimizing ground reaction forces may result in slower sprint speed. Sprinting is a major component of tactical movement; the "rush" is one of the three major individual movement techniques in the U.S. Army's doctrine (2). Tactical athletes must sprint to safe positions while under fire and while carrying external load. Thus, a slower sprint speed could make the tactical athlete more susceptible to enemy fire. The potential effects on tactical athlete performance and lethality must be evaluated before training tactical athlete *en masse* in a particular running technique.

INJURY REDUCTION

One of the claimed benefits of GR is a reduction in injuries. Although both the Pose Method and ChiRunning appear to decrease the eccentric work at the knee, it also appears to increases eccentric work at the ankle (1,13). Whether this reduces the risk of injury at some anatomical locations while increasing the risk at others is undetermined. Warr and colleagues found that heel strikers did not differ from non-heel strikers (midfoot or forefoot strikers) in terms of two-mile run performance or overuse injury rates among 341 male U.S. Army soldiers (18). Further, the Military Training Task Force of the Defense Safety Oversight Council found insufficient evidence in 2010 to recommend altering running stride length or cadence for injury reduction (3). There are some potentially positive aspects of GR in terms of shifting of stress from the knee to the ankle, potentially making it a suitable alternative for athletes with a history of knee injury (12). Also, to the authors' knowledge, there are no reports in peer-reviewed literature concerning GR style and injury risk for specific anatomic location and no data stratifying injury by running style. Thus, any claim that GR prevents injury does not appear to have sufficient support. Based on the current literature, further research and validation are needed before advocating for specific running techniques to reduce injuries among tactical athletes.

CONCLUSIONS

While GR instruction may have benefits for some, the science on running does not support it for everyone. Uniform/compulsory instruction to large populations may have unforeseen adverse effects and also waste personnel resources. GR technique should not become doctrinal or mandatory for military organizations or tactical athletes based on the current evidence. The current evidence does not support improvements in speed, running economy, or injury risk reduction through standardized instruction in a specific running technique. Further, the financial cost and the time required for GR training (up to 12 weeks, or possibly longer for experienced runners to adopt a specific running technique) do not justify investing in programs promoting GR instruction across a large military population. Military leaders should call for a more thorough evaluation of GR techniques and require empirical evidence to support the claims made by those who advocate for GR instruction. There is likely no single running technique that optimizes performance while minimizing injury risk for all runners.

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

TSAC REPORT—JULY 2019 RESEARCH COLUMN

THE EFFECT OF FIREFIGHTER PERSONAL PROTECTIVE EQUIPMENT ON STATIC AND DYNAMIC BALANCE. *ERGONOMICS* 62(9): 1-9, 2019.

BROWN, MN, CHAR, RM, HENRY, SO, TANIGAWA, J, AND YASUI, S.

A recent study published in the journal, *Ergonomics*, analyzed the effects of personal protective equipment (PPE) on static and dynamic balance in firefighters. Twenty-one career firefighters (20 males, 1 female) participated. The particpants had an average experience of 10 years and averaged 34 years of age. Participants completed the balance tasks under four conditions in random order: 1) athletic clothing [t-shirt, shorts, socks, running shoes], 2) turnouts [multiple layers of fire-resistant protective fabric, pants with suspenders, overcoat, gloves, boot, and a helmet], 3) turnouts and self-contained breathing apparatus (SCBA), and 4) turnouts, SCBA, and face mask.

After completing a one-hour familiarization session, participants performed: 1) static single-leg (SSL), 2) dynamic single-leg (DSL), and 3) limits of stability (LOS) tasks. Balance tasks were all performed on a Biodex Balance System™. The Biodex Balance System's platform can be adjusted to record at a static position or at various degrees of dynamic movement. The SSL task consisted of three 20-s trials with 10 s of rest between trials. Participants stood on their dominant leg with the other leg flexed 90 degrees. The DSL was performed in a similar fashion with the platform set a mid-level of dynamic movement commonly used for testing dynamic balance. This allowed the platform to move based on the force the participant exerted into the platform in order to maintain their balance. The LOS task used the same dynamic platform setup, but the participants had both feet on the platform. While viewing a screen in front of them, they were tasked with shifting their weight to move a cursor into eight targets set in a circle around the platform. Once the cursor hit the center of a target, participants were to bring the cursor back into the center of the platform before moving to the next target.

The results indicated there was no significant difference between the four conditions while performing the SSL. During the DSL task, condition (all equipment) was significantly different from control and PPE-only condition. Both conditions including SCBA were significantly different from the control during the LOS task, but the variability in the results was high; there appears to be only about 0.4 standard deviations of difference between conditions. The results indicate a small detriment to the balance of firefighters while wearing their full gear load. The biggest factor is most likely due to the additional weight the SCBA tank provides. The location and magnitude of the weight shifts the center of mass of firefighters, challenging balance. Based on this study, tactical facilitators who work with firefighters should include balance and agility drills with the inclusion of a SCBA or torso borne load. This will allow firefighters to have more experience adjusting their body movements under controlled conditions and in job-specific loads.

PROFILING THE OCCUPATIONAL TASKS AND PHYSICAL CONDITIONING OF SPECIALIST POLICE. *INTERNATIONAL JOURNAL OF EXERCISE SCIENCE* 12(3): 173, 2019.

IRVING, S, ORR, R, AND POPE, R.

One-hundred thirty-two officers in the Police Tactical Group (PTG) of the Australian-New Zealand Counter-Terrorism Committee completed a survey with questions related to demographics, occupational tasks/demands, occupational skills, physical conditioning, and injury history. Researchers in Australia analyzed these survey results to examine the occupational tasks and physical conditioning of specialist police. All officers included met three inclusion criteria: operational member of a PTG unit, currently attached to the operational teams of the unit, and serving full-time in the unit.

All 132 officers were male with an age range of 20 – 60 years, with the majority being 36 – 40 years. Most officers were 181 – 190 cm in height and 91 – 100 kg in weight. Occupational task results showed 61% of officers' most recent occupational task was the execution of a high-risk warrant with the next most common task being rural operations featuring long duration load carriage. Occupational tasks were reported by 84% to be completed in full operational equipment (PPE, ballistic helmet, ballistic vest, night vision goggles, gas mask, magazines, munitions, two or more weapons, and other task supporting equipment). During the most recent task, 76% reported carrying additional equipment essential to the task on top of their full operational load with the most commonly reported (31%) weight being 21 – 25 kg. The most common distance covered with these loads was between 501 m and 2 km (26%), but 17% reported an excess of 8.1 km. Thirty-seven percent reported having less than one hour to prepare for their most recent task, which reflects operational tasks' emergent nature.

Ninety percent (90%) of officers reported participation in both regular resistance training and aerobic activity, with 73% categorizing their physical training as occupation specific. The highest frequency of training over two weeks ranged from 4 – 8 times (83%), with 27% training less than four times in a two-week period and 17% training more than eight times. The most frequent duration of physical training was between 31 – 60 min (53%).

The results from the survey highlighted the occupational tasks specialist police are exposed to during their duties. Completing high-risk tasks while carrying 21 – 25 kg in both urban and rural environments demonstrates the need for these officers to be able to travel up to eight kilometers under load and still be able to perform their job at a high level once they reach their target destination. Since 32% noted the call-out nature of their most recent job task, the tactical facilitator will have logistical challenges in planning training sessions. Based on this study, tactical facilitators should focus on training methods that help police manage external loads, including the use of external loads during aerobic and anaerobic conditioning where appropriate.

PHYSICAL FITNESS PREDICTORS OF A WARRIOR TASK SIMULATION TEST. *THE JOURNAL OF STRENGTH AND CONDITIONING RESEARCH* 32(9): 2562-2568, 2018.

HUANG, HC, NAGAI, T, LOVALEKAR, M, CONNABOY, C, AND NINDL, BC.

Researchers at the University of Pittsburgh examined the relationship between different physical fitness components and the warrior task simulation test (WTST). Forty-three male participants (21.5 ± 2.9 years, 177.9 ± 7.7 cm, 77.8 ± 11.1 kg) were recruited for the study. Participants engaged in regular physical training at least five days per week for at least 60 min. The study was split into two sessions including a laboratory test session and a WTST session on an indoor football field. The WTST is essentially a modified Army Combat Readiness Test with a shorter running distance in order to perform the entire test on an indoor football field.

The WTST was a nine-station circuit course performed in a continuous and sequential order. The course began with a 282 m run followed by running over low hurdles (0.5 m) placed 1.8 m apart. This was followed by a 9.1 m crawl going under and over 1.4 m and 0.9 m tall hurdles. Participants then dragged an 81.6 kg sled in a figure eight pattern around two cones placed 9.1 m apart. This was followed by carrying two 13.6 kg ammunition cans across three 1.8 m long balance beams. Next, they were required to shimmy through an 8.5-m long obstacle while pointing a weighted plastic pipe in a firing position, then performed five 18.3 m up-backs while carrying two 13.6 kg ammunition cans. The final circuit included sprinting around six cones placed in an "S" pattern covering a 4.6 x 9.1 m area. Participants completed the course in athletic clothes, Army combat helmet, and a weighted plastic pipe that was a similar in size and weight to an M4 rifle.

The laboratory tests included: recording body composition and fat-free mass via bioelectrical impedance, pro-agility, sit-and-reach, dynamic postural stability during a one-legged landing task, knee muscular strength performed on an isokinetic dynamometer, shoulder muscular endurance performed on a isokinetic dynamometer (rotation), anaerobic capacity during a 30-s Wingate test, and aerobic capacity recorded via graded treadmill running test.

The results demonstrated a relationship between course completion time and muscular endurance (R2=0.123), aerobic capacity (R2=0.340), anaerobic capacity (R2=0.343), estimated percent body fat (R2=0.281), and agility (R2=0.176). Both aerobic and anaerobic capacity had the strongest relationship to course completion time and were nearly identical. Based on this data, the importance of both energy systems, when it comes to performing the WTST, even with the shorter running duration is essential. Tactical facilitators who work with potential Army recruits should monitor aerobic and anaerobic training status while including agility drills, and should monitor external load carriage whenever possible. Monitoring body fat percentage throughout a training program may also assist facilitators in knowing how training affects body composition.

SLEEP HEALTH AND ITS ASSOCIATION WITH PERFORMANCE AND MOTIVATION IN TACTICAL ATHLETES ENROLLED IN THE RESERVE OFFICERS' TRAINING CORPS. *SLEEP HEALTH* 5(3): 309-314, 2019.

RITLAND, BM, SIMONELLI, G, GENTILI, RJ, SMITH, JC, HE, X, OH, H, ET AL.

Researchers recently published a study examining how sleep health influences performance and motivation in the Reserve Officers' Training Corps (ROTC). Fifty-four students (29 males, 26 females) enrolled in the ROTC participated in the study. Participants wore wrist actigraphs to monitor their sleep-wake patterns for seven days prior to performing a battery of cognitive/motor tests and completed a sleep diary during the study. Each participant was asked to rate their sleep quality on a scale of one (very poor) to five (very good).

Performance testing was conducted after the seven days of sleep monitoring. Participants refrained from caffeine six hours prior to testing. After completing questionnaires on subjective sleepiness and anxiety, participants performed the cognitive/motor test battery. The tests included Psychomotor Vigilance Test, Flanker Task, Trail Making Task, Symbol Digit Modalities Task, and maximum broad jump. After each task, participants rated their motivation to complete the tasks. The Psychomotor Vigilance Test consisted of participants responding on a computer when a red circle appeared on screen. The test lasted for 5-minutes and response time for each response was recorded. The Flanker Task involved responding quickly and accurately to arrows displayed on a screen and using the keyboard to respond to the corresponding direction. Multiple arrows are displayed, with the correct direction being displayed in a different color. The Trail Making Task involved using pen and paper to draw lines connecting numbered circles

from 1 – 13. The Symbol Digit Modalities Task involved using a pen and paper to match as many numbers and geometric shapes in 90 s. There were nine different symbols that corresponded to the numbers 1 – 9. This task was repeated with the participant verbally instructing the researcher to write in the numbers corresponding to the shapes. Finally, participants were given three trials to perform a maximal broad jump with the average distance of the three reported.

