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BIOMECHANICAL EFFECTS OF LOADED MARCHING AND RESULTING TRAINING RECOMMENDATIONS

Loaded marching (rucking) is a critical component of military members conducting combat operations (2). Dismounted mobility, defined as the capability of a soldier to traverse through any kind of terrain irrespective of weather conditions, is often the only means of maneuvering to an objective if vehicle infiltration is infeasible or vehicle pickup and dropoff locations are used to maintain surprise (17,22). Army Training Publication 3-21.8, *Infantry Platoon and Squad* describes the characteristics of offensive operations as tempo, surprise, concentration, and audacity (1). To do this effectively, military personnel must move quickly over harsh terrain to maintain operational tempo and achieve surprise, carry all required combat equipment to mass the effects on target, and maintain a level of cognitive awareness to seize and maintain the initiative. Enabling military professionals to succeed in this environment requires an understanding of the biomechanics of loaded marching over terrain.

Military personnel are often required to carry gear, including ruck, weapon, and personal protective equipment exceeding 45% of their bodyweight in various environmental conditions (24). The impact on gait biomechanics often results in additional fatigue and injury risk which may detrimentally impact their ability to accomplish operational objectives (17). As the body means to move as efficiently as possible, it will adapt gait changes to ultimately 1) control the external load as much as possible and to 2) minimize the energy cost associated with carrying the load (6).

The addition of a weighted ruck sack will shift the center of mass (COM) posteriorly and superiorly relative to the body, and the more weight that is carried, the greater this shift will be. To manage this, the body will adopt strategies to maintain both the external load and the body's center of mass over the base of support. This is achieved primarily via a forward trunk lean. As ruck load increases, the angle of trunk lean may increase. Additionally, at certain thresholds of pack load relative to body weight, the neck and head may also be recruited for additional counterweight whereby the head is placed farther forward. These strategies result in increased demand on the spinal extensors muscles which may increase risk for strains of the low back and neck (5,6).

Step length is another variable that may change under load. Most research indicates that when walking speed is held constant, most people respond to load bearing gear by 1) decreasing their step length and/or 2) increasing step rate (6). It is important, however, to note that research is inconsistent with this finding in that sometimes it has been seen that individuals instead maintain walking speed by conversely increasing step length and decreasing step rate. To explain this inconsistency, it has been hypothesized that professionally trained individuals will respond with the

aforementioned step length decrease while untrained individuals will respond with a step length increase, but this may also be influenced by leg length and other morphological differences (5). Each strategy will have different biomechanical advantages and injury considerations.

Ground Reaction Force (GRF) describes the interaction between the individual and the ground during movement and is another variable that is affected by load carriage (7). To describe GRF, it is important to consider three GRF components: vertical GRF, anterior/posterior GRF, and mediolateral GRF. In unloaded walking, vertical GRF is the largest component with peaks registering at approximately 1.2 times/body weight and increases in walking speed promoting increases in GRF (7). The addition of load bearing gear has been shown to increase vertical GRF by approximately 10N for every 1 kg of external load added (6). Although the effect is less than with vertical GRF, anterior/posterior GRF are also affected by external load. Additionally, anterior/posterior GRF will be more affected by cadence changes with slower cadence associated with greater GRF (6). This ties back to earlier discussions regarding step length and step rate adjustment strategies.

Lastly, mediolateral GRF is the least affected by external load but still worth discussing especially when the load carrier may find themselves navigating overland terrain. Research has indicated that mediolateral GRFs increase as load carriage weight increases likely due to decreased stability and increased sway (5). This will become more pronounced on uneven terrain and will require training considerations to ensure that medial/lateral postural stabilizers are adequately trained. These training considerations will be discussed later in this article.

While the aforementioned biomechanical changes are adaptations to increase efficiency to manage the stress of the external load, there are important injury trend considerations that can happen as a result. As previously mentioned, increased forward trunk lean and head posture results in increased muscular demands of the cervical and lumbar paraspinals and then abdominal muscles which in turn can cause strains of the neck and back. Another effect of the increased forward trunk lean is that of increased angle of hip flexion relative to the trunk, which may increase demands through the hip joint and hip flexor muscle group. All of this then becomes magnified if navigating elevation gain and uphill climbs on overland and possibly uneven terrain.

As previously highlighted, GRF will increase with the addition of external load. First and foremost, this causes concern for the risk of bone stress injury (BSI) of the lower extremities as we increase demands on the skeletal system. BSI is an overuse injury that

BIOMECHANICAL EFFECTS OF LOADED MARCHING AND RESULTING TRAINING RECOMMENDATIONS

can occur when a bone is subjected to repeated stress causing microdamage which then exceeds the rate at which the body can remodel and form new bone. As the body fails to continue the required rate for bone remodeling due to sustained loading or inadequate rest periods, micro-fractures can develop. Common BSI sites in military recruits include the metatarsals, tibia, and femur. While there are additional modifiable risk factors increasing risk of BSI such as high body fat, use of certain medications, alcohol, and nicotine, and inadequate nutritional intake, this article will focus on the training priorities and program progressions that are recommended to decrease risk of injury (7).