Participants reported an average sleep time of 6.17 ± 0.69 hours with the average sleep quality rated as 3.40 ± 0.57. When controlling for age and gender, the Symbol Digit Modalities Task and motivation to perform the tasks were significantly associated with sleep duration. These results revealed how ROTC students on average got less than the recommended seven hours of sleep a night and how this lack of sleep affected cognitive processing speed and motivation level. Based on this study, while tactical facilitators do not have much control over the sleep routines of tactical athletes, it is important to inform them about the importance of sleep and encourage them to get the recommended seven hours of sleep to promote optimal cognitive function.

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ABDOMINAL AND LUMBO-PELVIC STABILITY EXERCISES FOR FIRST RESPONDERS

INTRODUCTION

Firefighters and police officers (i.e., first responders) perform a variety of tasks in their profession. These tasks can include lifting, dragging, carrying, and running (20,21,31). All of these tasks can be performed more efficiently if the first responder can actively and appropriately engage the muscles of the trunk and lumbo-pelvic region (22,33). In addition to this, several of these job tasks are performed under the load of the equipment required by the tactical professional (21,31). Numerous studies have indicated the benefits of strength to load carriage in tactical populations (21). The abdominal, lower back, and trunk/core region are an important part of this system. The term "core" can be used very generally; however, McGill provided a more specific definition (30). McGill defined the "core" as comprising the lumbar spine, abdominal wall muscles, back extensors, the quadratus lumborum, in addition to other muscles that pass through the core linking to more distal segments (30). The use of the term "core" in this article is within the context of this definition. The ability to dynamically lift, drag, and carry objects under load requires a necessary amount of core and lumbo-pelvic engagement (22,33). With appropriate engagement of the core, first responders will be able to more efficiently complete these movements.

The sit-up is an exercise that is most commonly used during both training and testing during academy for first responder recruits (7,8,31,34,35). This exercise is convenient to program as it requires no equipment, and it is a relatively easy test to administer. Despite its convenience, the sit-up does have limitations (3,6). Firstly, the sit-up has been found to generate very high compressive forces in the L4/L5 spinal region (1,3). Secondly, the sit-up does not target the entire core and lumbo-pelvic region of the body; it only targets a specific area (i.e., the rectus abdominis) (3). To achieve the most efficient movement and the full benefit of having a strong core, other muscles comprising the core and lumbo-pelvic region (e.g., rectus abdominis, internal and external obliques, transversus abdominis, multifidus, and quadratus lumborum) should be targeted during training, not just one part (1,3).

This article will discuss why it is important for first responders to have abdominal and lumbo-pelvic strength in relation to movements and tasks in their specific jobs. In accordance with this, other options for abdominal exercises that can be used for first responders will be provided (3,6,18). How these exercises could be introduced into training will also be discussed.

IMPORTANCE OF CORE (ABDOMINAL AND LUMBO-PELVIC) STRENGTH FOR FIRST RESPONDERS

As stated above, tasks such as lifting, dragging, and carrying are used throughout different tactical professions. For example, this is seen in both law enforcement and firefighting when lifting and moving equipment, dragging people, carrying hoses, and other tasks of that nature. To perform all of these tasks with accuracy and efficiency, core stability is necessary (1,22,33). Research has shown the importance of core stability in producing efficient trunk and limb actions for not only the generation and transfer of energy, but also for the control of energy (1,22,33).

In addition to the aforementioned tasks performed by tactical professionals, running and change of direction ability can be an important component in tactical fields as well. These capacities are demonstrated in different elements of the tactical profession, especially for law enforcement officers (e.g., during foot pursuits) (4,26,27). Firefighters must also move efficiently when they are carrying a charged hose, or traversing through urban or rugged terrain. The actions of first responders demand that their body can move in multiple directions very quickly as the situation demands. Numerous studies have shown that there is an improvement in the performance in multidirectional tasks when core stability is strong (1,22,33).

First responders are also required to perform their duties under the influence of their necessary body armor and equipment (21,31). The average load that law enforcement officers carry is 8 – 10 kg, while officers in specialists units can carry approximately 22 kg (21). Firefighters carry approximately 16 – 22 kg of additional load (21,31). While these loads are very specific and necessary for the chosen occupations, studies have shown a decrease in performance the higher the load carriage becomes (7,21). Police officers experience a decrease in performance by 13 – 42%, most noticeably in their mobility, while wearing approximately 10 kg of body armor (9,21). Officers are off-balance longer; slower to complete acceleration, grapple and mobility tasks; and will also complete fewer chin-ups as a measure of upper-body strength (9). Holewun and Lotens found that, on average, physical performance decreased by 1% per 1 kg of additional load (17). This decrease in performance is measured by the increased physical and physiological hardship correlated with the need to carry the load demanded by the job (9,21). Examples of physiological hardship include an increase in relative work as measured by heart rate and oxygen consumption, along with the decreased ability to produce force rapidly (9,21). Angelini et al. found that firefighters who

need to carry additional load intensified the fatigue effect, which potentially contributed to a greater trip and fall risk (2).

Decrements in job task performance are demonstrated in the lack of ability for first responders to sustain physical activity for prolonged periods of time, decreased ability to generate high amounts of force rapidly, and can also be due to limited mobility and loss of stability (7,21). Although several physiological factors can be related to this, a contributing factor is the ability to control the muscles about the abdominal and low back region. Lack of ample coordination in core musculature can lead to a decreased efficiency of movement (1). Numerous studies have shown that movement control and stability are developed in a core-to-extremity progression (1,22,33). Therefore, the stronger the core musculature is, the more safe and efficiently movement can be completed and load can be carried.

Although the need to carry occupational load can negatively affect the performance of certain tasks, several studies have also shown that performance will improve due to more stability in a strong core (10,22,33). When all of the core musculature is working synergistically and efficiently, this results in proper force distribution and maximum force generation with nominal compressive, translational, or shearing forces at the joints of the kinetic chain (1). As a result, tactical occupations can benefit from maintaining a strong core while still enduring the load of their body armor and equipment. This can be developed via the appropriate selection and implementation of exercises targeting this region of the body.

APPLICATION TO TRAINING

First responders serve in physically demanding occupations, therefore the inability to physically perform their duties due to poor strength and endurance could severely compromise their job tasks (7,31). Depending on the exercise, abdominal and lumbo-pelvic exercises should be performed for 2 – 6 sets with 12 or more repetitions when training for endurance or six or less repetitions when training for strength (11). They can also be performed for time making it more specific to the testing that often occurs during academy (7,8,31,34,35). Additionally, McGill has recommended that the duration of isometric exercises should be under 10 s and build endurance via repetitions, not by increasing the duration of the holds (30).

Core, abdominal, and lumbo-pelvic exercises could be completed at the end of a physical training session, or as part of a circuit. It should be noted that the exercises and prescription suggestions are for healthy individuals who are not experiencing any back pain or dealing with pain from a previous injury. There would ideally be accommodations made for any individual experiencing pain or dealing with an injury, and a medical provider should be consulted.

EXAMPLE EXERCISES

DEAD BUG

The dead bug can challenge the rectus abdominis, external obliques and internal obliques, and is shown in Figures 1 and 2 (32,41). This can be an effective exercise for promoting stabilization of the trunk and pelvis (41). Additionally, this may aid in superior generation, transfer, and control of forces from the trunk through to the distal segments of the arms and legs (22,33). This exercise may aid first responders when they have to maintain a stable base of support while also picking up and transferring equipment in multiple directions. The dead bug should be performed starting in a supine position. Both arms should be fully extended out in front. Both hips and knees should be flexed at a 90° angle (Figure 1). Either arm should then be moved via shoulder flexion until the elbow is next to the head. The opposite leg should move simultaneously until the hip and knee are fully extended (Figure 2). The exercise is continued for the required repetitions by alternating on each side.



FIGURE 1. DEAD BUG - STARTING POSITION



FIGURE 2. DEAD BUG - SHOULDER FLEXION AND LEG EXTENSION

BIRD DOG STARTING IN QUADRUPED (32,40)

This exercise targets the internal oblique of the elevated arm and the erector spinae on the side of the elevated leg (15). This exercise can be beneficial for the first responder population as it challenges trunk stability in both the frontal and sagittal plane, which could provide direct translation to job tasks as many movements occur in multiple planes of motion simultaneously (36). An example of this movement may be when first responders are on the floor in a quadruped position and have to maneuver objects or equipment out of the way. This exercise should be performed starting in the quadruped position with hands placed directly underneath the shoulders and knees placed directly underneath the hips (Figure 3). The contralateral arm (shoulder flexion) and leg (hip and knee extension) should then be moved fully forward and behind, respectively (Figure 4). To finish, the contralateral arm and leg should be brought back to the quadruped position and alternated to the other side for the required repetitions.



FIGURE 3. BIRD DOG—STARTING POSITION



FIGURE 4. BIRD DOG—SHOULDER FLEXION AND LEG EXTENSION

PLANK

The plank exercise primarily recruits the rectus abdominis, external obliques, and gluteus medius (19). The plank trains the large and small muscles to work synergistically to stabilize the trunk, thus improving physical functioning (24). Improving physical function can be useful to the first responder population because establishing proper movement patterns may help to prevent injury, for example when transferring and maneuvering patients in the field, therefore potentially contributing to a more efficient performance of job tasks. This exercise should be performed in a prone position with the hands placed directly underneath the shoulders and held isometrically for a specific time (Figure 5).



FIGURE 5. PLANK

BIRD DOG STARTING IN PLANK (32)

This is a good way to progress the bird dog starting in the quadruped position by starting in a full plank position. The hands should be placed directly underneath the shoulders with the feet shoulder-width apart (Figure 6). The contralateral arm (via shoulder flexion) and leg (via hip extension) should then be extended out fully (Figure 7), as they were in the first bird dog exercise. The contralateral arm and leg should return to the starting position and the same should be repeated on the other side for the required repetitions.

SIDE PLANK

The side plank is shown in Figures 8 and 9 (16,32). This exercise targets the rectus abdominis, external obliques, and quadratus lumborum (12,16,29). The side plank could be beneficial for first responders because isometric training has been shown to improve muscle strength, which may assist in performing tasks such as carrying hoses, dragging colleagues or civilians, and moving equipment (23). This exercise should be performed on either side and held isometrically for the duration specified by the tactical facilitator. The planted arm should be fully extended and the feet should be stacked on top of one another (Figure 8). The other arm should be reaching straight up and remain there for the duration of the exercise. To regress this exercise, the feet may be placed in a staggered stance, as shown in Figure 9.



FIGURE 6. BIRD DOG STARTING IN PLANK—STARTING POSITION



FIGURE 8. SIDE PLANK WITH FEET STACKED



FIGURE 7. BIRD DOG STARTING IN PLANK—SHOULDER FLEXION AND LEG EXTENSION



FIGURE 9. SIDE PLANK WITH FEET STAGGERED

PRONE BRIDGE PLANK ON SWISS BALL

The prone bridge plank on a Swiss ball targets the rectus abdominis, external obliques, and erector spinae (13,38). Performing this exercise with a Swiss ball increases the intensity versus the normal plank exercise and has been found to be effective in achieving trunk stability (24). This exercise could be beneficial for the first responder population because it provides adequate stimulus to increase anterior muscular strength and endurance and increases the challenge on the abdominal muscles (38). The exercise should be performed starting in a prone plank position with a Swiss ball placed directly underneath the shins and feet (Figure 10) (13,32). The hands should be placed underneath the shoulders and this position should be held isometrically for the time specific for the exercise.



FIGURE 10. PRONE BRIDGE PLANK ON SWISS BALL

SQUAT BALL THRUST WITH SWISS BALL (14)

This exercise targets the rectus abdominis, external obliques, and erector spinae (13,38). It could be beneficial for the first responder as it may increase anterior muscular strength and endurance (38). This exercise should be performed starting in a prone plank position with the hands placed directly underneath the shoulders and the shins resting on the Swiss ball (Figure 11). Using the anterior core musculature, the ball should be pulled in via flexion of the hips and knees until the ball is directly under the top of the feet or shoes (Figure 12). The ball should then be pushed back by extending the legs back out behind until the ball is resting underneath the shins again.



FIGURE 11. SQUAT BALL THRUST WITH SWISS BALL—STARTING POSITION



FIGURE 12. SQUAT BALL THRUST WITH SWISS BALL—HIP FLEXION AND KNEE FLEXION

MOUNTAIN CLIMBERS

Mountain climbers target the rectus abdominis and external obliques and are shown in Figures 13 and 14 (16,32). This exercise could be beneficial for first responders due to the exercise challenging coordination and balance, both of which are necessary in order to perform their dynamic job tasks with accuracy and efficiency (e.g., lifting, dragging, carrying) (16). This exercise should be performed starting in a prone plank position (Figure 13). The head and neck should be in a neutral position with the hands directly under the shoulders. Either knee should then be brought to the same side elbow (Figure 14) and repeated on the other side, alternating legs throughout the exercise for the required repetitions.

AB WHEEL ROLLOUT

This exercise challenges the rectus abdominis and the erector spinae as an isometric contraction for trunk stabilization (28). This exercise is commonly used for improving upper body and trunk strength and power (28). Research has shown that training with an exercise like the ab wheel rollout could improve proprioception and coordination, and this can have a favorable influence on power production (37). This could be very beneficial for the first responder population because adequate usage of power in the body aids in personal safety and mission success (21). This exercise is performed in a starting position with knees flexed at 90° and placed directly underneath the hips. The arms should be fully extended and positioned directly underneath the shoulders with the hands placed on either side of the ab wheel handles with a closed grip (Figure 15). The arms should then extend forward until the trunk is parallel with the floor (Figure 16). The ab wheel should then be rolled back towards the knees to complete one repetition. The core should remain engaged, and the pelvis should be positioned in a posterior pelvic tilt through the duration of the exercise.



FIGURE 13. MOUNTAIN CLIMBERS—STARTING POSITION



FIGURE 15. AB WHEEL ROLLOUT—HIP EXTENSION AND SHOULDER EXTENSION



FIGURE 14. MOUNTAIN CLIMBERS—HIP EXTENSION AND KNEE FLEXION



FIGURE 16. AB WHEEL ROLLOUT—STARTING POSITION



FIGURE 17. AROUND THE WORLD WITH A KETTLEBELL—STARTING POSITION



FIGURE 18. AROUND THE WORLD WITH A KETTLEBELL—RIGHT SHOULDER EXTERNAL ROTATION AND LEFT SHOULDER INTERNAL ROTATION



FIGURE 19. AROUND THE WORLD WITH A KETTLEBELL—RIGHT AND LEFT SHOULDER FLEXION



FIGURE 20. AROUND THE WORLD WITH A KETTLEBELL—RIGHT SHOULDER INTERNAL ROTATION AND LEFT SHOULDER EXTERNAL ROTATION

AROUND THE WORLD WITH A KETTLEBELL

Around the world with a kettlebell is displayed in Figures 17 – 20, and places emphasis on the muscles of the trunk that control motion in all three planes (i.e., sagittal, frontal, and transverse) (32). This exercise combines both mobility and stability, which should help provide local strength and balance (5,22). These types of adaptations could positively contribute to more efficient movement in the dynamic job tasks of first responders. This exercise should be performed standing upright with a kettlebell held in both hands (Figure 17). They should then lift the kettlebell overhead rotating to the right (Figure 18), continue until the kettlebell is positioned behind the head (Figure 19), then continue rotating to the right (Figure 20), and finish with the kettlebell back in the starting position. This is continued for the required number of repetitions specified by the tactical facilitator.

CONCLUSION

The first responder population performs a variety of tasks during their line of duty that requires lifting, dragging, bending, carrying, and running. These tasks will be performed most efficiently through proper training of the core musculature and lumbo-pelvic region. Although the sit-up is a common exercise that is utilized for training in this population, it does not target all of the necessary core musculature that is required to perform job tasks safely and efficiently. The first responder recruit population typically trains the core and lumbo-pelvic region for strength and endurance. Therefore, with appropriate prescription, the example exercises provided may be beneficial to a first responder training staff to design a well-rounded program resulting in superior fitness and job performance of recruits.

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ROD POPE, PHD

TSAC—REDUCING THE RISK OF INJURY—ESTIMATING AND COUNTERING TRUE INJURY RISKS

This article is part of a continuing series on practical, evidence-based approaches to reducing the risk of injury while developing tactical strength and conditioning.

INVISIBLE INJURIES: ESTIMATING AND COUNTERING TRUE INJURY RISKS

Tactical personnel often engender and operate within a culture of toughness and perseverance (2,5,6). This can be perceived as essential to job performance, whereby it may be expected that tasks are completed before team members take a break or tend to their tolerable injuries, since others and the mission may be depending on them, in critical circumstances. In such contexts, injuries frequently go unreported or reporting is delayed (4,5,7). For example, a recent survey in a United States Army brigade found that 49% of injuries experienced by personnel went unreported (7). Reasons given by personnel for not reporting or delaying reporting of injuries included "fear of future impact on one's career" (25%), "avoidance of a duty-limiting "profile" (23%), seeking treatment was inconvenient (18%), wanting to avoid negative perceptions (18%), and having had negative experiences with medical providers in the past (14%) (7). A companion study reported that more than half of participants agreed that aches and pains are a natural consequence of hard work (68.3%), that it is better to just work through pain (57.6%), that their unit believes in the "suck it up" mentality when it comes to injuries (54.7%), and seeking medical attention is an inconvenience (50.7%) (6). These reasons are similar to reasons reported by Australian Defence Force personnel (2,5), where substantial underreporting of injuries has also been observed (4,5). Affected personnel self-manage unreported injuries in a range of ways (6). In the U.S. Army study mentioned above, these included over-the-counter pain medication (81%), ice packs (55%), heat packs (52%), hot tub (40%), pain avoidance (37%), splints or braces (25%), and a range of less common approaches, including (in descending order of frequency) yoga, narcotics, meditation, topical/muscle rubs, illicit drugs, additional sleep, massage, and alcohol (6).

This background of under and delayed reporting in tactical populations means that true injury risks are often underestimated—in some instances, this has been by half (7) and in others by factors of 10 or more (4,5). Injury risk is traditionally estimated as the product of injury likelihood (or rates) and injury consequences (or adverse impacts, including for example personal and family impacts, financial costs to the individual and organization, and reductions in the size of the tactical force available to deploy due to injuries and associated disability). When underreporting of injuries occurs, both likelihoods and consequences of injuries can be underestimated, resulting in a substantial underestimation of the true injury risk and a lack of attention to properly managing those risks. Rates (or likelihoods) of injury occurring may be underestimated because unreported injuries are not considered (4,5,7). Injury consequences may be underestimated because the numbers of personnel affected by injuries and the associated impacts on tactical forces and teams are not properly understood, or because specific types of injury with unique or serious consequences are not adequately recognized as occurring in significant numbers (3).

One way of estimating the true rates of injury for a particular tactical population or organization is to construct an "injury pyramid," such as that depicted in Figure 1 (1). At the top of the pyramid, comprising a relatively small proportion of all injuries that occur, are the most serious types of injuries, including those resulting in death or significant long-term disability. It is likely that all of those very serious injuries will be recognized and reported, since reporting rules for such occupational injuries are often strict and enforced, and they are hard to miss due to their serious impacts and use of healthcare and administrative or command resources. Next level down in the pyramid are those injuries that are of a serious nature, often requiring hospitalization or extensive rehabilitation and care, but not causing death or significant long-term disability. These may include, for example, uncomplicated bone fractures. These are a few more in number and again tend to be reported, for reasons similar to those mentioned above for the most serious types of injuries. In the example provided in Figure 1, there are 162 serious injuries recorded for every one injury that results in death or significant long-term disability, but this ratio may differ in different tactical organizations. Following these, moving downward in the pyramid, and numbering many more, are injuries of moderate and minor severity, respectively. Moderate injuries generally result in some loss of work days, to allow time for affected body tissues to heal and for healthcare to be provided and because during this time affected personnel are unable to perform their job role at required levels. However, the work time lost with moderate injuries is typically much less than for serious injuries. Moderate injuries may include, for example, moderate ligament sprains, muscle strains and wounds. Minor injuries often result in minimal work time loss, and are frequently managed while personnel continue to work. Examples may include low-grade ankle sprains, finger joint injuries, cuts, and contusions, which might be adequately supported by boots, gloves, braces, dressings or strapping during job tasks and may allow continued work despite some discomfort. In the example provided in Figure 1, there are 1,702 moderate injuries and 10,182 minor injuries for

every one of the most serious injuries, but again these ratios will differ in different tactical organizations. It is at these lower levels of injury severity that non-reporting and delayed reporting typically occur, since these types of injuries can be self-managed or compensated-for, in many instances, at least for a time. Therefore, it is at these lower levels of the injury pyramid that a large proportion of injuries may go unreported (Figure 1, grey area). Such injuries may account for half or more of all injuries experienced in the respective tactical population, as reflected in the example provided in Figure 1 (4,5,7). Recognizing this group of unreported injuries can allow for more accurate estimation of true injury risks for the respective tactical population. All numbers in Figure 1 represent ratios, with each value calculated relative to one injury resulting in fatality or significant long-term disability. For example, Figure 1 indicates there are 162 serious injuries that occur for every one injury that results in death or significant long-term disability.

The benefit of constructing an injury pyramid for a tactical population is that it provides a clearer understanding of the true rates of injury, without requiring additional effort and expense to try to increase rates of reporting of injuries within existing systems. Existing injury reporting systems and their incomplete data can be used, in conjunction with the injury pyramid, to estimate true rates of injuries and so to better assess the true levels of injury risk. Risk management decisions can then be informed by these more accurate estimates of true injury risks. In this way, existing injury reporting systems will then provide "sentinel" data, which is incomplete but can be used, when paired with information from the injury pyramid, to more accurately inform efforts to reduce injury risks in the respective tactical population.

Injury pyramids, like the one depicted in Figure 1, can be developed for any tactical population, based on available injury records from existing injury reporting systems and on a formal or informal survey of tactical personnel, in which they are asked about their injury experiences over the previous 6- or 12-month period. Rates of injury reported in the survey, which will capture all or most injuries experienced by the surveyed personnel, can be compared to rates of injury derived from the available injury records in existing systems, so that the rates of non-reporting of injuries of particular levels of severity can be ascertained and used to construct the injury pyramid.

Alongside the injury pyramid, it may also be valuable to consider strategies that can be implemented to ensure usually unreported injuries are well managed and so reduce the consequences of these injuries, thereby reducing the overall risks of injury in the organization. Such strategies may include: ensuring all personnel receive training in initial injury management, both for themselves and for members of their team; providing ready access to equipment and consumables required for initial injury management; and providing on-location and highly visible initial