Additionally, the effect of increased braking mechanism as the load carrier attempts to reduce momentum from the external load must be considered (5). These considerations become even greater if we need to account for increased momentum associated with navigating downhill terrain. Braking mechanism and deceleration moments are characterized by rapid flexion of the hip, knee and ankle. This energy is then dissipated by eccentric muscle work and tendon loading. It has been found that high cumulative deceleration loading over a 2 – 4 week period leads to an increased risk of overuse injury. This is likely best explained as an imbalance in the load capacity and remodeling rate of the tissue versus the rate, duration, and intensity of the deceleration loading. Training considerations to improve eccentric strength capacity and avoid spikes in training volume should be given to help mitigate this injury risk (15).

To mitigate injury risk and improve loaded march performance, practitioners may consider using a concurrent total body resistance training and aerobic training approach. Kraemer et al. suggested that concurrent resistance and aerobic training showed the most significant improvement in a two-mile loaded run with a 44.7-kg ruck, compared to resistance training only or endurance training only in male soldiers (13). Given the aforementioned biomechanical analysis of loaded marching, a total body resistance training approach directly addresses the need to improve trunk and erector spinae musculature, along with eccentric quadricep strength and overall lower body strength and power.

Concurrent total body resistance and endurance training is a strong mitigating factor for potential BSI when workload is managed appropriately (25). It is well established in research literature that exposing bones to mechanical load that exceeds daily activities has an osteogenic effect (9). The challenge faced by practitioners in a concurrent resistance and aerobic training program is managing the training load. As important as it is to expose bone to increased mechanical loading, it is also necessary to manage the workload to avoid spikes in volume that increase risk of BSI. While some general rules or mitigation measures have been established (such as the “10% rule” or acute:chronic workload ratio), it is better to individualize workload progression due to the complex interaction between biomechanics, physiology, psychology, musculoskeletal qualities, and energy availability (25).

Strength and conditioning professionals should also recognize that service members are required to carry a ruck not only during formal fitness assessments—typically performed on roads or other stable surfaces—but also across variable and uneven terrain during tactical movement and maneuver tasks. As surface instability and grade change, mediolateral GRF and the associated postural demands become increasingly pronounced. These demands are further magnified by the addition of distally carried or elevated loads such as weapons systems, helmets, and upper-body mounted equipment. Because these loads increase the moment arm relative to the COM, even small increases in distal weight can create disproportionately large changes in trunk lean, lateral sway, and overall gait mechanics. This results in greater reliance on the lateral stabilizers of the hip and trunk and can compound fatigue during prolonged load carriage.

To mitigate these postural and biomechanical challenges and improve load-carriage efficiency, targeted strengthening of the lateral stabilizers (e.g., hip abductors and quadratus lumborum) should be incorporated. This can be effectively achieved through unilateral carry variations and lower-body movements such as squats, step-ups, and lunges, supplemented by frontal-plane exercises (e.g., lateral step-ups and lateral lunge variations).

In addition to targeted strength development, service members should undergo progressive acclimatization to the specific loads and equipment they are required to carry. Gradual exposure to operational loads allows the neuromuscular system to adapt to altered COM positioning, increased moment arms from distal equipment, and changes in trunk and pelvic mechanics. Load acclimatization has been shown to improve gait economy, reduce excessive trunk lean and mediolateral sway, and enhance tissue tolerance by distributing stress more effectively across the kinetic chain. Incorporating structured progressions in load, duration, and terrain complexity ensures that adaptations occur safely while minimizing the risk of overuse injury.

While traditional strength and conditioning can directly address many of the biomechanical effects of loaded marching, it is helpful to also consider that exposure to the terrain itself is a training variable that can be progressed. One study measuring variability of step length, step width, and COM during repeated exposure to uneven terrain found that as familiarity increased, step length increased and variability of anterior-posterior COM and step length reduced (10). This suggests that more time in the terrain itself will improve locomotor function and overall postural control. With this in mind, the strength and conditioning professional may consider gradually increasing the time or frequency that the service member spends in the environment to develop the locomotor skills to move efficiently over terrain.

SUMMARY OF STRENGTH AND CONDITIONING RECOMMENDATIONS

To optimize performance in loaded marching and mitigate injury risk, strength and conditioning programs should emphasize a combined approach integrating resistance training, aerobic conditioning, and terrain exposure.

1. CONCURRENT TRAINING APPROACH

Evidence indicates that concurrent resistance and endurance training yields superior improvements in load-carriage performance compared to resistance or endurance training alone. Kraemer et al. demonstrated that soldiers performing both modalities showed the greatest improvements in a 2-mile loaded run compared to single-modality groups (13). More recent reviews confirm that pairing progressive resistance training with aerobic conditioning, approximately three times per week, enhances resilience and reduces overuse injuries during load carriage (18,20).

2. LOAD-CARRIAGE SPECIFIC TRAINING FREQUENCY

Narrative reviews recommend including load-carriage sessions every 7–14 days, using progression strategies that manipulate load weight, terrain, and speed rather than simply increasing distance (20). Research from Orr et al. highlights that this frequency provides sufficient stimulus while allowing adequate recovery, and reducing musculoskeletal injury risk during repeated rucking demands (18).

3. LOWER-BODY STRENGTH AND POWER

Lower-body strength and power are key predictors of load-carriage performance. A systematic review and meta-analysis found significant correlations between squat strength, vertical jump performance, and marching capacity under load (19). Accordingly, programming should emphasize posterior chain development (deadlifts, hip hinge variations) and eccentric quadriceps strength (split squats, step-downs) to manage braking forces, particularly on descents.

4. TRUNK AND POSTURAL CONTROL

The biomechanics of rucking place increased demand on spinal extensors, abdominals, and hip flexors. Strengthening these tissues through trunk stability training (loaded carries, anti-extension core work, and posterior chain exercises) is essential. Emerging evidence suggests that upper-body strength (e.g., pull-ups, bench press) is also strongly correlated with load-carriage performance, likely due to its role in maintaining posture under load (16,20).

5. BONE STRESS INJURY MITIGATION

Bone health benefits from mechanical loading that exceeds daily activity, but progression must be carefully managed. Overuse injuries such as medial tibial stress syndrome and stress fractures are often associated with rapid spikes in training volume. Research supports gradual workload progression and individualized programming to mitigate these risks (8,18).

6. AEROBIC CONDITIONING AND FATIGUE MANAGEMENT

Aerobic fitness supports operational tempo by improving movement economy and delaying fatigue. Studies suggest managing pace and external load to maintain exercise intensity near 45 – 47% of VO_2max can prolong endurance under load (4). Steady-state sessions and intervals should both be integrated into the program to prepare soldiers for sustained marches and rapid maneuvering.

7. TERRAIN EXPOSURE AS TRAINING

Locomotor variability decreases with repeated exposure to uneven terrain, leading to improvements in step length, center of mass stability, and overall efficiency (10,23). Accordingly, programs should gradually increase training time in terrain environments to complement gym-based strength and conditioning interventions.

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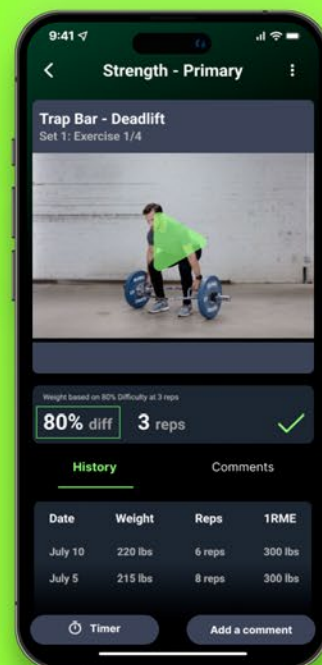
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FIRST RESPONDER RESEARCH COLUMN – UNDERSTANDING THE STRESS RESPONSE FOLLOWING OCCUPATIONAL EXPOSURES AMONG FIRST RESPONDERS

OVERVIEW

Prolonged elevated stress can lead to the development of chronic disease (11). First responders routinely encounter situations that psychologically and physically stress the body, which may contribute to chronic states of elevated physiological stress. Various biomarkers obtained from blood and saliva samples may be used to evaluate systemic stress. Salivary and blood biomarkers have been shown to remain elevated beyond 15 minutes following an occupational exposure (3,10), which may not facilitate full recovery prior to another call. Understanding first responders' physiological responses to emergency calls can help practitioners understand factors that contribute to chronically elevated levels of stress and identify appropriate countermeasures to manage cumulative acute arousal.

**PHYSIOLOGICAL STRESS RESPONSES TO A
LIVE-FIRE TRAINING EVOLUTION IN CAREER
STRUCTURAL FIREFIGHTERS. JOURNAL OF
OCCUPATIONAL AND ENVIRONMENTAL MEDICINE,
66(6), 475–480, 2024.**

**GONZALEZ, DE, DILLARD, CC, JOHNSON, SE, MARTIN, SE,
AND MCALLISTER, MJ**

BOTTOM LINE UP FRONT (BLUF)

Firefighters experience high levels of stress during live fire training evolutions but recover relatively quickly upon cessation.