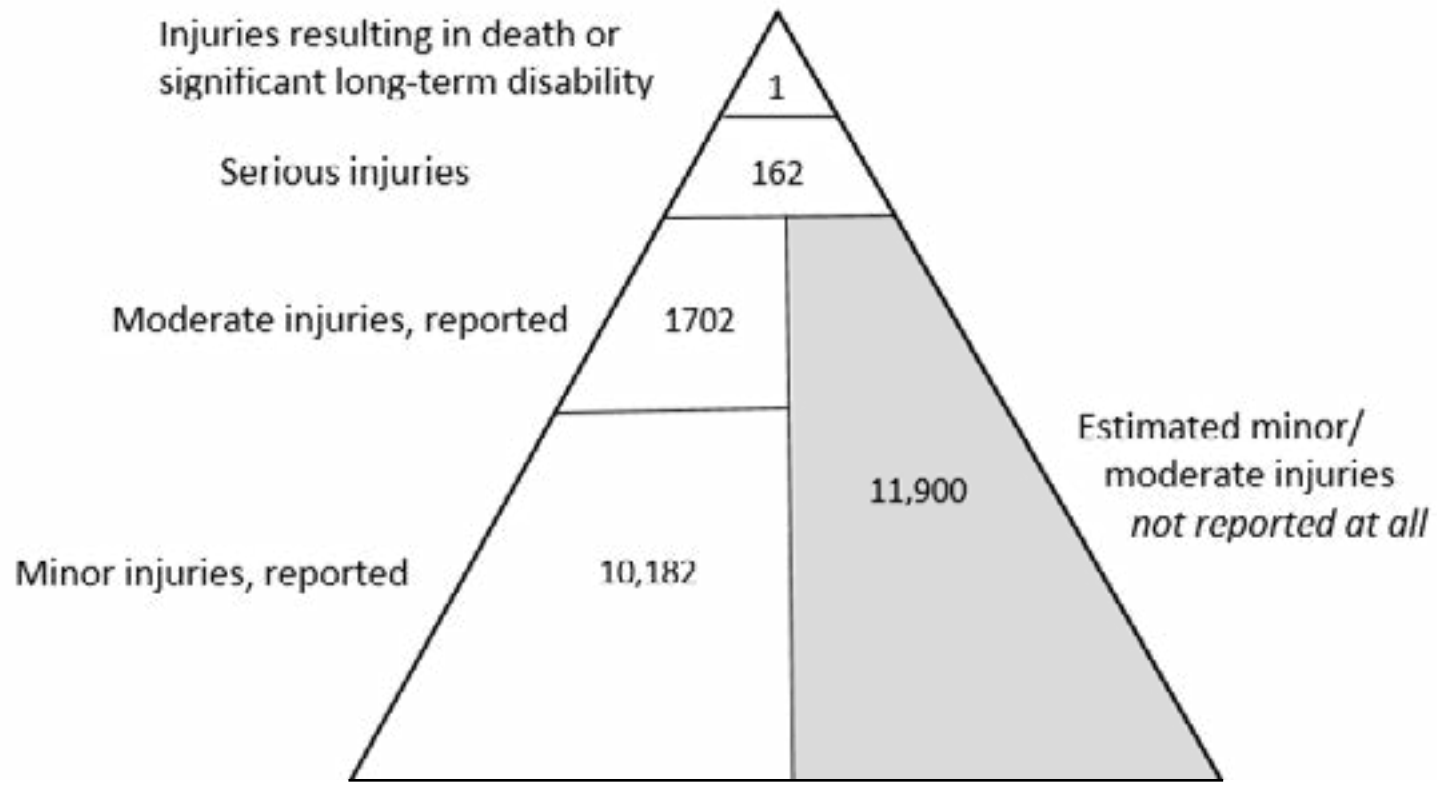


FIGURE 1. EXAMPLE OF AN "INJURY PYRAMID" FROM A FICTITIOUS TACTICAL ORGANIZATION

injury care (e.g., from athletic trainers, sports trainers, field medics, physical therapists) so that injuries occurring during training, team-building events, or sporting activities can receive appropriate initial care. For some types of injuries (e.g., blisters, cuts and scratches) routine checks conducted on-location during and immediately after an activity may identify the injuries if they have occurred and allow for their immediate initial management, preventing development of adverse outcomes (e.g., infection).

For the tactical facilitator, understanding these concepts will help them better assess and manage the true injury risks associated with training they facilitate, and advocate for strategies that will support personnel in their efforts to self-manage or access initial care for injuries they might sustain during training activities, whether they formally report them or not.

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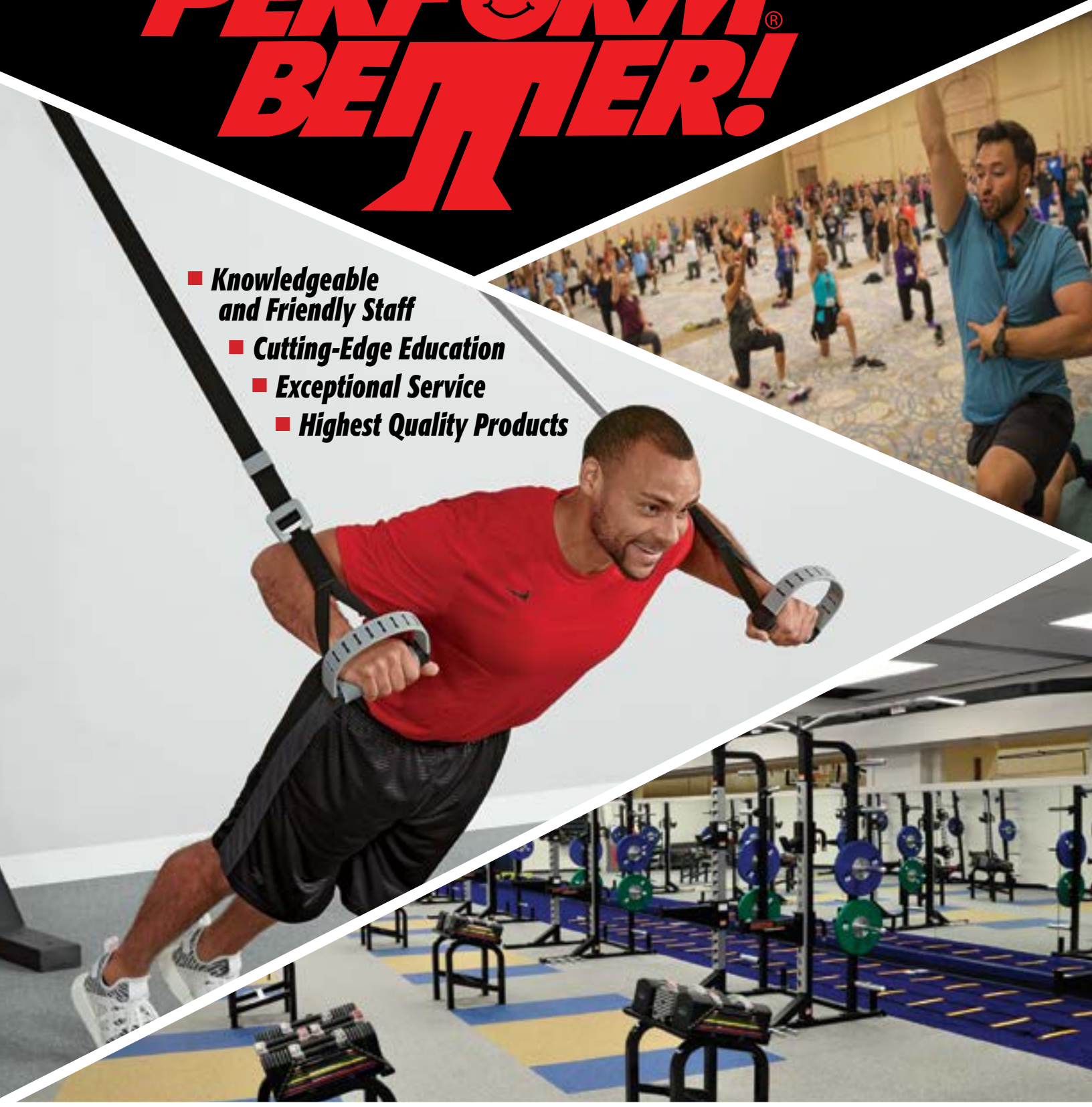
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Rod Pope is currently a Professor of Physiotherapy at Charles Sturt University and co-leads the Tactical Research Unit, headquartered at Bond University in Australia. Pope provided clinical physiotherapy, rehabilitation, and injury prevention services at the Australian Army Recruit Training Centre before establishing and leading the Australian Defence Injury Prevention Program, at the request of the Defence 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.

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ROBERT LOCKIE, PHD, TSAC-F

AN EXAMPLE FITNESS ASSESSMENT BATTERY FOR COMMUNITY SERVICE OFFICERS

INTRODUCTION

Community service officers (CSOs) are civilian, non-sworn officers that are often employed by police departments to provide additional support to police officers and perform activities supplemental to those of the sworn personnel. Meese described a CSO as essentially being an apprentice that worked under close supervision with police officers, unarmed, and without full law enforcement authority (34). Many colleges in the United States have a campus police force and will employ CSOs who are typically university students. The presence of CSOs can provide a positive link between the student body and the law enforcement and public safety personnel (48). The duties of a CSO can include: patrolling the campus in vehicles and on foot; answering questions from the public; observing and reporting suspicious activities or incidents to the university police; providing safety escorts to students; traffic control; assisting with community and athletic events; clerical duties; and aiding in emergency responses (41,48). Although the majority of these duties are low-intensity, any situations that increase stress (e.g., threat of physical violence from an offender during patrol) or require high-intensity activity (e.g., running to respond to an emergency) can increase the physiological demands on the CSO (14,21). How a CSO tolerates this stress could be influenced by their physical fitness (16). Accordingly, it may be surmised that greater physical fitness could be beneficial for CSOs as it pertains to their job tasks (24).

CSOs may choose to advance their careers and become sworn police officers (48). Before CSOs become police officers, they must complete certain fitness tests in order to be accepted for a law enforcement agency's academy training program. These fitness tests are conducted in order to ascertain whether the individual has the necessary physical traits to safely and effectively complete academy training (27,47), and potentially, the necessary job tasks (6). Depending on the agency, there could be general tests of fitness (e.g., push-ups and sit-ups to assess muscular endurance), or more job-specific tests (e.g., obstacle courses, dummy drags to simulate a casualty rescue) (17).

However, there is no consistent fitness testing battery or fitness standards across different agencies within the United States; certain agencies may use different assessments, and may also set different standards (4). Anecdotally, agencies that have more limited positions available could set higher standards in an attempt to recruit an individual with superior fitness, who would be more likely to graduate academy (12,27,47). It would be beneficial for CSOs to know their physical performance relative to other law enforcement recruits prior to applying to an academy. If this is known, then appropriate training could be prescribed to those CSOs during their law enforcement apprenticeship to better prepare them for the rigors of academy. Further to this, a CSO could also learn whether they have the fitness levels where they could apply to an agency that has a higher entry standard for fitness.

This article details an example assessment battery that could be used to measure the relative health and fitness of CSOs, within the context of similar populations (e.g., law enforcement recruits). The battery is designed to be as detailed and wide-ranging as possible, while also remaining practical for staff working with CSOs. Depending on the number of CSOs assessed, the assessments could be completed over a period of 1 – 2 hours. Nonetheless, the assessments could be split over two or more sessions if required. Any required equipment and the approximate costs will be documented. The assessments should ideally be completed in the order provided here, as this follows recommendations outlined by the National Strength and Conditioning Association (NSCA) (33):

1. Non-fatiguing tests (e.g., height, body mass, hip and waist circumference, sit-and-reach, grip strength)
2. Agility tests (e.g., Illinois agility test [IAT])
3. Maximum power tests (e.g., vertical jump and seated medicine ball throw)
4. Maximum strength tests (e.g., 165-lb dummy drag)
5. Local muscular endurance tests (e.g., push-ups and sit-ups)
6. Aerobic capacity tests (e.g., 20-m multistage fitness test)

A number of the physical qualities that underlie general health, fitness, and policing job tasks are assessed within this battery. It should be noted that a maximal strength assessment was not included in this battery due to the time and equipment demands required for measuring multiple CSOs within the one session. However, the 165-lb dummy drag was included as it provides some measure of strength (28), is a job-specific policing task (40), and is featured in the pre-entry fitness tests for certain law enforcement agencies (2,7,15). Table 1 also presents data for comparison for each assessment, and the population from which this data was taken.