Sudden cardiac death is the leading cause of mortality in firefighters, resulting in approximately 45-50% of on-duty fatalities (5,12). Previous research indicates that cardiovascular strain, oxidative stress, and inflammation contribute to the progression of cardiovascular disease (6,11). However, the roles of the hypothalamic-pituitary-adrenal (HPA) and sympathetic-adreno-medullar (SAM) axes have not been evaluated regarding physiological stress and their role in disease risk among firefighters. Activation of the HPA and SAM axes, and immune system can be reflected by the salivary markers α -amylase (AA), cortisol (CORT), and secretory immunoglobulin-A (SIgA), which have been shown to increase in high-stress simulated occupational scenarios (1,9). This study investigated the physiological stress response to a live fire training evolution (LFTE) among career structural firefighters by evaluating salivary AA, CORT, and SIgA levels.

Seventy-six healthy male career firefighters volunteered to complete a LFTE while on shift. Two teams of four firefighters responded to a randomly scheduled training operation to simulate a structure fire emergency. Upon arrival at the LFTE, firefighters were assigned roles, briefed on the scenario, and followed standard procedures. The LFTE utilized Class A combustibles (e.g., wood) and required firefighters to perform search and rescue tasks that took approximately 25 minutes. Details regarding the firefighters' activity during the post-LFTE period were not provided. Salivary samples were collected at the fire station at the beginning of the shift, immediately post-LFTE, and 30 minutes post-LFTE. The firefighters were instructed to perform a mouth rinse with water approximately 10 minutes before the samples were collected using the passive drool technique. Immediately after receiving samples, they were stored on ice for later analysis.

The LFTE had an impact on salivary stress markers, as noted by significant increases in AA (94% increase, $p < 0.001$, Cohen's $d = 0.83$), CORT (91% increase, $p < 0.001$, Cohen's $d = 0.77$), and SIgA (42% increase, $p < 0.001$, Cohen's $d = 0.61$) immediately following the LFTE. Despite the relatively large increases in these biomarkers, each returned to baseline values within 30 minutes post-LFTE ($p < 0.001$). These findings provide evidence that the LFTE placed considerable stress on the firefighters but returned to baseline levels relatively quickly upon cessation of firefighting tasks.

**ACTIVE SHOOTER TRAINING DRILL INCREASES
BLOOD AND SALIVARY MARKERS OF STRESS.
INTERNATIONAL JOURNAL OF ENVIRONMENTAL
RESEARCH AND PUBLIC HEALTH, 17(14), 5042, 2020.**
MCALLISTER, MJ, MARTAINDALE, MH., AND RENTERÍA, LI

BOTTOM LINE UP FRONT (BLUF)

Brief law enforcement occupational scenarios elicit an acute stress response.

Simulated policing activities with and without the threat of a firearm have been shown to increase stress markers like blood and salivary cortisol (2,4,9,13,14). Notably, video-based scenarios have also shown increases in AA, CORT, and SIgA. Fewer studies have incorporated live scenarios, resulting in a lack of research regarding biomarkers during live scenarios. Temporary increases in AA, CORT, and SIgA may help the body meet the demands of acute stress, but chronic elevation can lead to obesity and

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cardiometabolic diseases even in officers exhibiting improved performance (6,11).

Thirty-one physically active university students (15 males, 16 females) were recruited to serve as mock law enforcement officers in this study. Upon arrival, saliva samples were collected using the passive drool technique 30 minutes and 5 minutes prior to the active shooter drill (ASD) to measure baseline AA, SlgA, and CORT concentrations, respectively. Blood samples were also taken 15 minutes prior to the ASD to measure epinephrine and norepinephrine concentrations. Participants were then transported to the ASD, explained their role as the mock law enforcement officer, and informed that they would be given information through radio traffic, simulating a realistic active shooter scenario. The ASD was designed to mimic real world conditions by having live actors role play the shooter and victims roles, including realistic wounds and simulated blood to enhance ecological validity. Participants had time to acclimate themselves to their training pistol prior to beginning the ASD. When the participant indicated that they were ready, radio traffic began to initiate the call. Twenty seconds into the radio traffic, the active shooter began firing a blank gun in the building, a simulated fire alarm was activated, additional shots were fired, and acting victims began to scream. The participants then entered the building and were met with four victims throughout the house with injuries of varying severity. In the ASD room, the final victim collapsed after the shooter fired multiple rounds, before turning toward the participant where the participant either fired at the shooter or vice versa. The ASD lasted approximately 50 seconds in total. Salivary samples were then taken 5 minutes and 30 minutes post-ASD. A final blood sample was taken 15 minutes after the ASD.

Salivary and blood biomarkers both indicated that substantial stress was incurred during the ASD. Salivary AA ($p < 0.01$, $\eta^2 = 0.41$) and plasma epinephrine ($p = 0.009$, Cohen's $d = 0.68$) concentrations appear most affected by a live-action ASD, each demonstrating a significant increase between pre- and post-ASD measures. Interestingly, CORT continuously declined during the operation, and there was a lack of significance observed in SlgA between pre- and 5 minutes post-ASD samples. It is possible that pre-ASD stress markers did not reflect true resting conditions, as the civilian participants are not trained to encounter such intense simulations and may have exhibited anticipatory stress in pre-ASD measurements. Nevertheless, all three salivary markers decreased to baseline conditions or lower within 30 minutes of concluding the ASD.

RELEVANCE FOR THE TACTICAL FACILITATOR

The findings from both studies demonstrated that performing fire or law enforcement emergency responses places considerable acute stress on the participants. However, salivary stress markers returned to baseline or lower within 30 minutes, suggesting a relatively rapid recovery. It is worth reiterating that pre-exposure

biomarkers may not reflect true resting measures, which can be influenced by other psychological and social stressors often observed in tactical professions (e.g., interpersonal relationships at work and home, PTSD). Furthermore, the exposures included in these studies had defined end points (i.e., 25 minutes and -50 seconds), which are likely shorter than actual scenarios and may have elicited a response of lesser magnitude than a real emergency. Incorporating stress inoculation into training may help first responders reduce the stress response and expedite recovery following occupational stressors, though neither study considered experience or fitness level into the analysis. It is also important for first responders to practice lifestyle stress management techniques (see Table 1) to mitigate chronic overactivation of the HPA and SAM axes.

TABLE 1. TECHNIQUES FOR MANAGING STRESS

TECHNIQUES	
Get active	Yoga
Eat healthy	Sleep
Meditate	Journal
Healthy social circle	Counseling

Note: Techniques suggested from the Mayo Clinic (7)

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REHABILITATION TO PERFORMANCE OF THE SHOULDER FOR THE TACTICAL ATHLETE

Shoulder pain is one of the most common upper-extremity musculoskeletal complaints among tactical athletes, a term that encompasses military personnel, law enforcement officers, firefighters, and other first responders (10). Reported incidence of shoulder injuries varies widely, ranging from 8.3% to as high as 43% of all injuries in these populations (10,21). Although shoulder pain is typically multifactorial, chronic symptoms often follow predictable pathological patterns influenced by prior trauma, repetitive occupational demands, participation in overhead sports, congenital or acquired ligamentous laxity, and postural adaptations (1,5,6,7,9,10).

This review examines the primary historical and occupational risk factors contributing to shoulder pain in tactical athletes, outlines relevant pathoanatomy, and provides evidence-based rehabilitation and prehabilitation strategies. By understanding these mechanisms, clinicians and strength and conditioning professionals can implement targeted screening, corrective exercise programming, and load-management strategies to reduce injury risk and restore pain-free function.

HISTORICAL RISK FACTORS

A thorough history remains critical in the evaluation of shoulder pain. Prior participation in overhead sports—such as baseball, swimming, tennis, water polo, or volleyball—significantly increases the likelihood of subsequent shoulder pathology (1,5,6). Previous episodes of glenohumeral dislocation or subluxation markedly elevate recurrence risk and are frequently accompanied by capsular laxity or labral injury (5,7). Cervical spine pathology must also be considered, as referred pain from the cervical region to the scapular or shoulder area is common, often presenting as interscapular or posterior shoulder discomfort (5).

OCCUPATIONAL AND TRAINING-RELATED RISK FACTORS

Overuse injuries are prevalent among tactical athletes because of the repetitive and high-volume nature of both training and operational demands (9,10,21). Large numbers of push-ups performed during physical fitness testing and daily training impose considerable repetitive stress on the shoulder complex, particularly in recruit populations, and should not be overlooked as a contributing factor to pain and injury (21). However, push-ups represent only one component of a broader repetitive-loading profile.

On duty, tactical athletes routinely perform prolonged weapon carrying, heavy load carriage (body armor, hoses, breaching tools, or casualties), overhead tasks during building entry or vehicle extrication, repetitive throwing (flashbangs), and sustained awkward postures (9,10). These activities can lead to subacromial

impingement, rotator cuff tendinopathy, labral tears, glenohumeral instability, and biceps pathology (9,10,21).

PATHO-ANATOMY

The shoulder complex consists of the glenohumeral (GH), acromioclavicular (AC), and scapulothoracic (ST) joints. The GH joint, a ball-and-socket articulation between the large humeral head and shallow glenoid fossa, provides the greatest range of motion in the human body but sacrifices inherent bony stability, often compared to a golf ball on a tee (5,9).