TABLE 1. SELECT COMPARATIVE DATA FOR THE CSO ASSESSMENT BATTERY

ASSESSMENT	COMPARATIVE VALUES	POPULATION	REFERENCE
Waist Circumference	90.91 ± 9.14 cm 80.65 ± 8.16 cm	Male recruits Female recruits	Lockie et al. (32)
Waist-to-Hip Ratio	0.91 ± 0.08 0.85 ± 0.12	Male recruits Female recruits	Lockie et al. (32)
Sit and Reach Test	44.65 ± 8.34 cm 54.45 ± 3.82 cm	Male officers aged 20-29 years Female officers aged 20-29 years	Lockie et al. (29)
Grip Strength	Left: 41.91 ± 8.53 kg Right: 42.15 ± 8.29 kg Left: 46.26 ± 9.56 kg Right: 47.96 ± 9.70 kg Left: 31.91 ± 4.83 kg Right: 34.17 ± 6.28 kg	Police recruits Male custody assistant recruits Female custody assistant recruits	Orr et al. (39) Lockie et al. (30)
Illinois Agility Test	18.2 ± 1.6 s	Male campus law enforcement officers	Beck et al. (3)
Vertical Jump	54.36 ± 11.21 cm 38.20 ± 10.34 cm	Male recruits Female recruits	Lockie et al. (25)
Seated Medicine Ball Throw	6.21 ± 0.99 m 4.01 ± 0.61 m	Male recruits Female recruits	Lockie et al. (25)
165-lb Body Drag	5.41 ± 3.19 s <31 s <27 s	Graduated recruits Fullerton PD standard Anaheim PD standard	Lockie et al. (24) Fullerton Police Department (15) Anaheim Police Department (2)
Push-Ups in 60 s	42.94 ± 12.26 reps 23.70 ± 8.76 reps 49.57 ± 11.76 reps 37.50 ± 7.04 reps	Male recruits Female recruits Male cadets Female cadets	Bloodgood et al. (5) Dawes et al. (12)
Sit-Ups in 60 s	40.35 ± 9.21 reps 36.21 ± 7.23 reps 44.24 ± 5.57 reps 43.16 ± 10.05 reps	Male recruits Female recruits Male cadets Female cadets	Bloodgood et al. (5) Dawes et al. (12)
20-M Multistage Fitness Test	53 ± 17 shuttles 46 ± 15 shuttles 62.97 ± 16.17 shuttles 39.67 ± 11.46 shuttles	Male recruits Female recruits Male cadets Female cadets	Lockie et al. (31) Dawes et al. (12)

ANTHROMETRICS

Height and body mass are standard anthropometrical measurements to take prior to a fitness assessment. These two variables can be used to calculate body mass index (BMI) via the formula: *body mass in kilograms (kg) ÷ (height in m)*^{2}. Although there are limitations in using BMI as a measure of body composition as it does not take into consideration the specific volume of lean body mass or fat mass, it does still provide an initial useful indicator of health risks and performance of policing tasks for an individual (9,11). In addition to this, certain commercial scales can also provide an estimate of lean body mass and fat mass via bioelectrical impedance analysis. Although the accuracy of equipment like this can vary, these scales could provide additional information for the tactical facilitator and CSO (35). A portable stadiometer can be purchased for less than $200. Portable bioelectrical impedance scales can range in cost from $30 – $350, depending on the budget of the staff and the desired information.

Waist and hip circumference are also practical indicators of body fat distribution (45). Additionally, a greater waist circumference has been related to poorer fitness (fewer push-ups and sit-ups in 60 s, lower vertical jump, slower 75-yard pursuit run, and fewer multistage fitness test shuttles completed) in law enforcement recruits (32). The only required equipment is a handheld tape measure, which can be purchased for less than $5. Waist circumference is measured at the narrowest part of the waist just superior to the naval (Figure 1A). Hip circumference is measured at the greatest posterior extension of the hip (Figure 1B). Ideally, there should be as minimal clothing as possible between the hip or waist and the tape measure. However, if the circumferences are measured above clothing this should be noted. Waist-to-hip ratio, which can also provide an indication of cardiovascular disease risk, can then be calculated via the formula: waist circumference hip circumference (13).



FIGURE 1. (A) WAIST CIRCUMFERENCE (B) HIP CIRCUMFERENCE

SIT AND REACH TEST

The sit and reach test has been used to assess low back and hamstring flexibility in law enforcement populations (29). Flexibility can be important when law enforcement and correctional officers execute searches (19). A sit and reach test measurement box is required, which can cost between $100 - $200 depending on the brand. CSOs remove their shoes and sit down with their legs extended, and place the soles of both feet inside the box (Figure 2A). The hands are then positioned on top of each other (tips of the middle fingers aligned), with the palms down. The CSO then reaches slowly forward and, while tucking the head, touches as far along the scale as possible. This position is held for 5 s, and the point where the tip of the middle fingers touch the scale is the distance measured (Figure 2B). Two or three attempts are generally provided, with the furthest attempt used.

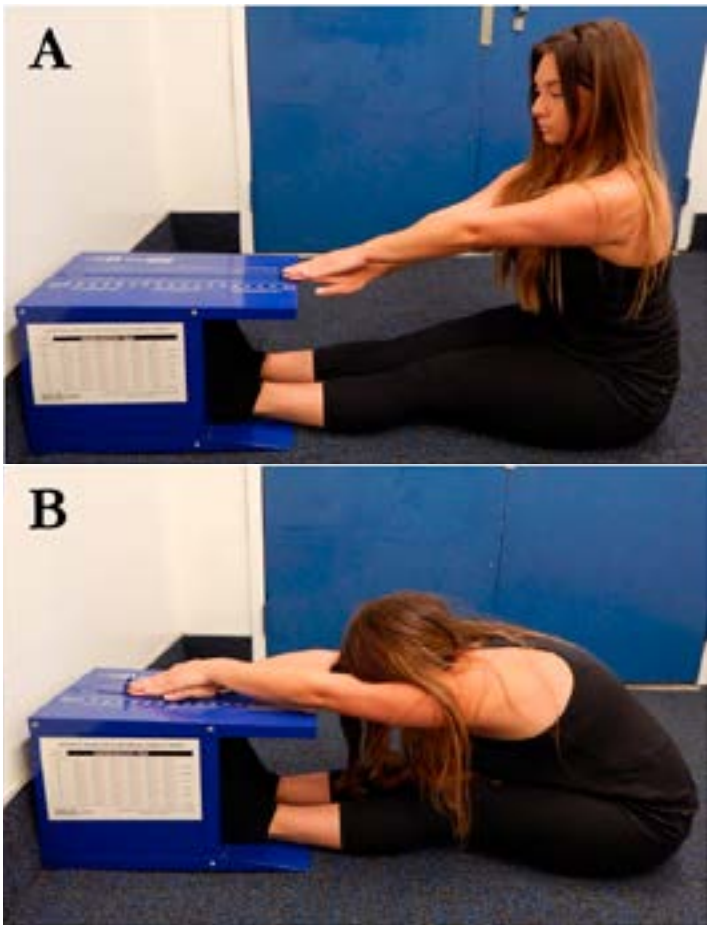


FIGURE 2. THE SIT-AND-REACH TEST— (A) START POSITION (B) FINISH POSITION

GRIP STRENGTH

Grip strength is a common strength measurement used for law enforcement populations, and has been linked to the ability to support one's body mass during searches, restraining uncooperative offenders, and firearm marksmanship (8,19,39). A hand grip dynamometer is required, and depending on the brand, can retail from between $30 – $300. Although there are several methods that can be used to assess grip strength, a procedure commonly used in tactical populations is where the individual keeps their arm fully extended by their side and squeezes the handle of a dynamometer as hard as possible for 2 s (8,30,32). Two or three attempts are ideally provided, with the highest score in kg utilized.

ILLINOIS AGILITY TEST (IAT)

An important job task for law enforcement officers is a foot pursuit (20). The underlying physical qualities important for this task are often assessed via change of direction (COD) speed tests (5,6,24,32). COD speed incorporates the skills and abilities required to change direction or velocity, and involves qualities such as movement technique, lower-body strength and power, and running speed (46). The Illinois agility test (IAT) is a common assessment adopted to measure COD speed, has been utilized in law enforcement and public safety populations, and so has application for CSOs (1,3,23). The required equipment are a tape measure (~$50 or less), eight cones (sets of 50 cones can be purchased for less than $20), and either two pairs of timing gates (~$1,500 for the most affordable model) or a stopwatch (~$10 or less) to measure time. Although timing gates are more accurate than handheld devices, such as a stopwatch or cellphone app, they are more expensive. Furthermore, testers trained in the procedures for recording sprint times with handheld device can still record accurate data (18).

The dimensions and running direction for the IAT are shown in Figure 3. As described by Lockie, four cones are used to indicate an area that is 10 m (10.94 yards) long and 5 m (5.47 yards) wide (23). In the center of the area (2.5 m [2.73 yards] away from the sides of the area), four markers are placed 3.3 m (3.61 yards) apart. If timing gates are used, they are positioned at the start and finish points of the IAT, and the CSO should be positioned 0.3-0.5 m (11.81 – 19.69 inches) behind the start gate to initiate timing procedures (Figure 4) (23). If a stopwatch is to be used by the TSAC-F, then the CSO can start level with the first cone. Once ready, the CSO sprints from cone A to cone B, and then cuts around this cone to sprint towards cone 1. The athlete then weaves in and out of cones 1 through 4 using a zig-zag motion, circles cone 4, and then returns to cone 1, weaving through the center cones (2 and 3) in the opposite direction. They then sprint to cone C, cut around this cone and sprint to cone D to finish the test. Time is started from the initiation of movement until the CSO passes cone D. The CSO should step around and not over the cones. Two to three trials should be completed with sufficient recovery times of 2 – 3 min between trials, with the fastest trial used.

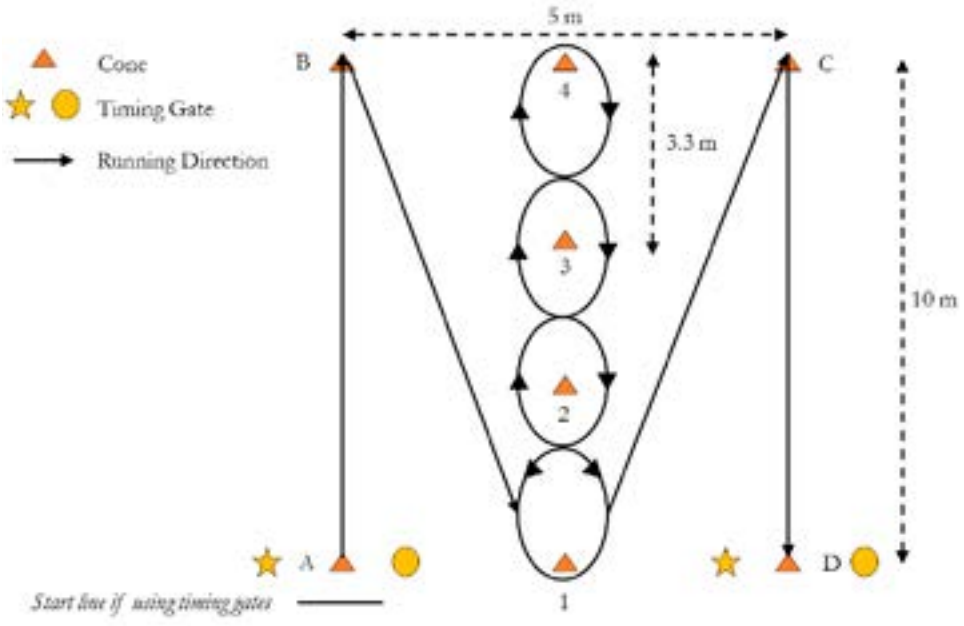


FIGURE 3. DIMENSIONS AND RUNNING DIRECTION FOR THE IAT



FIGURE 4. START POSITION FOR THE IAT IF TIMING GATES ARE USED

VERTICAL JUMP (VJ)

The vertical jump (VJ) is one of the most common methods used to measure lower-body power. In addition to this, police recruits with a poorer VJ were more likely to suffer an injury or illness during academy training (38). In highway patrol officers, a superior VJ related to faster performance of a job-specific physical ability test including an obstacle course, barrier climb, and lifting, carrying, and dragging tasks (10). Lockie et al. described the VJ assessment performed with a Vertec-style device (26). A jump mat can also be used to measure the VJ, and has been utilized when assessing the performance of law enforcement recruits or officers (10). The jump mat calculates jump height via flight time and gravity, and retails for ~$600. The CSO will stand on the jump mat, and complete a countermovement (flexion of the hips and knees, extension of the shoulders; Figure 5A) prior to jumping as high as possible (Figure 5B), before landing back on the mat (the hips and knees should flex again to absorb the landing; Figure 5C). No restrictions should be placed on the degree of countermovement or arm swing used. Two or three trials should be completed with approximately 60 s rest between efforts, with the highest jump used.

SEATED MEDICINE BALL THROW

The seated medicine ball throw can assess upper-body power, and has been used to delineate between law enforcement recruits by sex and age (25). Better upper-body power as measured by the seated medicine ball throw could prove beneficial when a LEO has to physically engage with a suspect (25), and thus has application for a CSO working towards a career in law enforcement. The procedures for this assessment have been described by Lockie et al. (26), but will be stated here. A 2-kg medicine ball (~$20) and tape measure are required, along with a wall and open area. Hand chalk is also useful, so that the ball can be lightly dusted to aid with grip, and to indicate the landing spot (26). The tape measure should be taped to the testing surface from the base of the wall (which is the zero point). The CSO sits on the ground with their head, shoulders, and lower back against a wall, and legs extended in front of the body on the ground. These points of contact should be maintained throughout the movement. The ball is gripped with two hands and brought to the chest such that the elbows are at the sides of the body (Figure 6A). The individual should then project the ball at an approximate 45° angle as far as possible by extending the arms (Figure 6B). The measurement is taken as the perpendicular distance from the wall to the initial landing point of the ball.