This mobility-stability trade-off requires robust static and dynamic stabilizers. Static stabilizers include the glenoid labrum, which deepens the glenoid concavity from roughly 2.5 mm to 5 mm (4,7,9); the joint capsule; the coracohumeral ligament (CHL); and the superior, middle, and inferior glenohumeral ligaments (SGHL, MGHL, IGHL, respectively) (4). Dynamic stabilizers are led by the rotator cuff (supraspinatus, infraspinatus, teres minor, subscapularis), long head of the biceps, and deltoid, with secondary contributions from pectoralis major, latissimus dorsi, and teres major (5,9). Scapulothoracic muscles (serratus anterior, trapezius, rhomboids, pectoralis minor) provide a stable base for the entire complex as they control the position of the scapula (7).

Tactical athletes (or former overhead athletes) utilizing overhead movements can involve repetitive abduction with external rotation stressing the anterior capsule and associated ligaments causing them to stretch over time producing increased external rotation (4,5,14,15). Posterosuperior (SLAP) labral tears can exacerbate humeral head translation by allowing more humeral head movement and further mimic anterior laxity (4,7,15). Conversely, an increase in range of motion with external rotation is typically accompanied by a subsequent loss of internal rotation, termed glenohumeral internal rotation deficit (GIRD; defined as a deficit measuring greater than 20° compared with the non-dominant arm), caused by posteroinferior capsular contracture (4,5,16).

Additionally, the sub-acromial space can become narrowed impinging on tendons and structures that reside within that space. Contracture of the posterior band of the IGHL shifts the humeral head posterosuperiorly during abduction with external rotation, altering the center of rotation for the humeral head in relation to the glenoid (4,16). These kinematic changes, combined with scapular dyskinesis (abnormal positioning of the scapula due to altered shoulder mechanics and lack of stabilizing muscular control), narrow the subacromial space and increase compression of the supraspinatus tendon and biceps tendon, commonly resulting in posterosuperior rotator cuff tears and tendinopathy (4,7,13).

CHRONIC SHOULDER PAIN

Common chronic shoulder injuries include subacromial impingement, rotator cuff tendinopathy, glenoid labral tears (including SLAP lesions), and shoulder instability (4,5). A history of repetitive overhead activity, whether from youth sports such as baseball or from occupational demands, significantly influences current shoulder pain and must be considered when designing exercise programs. Even if an individual has not thrown overhead for decades, prior exposure can produce lasting adaptations collectively known as “thrower’s shoulder” (4,5,15).

Thrower’s shoulder arises from repetitive overhead motion and typically produces specific biomechanical faults (4,5). A hallmark adaptation is posterior glenohumeral joint capsule contracture, which posteriorly shifts the humeral head’s center of rotation. This alteration may also manifest as excessive glenohumeral external rotation coupled with restricted internal rotation, a condition termed glenohumeral internal rotation deficit (GIRD). GIRD has two primary consequences: (1) increased shear forces at the superior labrum, elevating risk of superior labrum anterior-to-posterior (SLAP) tears at the biceps anchor, and (2) concomitant anterior capsule stretching, which promotes anterior glenohumeral instability (4,5,15). Secondary subacromial impingement and rotator cuff overload often follow as the humeral head migrates superoposteriorly during throwing or overhead activity (4,5,11).

Finally, chronic anterior capsule laxity—whether from prior dislocation or repetitive microtrauma—can markedly impair progression of horizontal pressing exercises (4,5,25). During the transition from eccentric to concentric phases of the bench press or push-up, excessive anterior humeral head translation may occur, resulting in painful subluxation or apprehension (4,5,20,25).

ASSESSMENT REHAB TO PERFORMANCE TEAM

When working with this population, it is highly recommended to have a team of specialists to help return the tactical athlete to duty. The tactical athlete should be seen by a Doctor of Physical Therapy (DPT), Orthopedic Surgeon, or Sports Medicine Chiropractor for clinical pathology prior to beginning a program. While the strength and conditioning specialist may sometimes be the point of access to care tactical athlete, if the tactical athlete has the complaints, they should be assessed by a healthcare provider:

1. Shoulder pain at night regardless of sleeping position,
2. Painful popping and clicking in the shoulder,
3. Recurring shoulder dislocations,
4. Progressive weakness or recurring numbness and tingling in the arm or hand,
5. Failure of conservative care,
6. Loss of range of motion or visible atrophy (muscle loss),
7. Inability to perform activities of daily living,

Part of the return to performance model should include a clinical examination and diagnosis. A specialist can help determine, in the clinical setting, if the tactical athlete is a good candidate for rehabilitation or if further work-up is necessary. Dynamic orthopedic shoulder examinations are critical in the decision-making process. Though not limited to, an often-used cluster of examinations for shoulder instability are the anterior apprehension test, followed by relocation test then the reverse relocation test (7). This clinical examination should take place prior to any fitness or movement assessment occurs. Lastly, a determination of congenital ligament laxity or suspicion of connective tissue disorder is important.

a. Congenital Ligament Laxity

A nine-point assessment should be performed on the tactical athlete to see if congenital joint hypermobility is present. However, this is not diagnostic and can be a screen for the strength and conditioning coach (Figure 1):

1. Left and right 5th digit passive dorsiflexion beyond 90°
2. Left and right thumb passive dorsiflexion to the flexor aspect of the forearm.
3. Left and right elbow hyperextends beyond 10°
4. Left and right knee hyperextends beyond 10°
5. Forward flexion of trunk with knees full extended.