FIGURE 5. VERTICAL JUMP WITH A JUMP MAT—(A) START POSITION (B) FLIGHT (C) LANDING POSITION

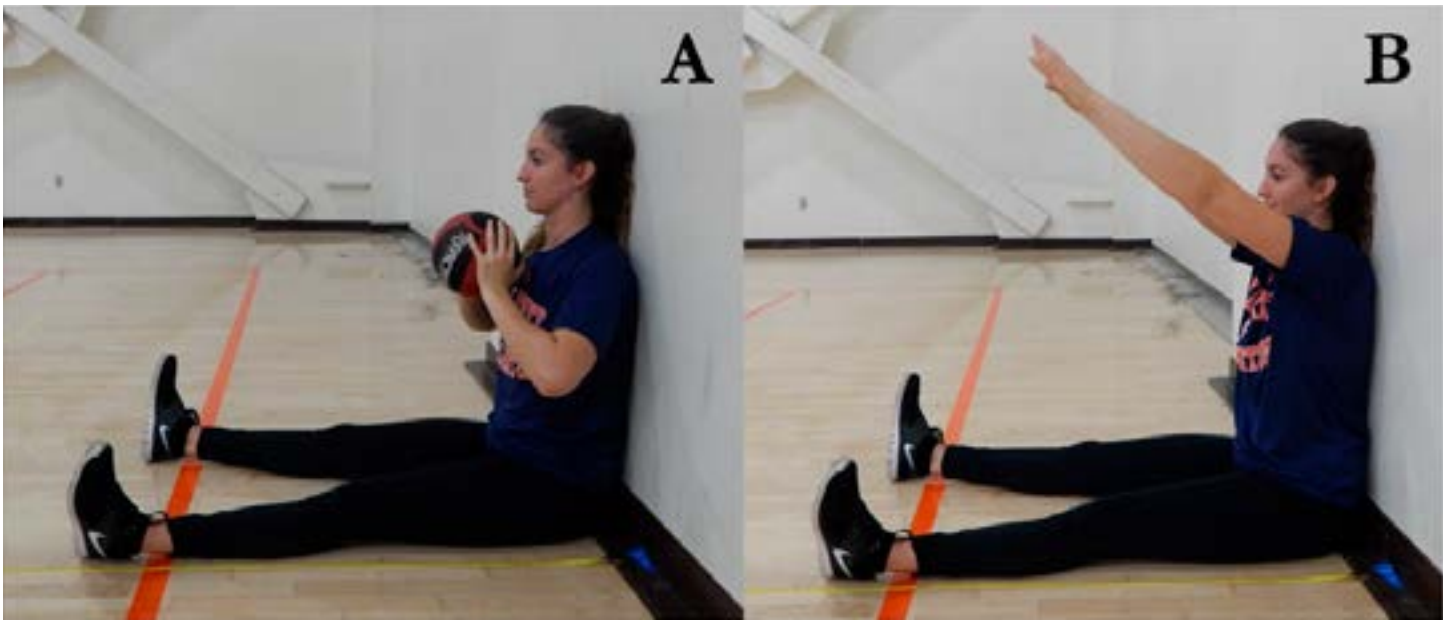


FIGURE 6. SEATED MEDICINE BALL THROW—(A) START POSITION (B) FINISH POSITION

165-LB DUMMY DRAG

The 165-lb (74.84-kg) dummy drag is a test within the Work Sample Test Battery designed by Peace Officer Standards and Training in California, and must be completed before a recruit can graduate from academy in California (40). Although originally designed to be part of an exit examination, some agencies also use this as a pre-academy entry fitness/skills test (2,7,15). Therefore, if a CSO wants to apply to one of these law enforcement agencies, they should know whether they can effectively perform a dummy drag. The dummy drag should also provide some measure of strength, as the CSO is required to lift the 165-lb dummy to a standing position (28). This assessment will require four cones to mark the start and finish lines (two cones at each end), a tape measure, stopwatch, and a 165-lb dummy. A high-quality dummy will cost ~$1,200. Standard procedures will be used for this assessment (24,37,40). The 32-ft (9.75-m) dragging distance should be marked with cones. The dummy will be positioned face side up, with the head orientated towards the finish line. The CSO will pick the dummy up by wrapping their arms underneath the arms of the dummy (the hands may be interlocked) and lift it to a standing position by extending the hips and knees (Figure 7). Once the CSO is standing with the dummy and they inform the TSAC-F they are ready, they will begin the drag. Timing is initiated when the feet of the dummy pass the start line, and the CSO is to drag the dummy as quickly as possible by walking backwards over the required distance. Time is stopped when the dummies' feet pass the finish line. At least two trials should be provided with 3 – 5 min recovery between trials, and the fastest trial should be utilized.



FIGURE 7. START POSITION FOR THE 165-LB DUMMY DRAG

PUSH-UPS

The maximal number of push-ups completed in 60 s is a common test of upper-body endurance in law enforcement recruits (5,6,24,30,47). The inclusion of this assessment would provide comparable data for CSOs who want to become police officers. Recruits who perform better in this assessment are more likely to graduate academy (12,47). Additionally, push-ups were predictive of performance of job-specific policing tasks including a 99-yd obstacle course, 6-ft chain link and solid wall climbs, and a 500-yd run (24). Accordingly, there is value in having CSOs complete this assessment. The CSOs will start in the "up" position, with the body taut and straight, with the hands positioned shoulder-width apart. A physical prompt should be used to ensure the CSO reaches the appropriate depth; some agencies use equipment such as a water bottle, while a partner can also place their fist underneath the chest of the CSO completing the assessment (males should be paired with males, and females with females) (6,29,30). On the start command, the tactical facilitator will begin the stopwatch and the CSO will flex their elbows and lower themselves until their chests contact the physical prompt, before extending their elbows to return to the start position. They will complete as many repetitions as possible using this technique within the 60-s time period.

SIT-UPS

The maximal number of sit-ups completed in 60 s is a common test of abdominal endurance in law enforcement recruits (5,6,24,30,47). Lockie et al. found that recruits who could complete more sit-ups tended to be faster in job-specific tasks such as a 99-yd obstacle course, 6-ft chain link fence climb, and 500-yd run (24). To complete this assessment, the CSO will lay in a supine position with their knees flexed to 90°, heels flat on the ground, and arms positioned in front of the body and wrapped across the chest so that each hand is on the opposite shoulder (10). The feet will be held to the ground by a partner during the assessment. On the start command, the tactical facilitator will begin the stopwatch and the CSO will flex the trunk and elevate their shoulders off the ground until their elbows touch their knees (10). The CSO will then descend back down until their shoulder blades contact the ground, and complete as many repetitions as possible using this technique within the 60-s time period.

20-M MULTISTAGE FITNESS TEST

Numerous studies have indicated the value of aerobic fitness for law enforcement populations, with regards to academy graduation (12,27,47), relationships to job-specific tasks (10,24), load carriage (43), and general health (44). The 20-m multistage fitness test will be used to measure aerobic fitness in the CSOs, as it has been previously adopted for law enforcement populations (10,12,31,32), and maximal aerobic capacity can be estimated from the results (42). Furthermore, the 20-m multistage fitness test has potentially greater value than an assessment such as the 1.5-mile (2.4-km) run, as the 20-m multistage fitness test demands an external pacing strategy (31). This has greater applicability to policing, where the intensity of job tasks is often dictated by external influences (e.g., the actions of offenders or civilians) (14,22). The 20-m multistage fitness test has also been correlated to 300-m run time in law enforcement officers, so it could indicate ability in running tests closer to this type of distance (36). The equipment required for the 20-m multistage fitness test include cones (how many will depend on how many CSOs complete the 20-m multistage fitness test at once), a tape measure, a cellphone or tablet with an app to play the 20-m multistage fitness test, and a portable speaker (good speakers can cost between $100 – $200). There are multiple apps available that feature the 20-m multistage fitness test; tactical facilitators should ensure the number of shuttles per stage matches that presented in Table 1. The dimensions for the 20-m multistage fitness test are shown in Figure 8. CSOs will be required to run back and forth between two lines spaced 20 m apart, indicated by the cones. The speed of running for the 20-m multistage fitness test is standardized by the pre-recorded auditory cues (i.e., beeps) played from the phone/tablet and app connected to the portable speaker. The speaker should be positioned such that it does not interfere with the assessment, but every CSO can hear the beeps. CSOs continue running back and forth between the lines until they are unable to reach the lines twice in a row in accordance with the auditory cues, or by voluntary cessation. The 20-m multistage fitness test is scored according to the final stage the CSO is able to achieve, and the stage is used to calculate the total number of completed shuttles. Ramsbottom et al. has also presented a table where the shuttle level attained can be used to estimate maximal aerobic capacity (42).

TABLE 2. 20-M MULTISTAGE FITNESS TEST LEVELS, NUMBER OF SHUTTLES PER LEVEL, TIME PER SHUTTLE, AND RUNNING SPEED FOR EACH SHUTTLE

LEVEL	SHUTTLES	TIME PER SHUTTLE (S)	RUNNING SPEED (M/S)
1	7	9.00	2.22
2	8	8.00	2.50
3	8	7.58	2.64
4	9	7.20	2.78
5	9	6.86	2.91
6	10	6.55	3.05
7	10	6.26	3.19
8	11	6.00	3.33
9	11	5.76	3.47
10	11	5.54	3.61
11	12	5.33	3.75
12	12	5.14	3.89
13	13	4.97	4.02
14	13	4.80	4.17
15	13	4.65	4.30
16	14	4.50	4.44
17	14	4.36	4.59
18	15	4.24	4.72
19	15	4.11	4.87
20	16	4.00	5.00
21	16	3.89	5.14

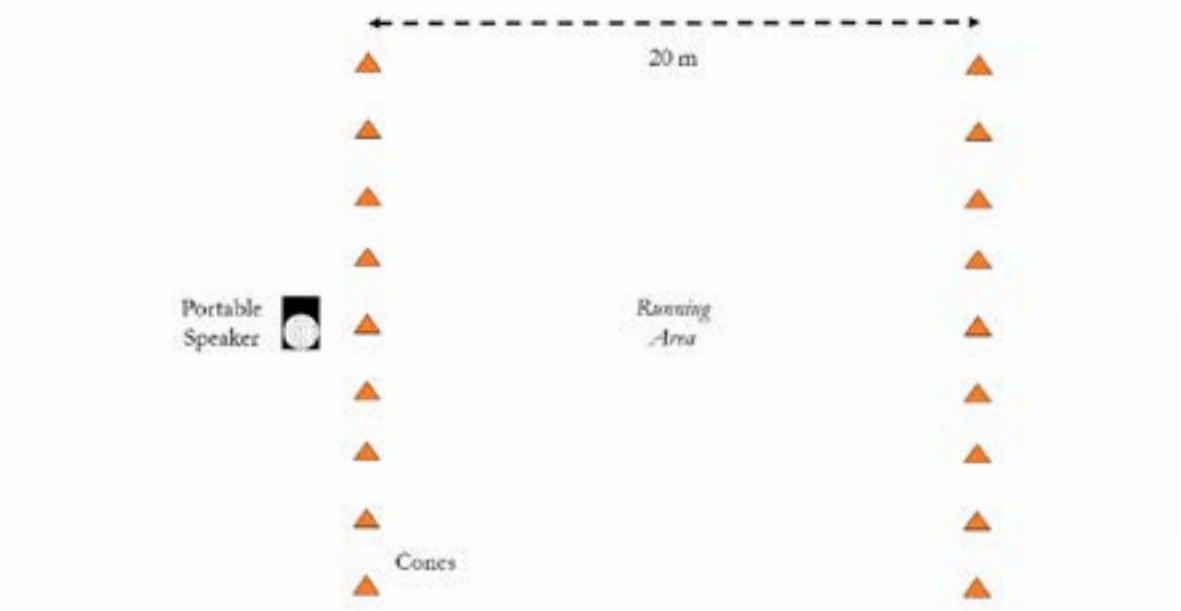


FIGURE 8. DIMENSIONS FOR THE 20-M MULTISTAGE FITNESS TEST

CONCLUSION

This article provided an example fitness assessment battery that could be used for CSOs or any individual who wishes to apply for a law enforcement position where they need to complete a training academy. A range of physical characteristics are assessed and provide indicators of fitness that could support an individual's ability to complete academy and certain job tasks. It should be noted that there are other assessments that could be used in lieu of those presented here, especially if a CSO is applying to an agency that uses different entry fitness tests. For example, the 75-yd pursuit run could be used in place of the IAT (6,32); the standing broad jump could be used instead of the vertical jump, as this assessment also indicates lower-body power, and only a tape measure is required for this jump test (37); and the 1.5 mile run could be adopted instead of the 20-m multistage fitness test, as this also provides an indication of aerobic capacity (6,10,31). Further, if staff are limited by time or budget considerations, they could choose to use only a sample of assessments presented here rather than the full battery. Nevertheless, should a tactical facilitator implement this battery for their CSOs, they could be confident in attaining a detailed profile as to the health and fitness of their team.