Each joint assessed is one point, for a total possibility of nine points. A score above six indicates global hypermobility (but not necessarily a connective tissue disorder such as Ehlers-Danlos Syndrome (4,5). If an athlete has six of these points, with chronic shoulder problems or difficulty with horizontal presses, for example, the presence of atraumatic multi-directional, rehab as treatment, instability (AMBRI) should be considered.

b. Glenohumeral Internal Rotation Deficit (GIRD)

Tactical athletes with GIRD can be asymptomatic. GIRD is an adaptive process in which the dominant shoulder experiences a loss of internal rotation (IR) (4,5,23). Most commonly defined by a loss of >20° of IR compared to the opposite shoulder (4,23). The typical cause of GIRD is posterior glenohumeral ligament (capsule) contracture, as previously discussed. GIRD is often associated with several related diagnosis including subacromial impingement, articular side rotator cuff tears, and glenoid labrum tears (4,5).

Figure 2 demonstrates a quick screen to see if GIRD is present. This tactical athlete is suspected of having GIRD on his right side. There is a more precise way to measure GIRD, but this requires a partner and a goniometer. If an asymmetry is seen here, the remedy is often “the sleeper stretch” (Figure 3). Try performing this stretch before any pressing workout or overhead activity (swimming included), start with 3 sets of 10 second hold on the affected side.

c. Thoracic spine motion

Persistent shoulder pain should prompt consideration of thoracic spine immobility as a contributing factor. Restricted thoracic extension is frequently associated with shoulder pain and reduced active range of motion (2,8).

Assessing thoracic spine mobility is generally more challenging than assessing cervical or lumbar motion because the thoracic region is inherently less mobile. Several reliable methods exist:

- Thoracic rotation can be evaluated using the “T4 rotation” test (Figure 4).
- Thoracic flexion and extension are best assessed in quadruped or seated positions.

In each case, the patient should move slowly into end-range, hold for 2 – 3 seconds, and stop if pain is provoked. The goal is to identify true mechanical restriction rather than pain-limited motion.

Improved thoracic mobility positively influences scapulothoracic rhythm and overall shoulder range of motion. Notably, one randomized study demonstrated that a thoracic mobility program significantly reduced pain and improved function in patients with chronic rotator cuff tendinopathy (8,20). Although alterations in scapular motion (scapular dyskinesis) are often discussed in this context, the topic remains controversial and is beyond the scope of this article.

REHABILITATION TO PERFORMANCE START POINT

a. Rotator Cuff Exercises

The rotator cuff provides dynamic glenohumeral stability and must remain a cornerstone of both rehabilitation and long-term shoulder health programming for tactical athletes. Imbalances—particularly weakness of the supraspinatus, infraspinatus, and teres minor relative to the stronger internal rotators (subscapularis, pectoralis major, latissimus dorsi)—are common in this population and may contribute to impingement, superior humeral head migration, and secondary labral overload (5,11,18).

High-priority, low-load rotator cuff exercises should be performed 3 – 5 times per week and precede all pressing or pulling sessions. The following three side-lying exercises are safe, effective, and easily progressed (11):

1. Side-lying Abduction to 45° Primary target: supraspinatus. Maintains humeral head depression during early abduction and counters deltoid-driven superior translation (Figure 5).
2. Side-lying External Rotation (arm at side, 0° abduction) Primary target: infraspinatus and teres minor. Directly addresses the external-rotation weakness that exacerbates GIRD, anterior capsule stress, and impingement (Figure 6).

3. Side-lying Horizontal Extension (“T” movement, arm in line with torso) Primary target: posterior cuff and lower trapezius/scapular retractors. Reinforces scapular posterior tilt and humeral head centering (Figure 7).