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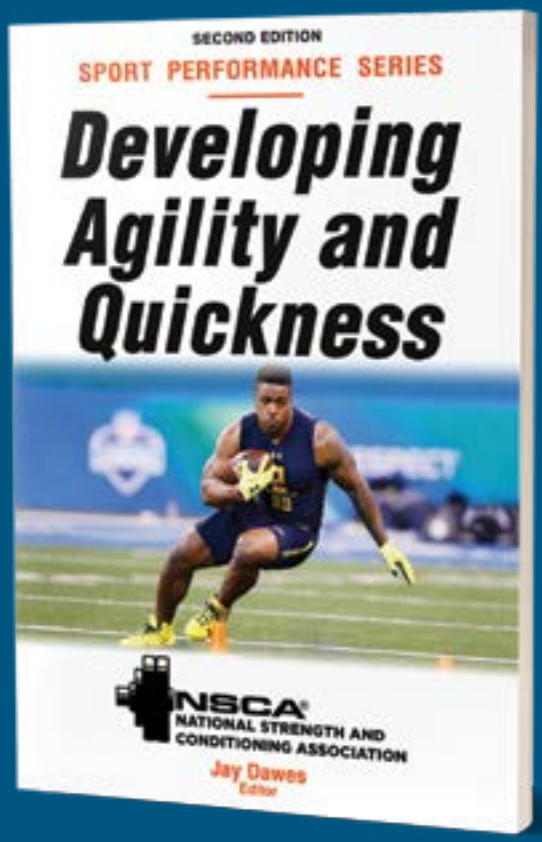
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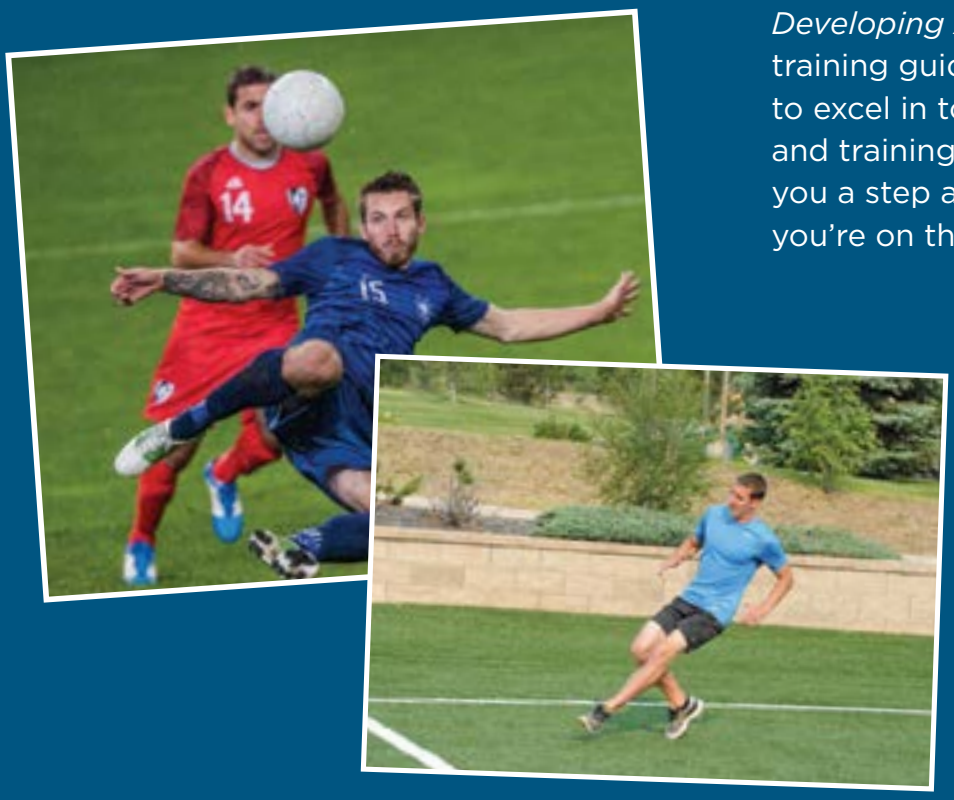


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GUY LEAHY, MED, CSCS,*D

TACTICAL FITNESS RESEARCH, 2019

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The American College of Sports Medicine (ACSM) 66th Annual Meeting was held in Orlando, FL, May 28 – June 1, 2019. Military topics were well represented, and included 54 posters with a tactical emphasis, a poster session on military physiology, and a symposium on the effect of traumatic brain injury (TBI) and combat role in Special Operations Forces (SOF). The Tactical and Military Special Interest Group drew an audience of over 50 attendees, continuing a trend of increasing interest in the study of tactical professionals. The ACSM and National Strength and Conditioning Association (NSCA) are the two largest sports science organizations which are involved in research on tactical populations. Therefore, research presented at ACSM has important implications for improving the readiness and lethality of military personnel.

MILITARY OPERATIONS AND ENERGY EXPENDITURE

The high energetic cost of military training and deployment was the focus of several presentations. One of these assessed the energy cost of United States Army SOF soldiers in the Central Command (CENTCOM) region (2). The subjects averaged 30 years of age, with an average height of 70.65 in. and average weight of 195 lb. The subjects were deployed at eight locations in the CENTCOM theater of operations. A total of 46 soldiers participated in the survey. Information collected included mission energy requirements and difficulty of exertion pre-, during-, and post-mission.

The survey information was then used to calculate estimated energy expenditure based on a SOF-specific equation. During the six-month deployment period, soldiers participated in many missions (17.25+8.66). Ninety percent of respondents reported carrying a load 40% heavier than recommended fighting load (32.9+8.62 versus 21.8 kg). Average estimated energy expenditure (4848+525 kcal/day^{-1}) was far above the military dietary reference intake of 3400 kcal/day^{-1}. All but three soldiers reported a rate of energy expenditure exceeding the benchmark of 3,400 kcal/day^{-1} needed to maintain adequate energy reserves upon enemy contact. This high energy expenditure was the result of a combination of high marching speed and load. To bring the energy expenditure under the benchmark, either the marching speed and/or the external load would have to be reduced. The authors concluded that excessive load carriage is a major contributor to high energy expenditure. The loads reported by soldiers exceeded Army doctrine recommendations. This imbalance between energy expenditure and energy intake could result in performance decrements, which may compromise mission success. Practical application of this research involves special attention to pack weights during pre-mission planning, plus preemptive nutrition strategies designed to meet mission demands and recovery from strenuous activity.

The goal of one study was to determine the metabolic and physiological differences between males with low testosterone (LT) versus those with normal testosterone (NT) following eight days of strenuous military training (1). One consequence of severe negative energy balance (55% reduction from maintenance energy intake) is that male U.S. military personnel may experience marked reductions in circulating total testosterone; levels frequently fall below the normal range (< 300 ng/dL) (1). These testosterone fluctuations, as a result of severe negative energy balance are not consistent, and little is known as to why some males experience LT while others are able to maintain NT. The study utilized 68 male U.S. Marines, who were grouped based on testosterone concentration (more or less 300 ng/dL) following eight days of severe negative energy balance (55% reduction in required calories to maintain fat-free mass) incurred during military training. Body composition (DEXA) and whole-body protein turnover were measured and blood+ urine samples collected before (pre) and after (post) training. Testosterone concentrations decreased pre (505+ 135 ng/dL) to post (284 + 115 ng/dL, $P < 0.01$). When the subjects were grouped by post testosterone status, pre body mass index (BMI), total fat mass, and testosterone were greater in NT compared to LT ($p < 0.05$). Those with LT lost more fat-free mass (FFM, -3.4 + 1.3 kg) and less fat mass (-2.4 + 1.2 kg) compared to NT (-2.4 + 2.0 and -3.2 + 1,6 kg, respectively; p(interaction) < 0.03). Insulin and norepinephrine increased from pre to post in LT, whereas no changed occurred in NT, resulting in significant differences between groups (p(interaction) < 0.02). Independent of time, LT had greater whole-body protein synthesis, breakdown, and flux (p (status) < 0.01) but not net balance (p (status) = 0.2), compared to NT. This research indicates military personnel predisposed to operational stress-induced LT may be more likely to experience greater FFM loss during periods of negative energy balance during strenuous tactical training. A possible solution to the loss of FFM is supplementing soldiers with exogenous testosterone, to maintain FFM in the presence of an energy deficit. One such clinical trial is currently ongoing (5).

Most energy balance studies have been conducted with male subjects, but with women now eligible for front line combat roles in the U.S. military, such studies with female subjects have become paramount. This study examined sex differences in energy balance across 44 weeks (three terms of 14 weeks) of arduous military training (10). Twenty officer cadets (8 males, 12 females) participated in the study. Dietary intake was measured during each term by researcher-led weighed food (food pre-weighed prior to

meals) during scheduled mealtimes, and food diaries and wrapper collection during non-scheduled mealtimes, over three 10-day periods (one per term). Total energy expenditure (TEE) was measured over each 10-day sampling period using doubly labelled water. Body composition was measured by DEXA at the start of training and at the end of each term. Average energy intake (3,160 + 568 versus 2,609 + 568 kcal/day^{-1}) and TEE (4,552 + 534 versus 3,365 + 416 kcal/day^{-1}) were higher for men than women (both $p < 0.005$). Both sexes displayed negative average energy balance with a greater deficit in men (-1,333 + 965 versus -756 + 826 kcal/day^{-1}, respectively, $p = 0.016$). There was no difference in average daily carbohydrate, protein or fat intake between men and women ($p > 0.167$). Lean and fat mass did not differ in either sex over time (all $p > 0.336$). The greater energy deficit in men was primarily the result of a higher TEE, so the researchers concluded. Surprisingly, there were no differences in lean or fat mass in either sex at any timepoint, despite the energy deficits.

Explanations for this include underestimating of energy intake, or the limited frequency of DEXA assessments. Practical applications of this work include adjusting food intake upwards in both sexes, particularly males, to compensate for the higher TEE. Future research is needed regarding the optimization of energy intake in arduous military training scenarios.

BODY MASS AND BODY COMPOSITION

Previous research documents that body mass significantly affects performance on physical fitness assessments (7,8). Test components which involve body mass only (e.g., distance run, push-ups, sit-ups) favor smaller individuals, whereas tests with an added mass component (e.g., deadlift, bench press) favor larger individuals. This body mass bias (BMB) makes it difficult to assess the fitness of tactical personnel whose body mass varies widely, as body mass influences the outcome, independently of which fitness component is being tested. The retrospective study below looked to determine if there is BMB in the physical fitness test battery used by Naval Special Warfare Command, and if an optimum body mass for each component could be determined (11). Data from 333 male subjects (age 28.4 + 5.0 yr; height: 178.4 + 6.2 cm; mass: 86.0 + 9.2 kg) were analyzed to compare body mass to performance on eight tests: standing long jump, pro-agility test, weighted pull-up, bodyweight bench press, one repetition maximum (1RM) deadlift, 274-m shuttle run, 4.83-km run, and 800-m swim. The results indicated significantly better performance for lighter subjects for all test components except the 1RM deadlift. There was no BMB for the long jump and swim components. Second-degree polynomial regression revealed optimum body mass for the pro-agility test, 274-m shuttle run, and 4.83-km run to be slightly heavier than the lowest subject body mass (63.6 kg). Consistent with other research, the test components exhibited BMB, primarily in favor of lighter operators. Thus, lighter subjects will have a built-in advantage in most test components, independent of baseline fitness (7). Practical applications of this research may involve correcting for this BMB, such as wearing an added mass backpack during test components (8). Another possible solution, suggested by the researchers, is to cluster test subjects into body mass groups, as is done in many professional sports. That way, tactical athletes would only be compared to others within their body mass group. A third option is to combine test components which in some cases favor smaller subjects, and in other cases, favor larger subjects. For example, the sum score of the Marine Corps Combat Fitness Test is independent of body mass (9).

Little data exists comparing the body composition of active duty (AD) and civilian (CIV) personal who work at the same installation. The purpose of this study was to compare fat mass (FM), FFM, and percent body fat (%fat) in AD and CIV men and women (3). AD men (n = 213, 32.1 + 7.5 yrs, 177.6 + 6.9 cm, 87.6 + 12.7 kg) and women, (n = 115, 32.2 + 9.3 yrs, 163.1 + 8.0 cm, 70.4 + 11.3 kg) and CIV men (n = 64, 46.1 + 7.5 yrs, 177.7 + 7.6 cm, 89.6 + 15 kg) and women (n = 46, 40.0 + 9.6 yrs, 163.4 + 6.4 cm, 75.9 + 15.9 kg) were stratified by exercise level. These levels were sedentary (SED), low active (LACT), active (ACT), and very active (VACT), based on standard parameters. Each participant volunteered to have their %fat assessed via air displacement plethysmography. A sex x duty x activity (2 x 2 x 4) MANOVA produced nonsignificant interaction effects ($p > 0.32$) for %fat, FM, and FFM. Men were significantly lower in %fat (23.5 + 8.3%) and higher in FFM (66.6 + 8.3 kg) than women (33.6 + 8.5% and 47.3 + 6.0 kg, respectively), with no significant difference in FM (21.6 + 10.2 versus 25.1 + 10.2 kg). AD (men and women combined) were significantly lower in %fat (26.5 + 9.3%) and FM (21.8 + 9.3 kg) and higher in FFM (59.7 + 11.9 kg) than CIV (men and women combined; 31.2 + 10.4%, 26.0 + 11.5 kg, and 55.6 + 12.0 kg, respectively). More active individuals had significantly lower %fat (24.1 + 9.0%) and FM (19.8 + 8.9 kg) with no significant difference in FFM (61.2 + 12.1 kg) than sedentary individuals (33.0 + 8.2%, 27.7 + 9.9 kg, and 54.9 + 10.9 kg, respectively). Age was significantly correlated with %fat ($r = 0.20$) and FM ($r = 0.18$) but only accounted for 4% of the variance in %fat and FM. Age was negatively correlated with activity level in AD ($r = -0.23$, $p < 0.001$) but not in CIV ($r = -0.03$, $p = 0.78$). When sex was partitioned out, body mass index (BMI) had a slightly stronger correlation with %fat and FM in CIV ($r = 0.78$ and 0.91, respectively) than in AD ($r = 0.70$ and 0.82, respectively). AD personnel have better body composition profiles than CIV personnel at the same installation, though both appear to gain FM and %fat over time. Future research could include repeating these comparisons with other services, to see if similar differences exist. In addition, further investigation of the lack of correlation between activity level and %fat, but not FFM, appears warranted.

SKIN TATTOOS AND SWEAT RATE

Skin tattoos are very popular with tactical populations. Previous research suggests that extensive tattoos may negatively alter sweat rate and sodium sweat concentrations (4). This research artificially stimulated sweating via iontophoresis, which may not

mimic sweating produced as a result of exercise. This study tested whether tattoos would inhibit the sweat response under exercise-induced conditions (6). Twenty-two healthy individuals (25.1 + 4.8 yrs, 14 males) with a unilateral tattoo more than 11.4 cm^2 in size, more than two months in age, and shaded more than 50% participated in this investigation. Participants undertook 20 min of intermittent cycling (4 x 5 min intervals) on a stationary ergometer in a controlled environment (24.6 + 1.10C, RH 64 + 6%). Resultant sweat was collected into absorbent patches applied as two pairs of contralateral skin sites (pair 1: Tattoo versus Non-Tattoo, pair 2: Control 1 versus Control 2 (both non-tattooed), for determination of sweat rate and sweat sodium [Na+]. Paired samples t tests were employed to determine differences between contralateral sites. For Tattoo versus Non-Tattoo, neither sweat rate ($p = 1.000$) nor sweat [Na+] differed significantly ($p = 0.827$). For Control 1 versus Control 2, neither sweat rate ($p = 0.917$) nor sweat [Na+] ($p = 0.147$) differed significantly. The non-significant differences for Tattoo versus Non-Tattoo were within the range of normal variability (sweat rate = 5.4%; sweat [Na+] = 4.4%). Skin tattoos do not appear to affect sweat rate or sweat [Na+] under exercise conditions. Practical applications indicate that tactical personnel with extensive tattoos do not have to take special precautions regarding thermoregulation during exercise in hot environments.

Research presented at conferences, such as those hosted by the ACSM and NSCA, provide the scientific foundation for evidence-based training and nutrition of military personnel. It is exciting to see more and more presentations with this focus. The ever-widening scope of this research also enables the fine tuning of operational performance to a degree not possible a few years ago. This type of information is critical in enabling tactical populations to successfully accomplish their missions, as well as reduce injury and increase lethality.

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IMPLEMENTING STRENGTH TRAINING TO IMPROVE RUCK MARCH CAPACITY

WHAT IS RUCK MARCHING?

Ruck marching can be described as transporting gear from one location to another while wearing a backpack. It can be a rather grueling task performed during military training. Two examples of when ruck marches are conducted during the United States Army's Infantry Basic Officer Leadership (IBOLC) course are: 1) early in the morning with little to no sleep or 2) at the end of a training exercise.

During the 19-week course of IBOLC, each soldier will conduct a 4-, 6-, 8-, 10-, 12-, and 16-mile ruck march with 3 – 4 weeks in between each trial, with only the 6- and the 16-mile ruck march being "tactical"—meaning a heavier load at a slower pace (1). For ruck marching, each soldier will have a packed 35-lb ruck, Operational Camouflage Pattern (OCP) uniform, boots, tactical assault panel used to keep essential items readily accessible, the soldier's rifle, and eight quarts of water (equated to roughly 50 lb on the soldier's back). Generally, each mile will be completed within a sub-15-min standard (9). The training process implemented to build the soldier's capacity to ruck is typically done by increasing both intensity and volume with no formal train up during regular physical training hours poses many issues, one of which being that there is more emphasis on cardiovascular performance than load carrying capability.

TRAINING FOCUS

The issue with this training progression is that it does not allow for continuous adaptations that a combat-branch military occupation demands. This time-intensive style of training does not imitate the real-life application of conducting patrols while hiking over rugged terrain and wearing personal protective equipment (PPE) (much heavier weight than 50 lb stated above). However, as well as being able to carry loads far distances, each individual soldier must be able to carry heavier loads for shorter distances. When training for ruck marches, the intent should be to become as lethal as possible after having completed the ruck, not simply completing a 12-mile ruck march because that is what is expected during other training events, such as earning the Expert Infantry Badge or the Ranger tab. The Army field manual on foot marches, FM 21-18 states, "the primary consideration is not how much a soldier can carry, but how much he can carry without impaired combat effectiveness—mentally or physically," (3).

HOW TO TRAIN FOR RUCK MARCHES

RUCK EMPHASIS

When regular ruck marching with loads (at least twice a month) was included in a training program that also involved running and resistance training, service members marched faster than if march training was not included (4). Kraemer et al. found with a 12-week physical training program involving a combination of cardiovascular training and resistance training improved the speed at which men completed a 3.2-km distance carrying 46 kg (6).

The soldier can progressively overload in many ways including, but not limited to: 1) moving faster, 2) adding more weight, or 3) changing the grade of the incline. Performing longer, lighter ruck marches can be implemented in a training plan as a recovery tool that also follows the principle of specificity. After including heavier ruck marches into the organized physical training schedule, individual soldiers may find moving under lighter loads for longer distances is physically less demanding. Walking with backpack loads over several weeks can result in a decrease in the energy cost of carrying the load (9).

TRAINING CONSIDERATIONS

If training for an assessment like Ranger School, where they test a timed 12-mile ruck, a solider might consider training with a load lighter than what is used in the test but training at a faster pace. Alternatively, for a tactical training event, or pre-deployment, soldiers could consider adding more weight to get used to carrying all mission-essential equipment and PPE carried while conducting patrols. Research suggests that load-carriage training should focus less on distance and frequency and more on higher intensity (8). However, higher intensity must be balanced with proper gradual progression and rest periods in combination with other forms of physical training (8).

STRENGTH TRAINING EMPHASIS

Many units currently rely on load carriage training as the predominant method of exercise for ruck marches. The principle of specificity should be followed in order to develop load carriage capacity, but it is important to note that aerobic fitness, fat-free mass, and leg/back strength are important physiological factors associated with load carriage performance and changes in load carriage performance (7).

Often, unit physical training focuses on aerobic conditioning, which could potentially increase the risk of overuse injuries. There is potential to reduce the risk for overuse injuries and improve ruck capacity by including strength training into the training program. Research suggests that a balanced training schedule should include some load-carriage training as well as non-marching training focused on enhancing muscular strength and endurance (8). The Army Physical Readiness Training (PRT) program alternates aerobic and calisthenics-focused days (9). If resistance training is included in the training program and emphasizes strength development of the trunk and lower body musculature, it may be possible to reduce the risk for overuse injuries (1). With the

combination of resistance training and specific loaded marches, muscle economy could potentially be increased and allow each soldier to use less energy per given task.

However, it should not be ignored that "strength training alone can improve the capacity to ruck even when load carriage itself is not integrated in the PT schedule," (2). Load carriage exerts large forces on the lumbar spine as well as the hips, shoulders, and knees (4,5). A program that focuses on squats, deadlifts, shoulder presses, and farmer's walks may help develop more stabilized trunk musculature, which could help protect the spine and hips, and replicate a similar protection to the neck and trapezius during ruck marching. It is imperative to each soldier that if they want to be successful in their Army career, they must put extra time into strength training. Since these lifts are not emphasized during Army Physical Readiness Training (PRT) each soldier should start with a higher repetition scheme to learn the fundamentals of each movement. After the soldier learns each movement, progressions can be utilized to focus on strength development. Periodizing a program is a systematic planning of physical training that involves progressive cycling of various aspects of a training program.

Table 1 provides a sample of training progression after the solider has learned the movements. This table shows a two-week block of training focused on training strength, as the soldier is asked to lift at a high intensity for a low repetition count. It is beyond the scope of this article to explain proper warm-up, lifting, accessory work, cool-down, and mobilization practices, but this sample could be used as a template for developing a comprehensive or customized training program for soldiers wanting to improve ruck march performance.

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TABLE 1. SAMPLE TWO-WEEK TRAINING SCHEDULE

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
WEEK 1	Long steady distance run 3 miles at 8:30 min pace	Squat 3 – 5 x 5 Cable row 4 x 8 Dumbbell walking lunges 4 x 6 each	Work capacity circuit with duty uniform and improved outer tactical vest	Deadlift 5 x 10 Bench press 4 x 8 Split squat 4 x 6 each	Acceleration, deceleration, and change of direction work
	MONDAY	**TUESDAY**	**WEDNESDAY**	**THURSDAY**	**FRIDAY**
WEEK 2	Long steady distance run 4 miles at 9:15 min pace	Shoulder press 5 x 10 Farmer's walk 4 x 30 yards Barbell reverse lunge 4 x 6 each	Running pyramid - 4 x 200 m - 2 x 400 m - 1 x 800 m - 2 x 400 m - 4 x 200 m 1 mile cool-down jog	Active recovery/ sports day	Road march 4 miles at 15 min pace

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