These exercises are non-fatiguing at the prescribed loads yet produce rapid improvements in cuff endurance and glenohumeral force-couple efficiency—essential prerequisites before advancing to compound pressing, pulling, or overhead movements in tactical athletes with chronic shoulder pain (11,18). The following represents prescription guidelines across phases of possible rehabilitation and continued performance-related training (11):

- Rehabilitation phase (active pain or recent injury): 1 – 5 lb dumbbell, 3 – 4 sets of 12 – 20 slow, controlled repetitions.
- Prehabilitation/maintenance phase: 5 – 15 lb dumbbell, 3 sets of 10 – 15 repetitions with 2 – 3 s eccentric focus.
- Perform daily or before every upper-body session; fatigue should be localized to the cuff, not the deltoid or neck.

b. Horizontal and Vertical Presses

A fundamental movement pattern in upper body strength training is pressing. The press can be performed horizontally (example: bench press) or vertically (example: an overhead press). Regardless of the type of press, if a shoulder is unstable the tactical athlete may experience pain and potential injury. Modifications can be made to pressing movements to modify the exercise to make it more beneficial and reduce risk of further aggravation to the tactical athlete with an unstable shoulder.

With the vertical press, a more unstable load being pressed overhead may result in greater activation of the shoulder stabilizing musculature (6). This means an overhead press exercise like a machine press is going to require the least amount of stabilization and will make it easier for the humeral head to stay centered in the glenoid socket as compared to a barbell, kettlebell, or dumbbell press. For a tactical athlete with shoulder instability, starting with a machine press may be preferential for pain tolerance and re-establishing baseline strength. Overtime as they become stronger overhead and with concurrent strengthening of the shoulder stabilizing muscles they should be progressed if it can be tolerated. The barbell press should be considered the first progression from a machine press as the dumbbell or kettlebell will require the greatest amount of stabilization to keep the humeral head centered in the glenoid as it is a single arm movement (6).

Research has suggested that using a wider grip with bench pressing increases the compression and shear forces within the glenohumeral joint while horizontal pressing (19). Therefore, if the tactical athlete has an unstable shoulder, they should be able to bench press with less pain and decrease further injury risk by

using a narrower grip. Specifically a grip width between 1 and 1.5 bi-acromial widths has been suggested as the most advantageous to minimize compression and shear forces within the GH joint (19). To measure the bi-acromial width of a tactical athlete, a measurement is taken from one acromion process to the other. Noteboom et al. (19) also found that maintaining a retracted scapula can also decrease the GH compressive and shearing forces experienced during a bench press. By using a narrower grip and keeping the scapula retracted during the bench press, the tactical athlete with an unstable shoulder should be able to minimize the amount of compression and shear forces that the GH joint goes through during the movement (19). This will hopefully minimize the need for reliance on the stabilizing structures of the shoulder as the humeral head stays centered in the glenoid (19,24).

c. Horizontal and Vertical Pulls

Prior to integrating any horizontal or vertical pulls, it is important to ensure there is appropriate rotator cuff strength and stability. Both horizontal and vertical pulling exercises can be initiated once the tactical athlete has progressed in the rudimentary side-lying rotator cuff exercises discussed above. Without adequate rotator cuff strength, there is increased stress placed on the glenohumeral joint itself (2). Vertical pulling exercises, such as the latissimus dorsi “pull-down” and the horizontal pulling exercises, such as the seal row or bent over row can be used in both rehabilitation settings and ongoing performance training for those with chronic shoulder pain. These exercises involve the shoulder as they target, but not exclusively, the teres major and latissimus dorsi, both of which are dynamic shoulder stabilizers.

The latissimus dorsi exercise should be performed in front of the neck while avoiding full extension of arms to avoid excessive shearing forces at the glenoid (2). Additionally, the intent of avoiding the “pull-down” behind the neck is to avoid excessive stress at the anterior glenohumeral ligament complex (2). Neutral, supination and/or pronation grip can be used with a narrower spacing. Aggressive, rapid movements should be avoided with a focus of the eccentric portion of the exercise to avoid the previously discussed shearing at the glenoid (2). Furthermore, the bent-over row is a great exercise selection for tactical athletes with instability as the exercise limits stress placed on the anterior glenohumeral capsule. Optimizing this lift should include a neutral grip, with arm abduction less than 30° (2).

d. Lateral Raise

The lateral deltoid raise is a popular exercise to strengthen the deltoid and the entire shoulder complex. The biggest issue with the lateral deltoid raise is that when the shoulders are abducted with internal rotation, impingement of the supraspinatus can occur between the humeral head and the acromion process (4,11). If a tactical athlete has an unstable shoulder, this impingement can become more pronounced due to the superior migration of the humeral head that has been observed with unstable shoulders. For example, Kolber et al. (16) found that maximum shoulder impingement occurred above 90° of abduction. Therefore, the first strategy for tactical athletes training with an unstable shoulder that want to perform the exercise should stop the range of motion below 90° of abduction. Additionally, it was found that the strength of the rotator cuff had an inverse relationship with symptoms of shoulder impingement. This relationship shows that a stronger rotator cuff can be useful to minimize the superior translation of the humeral head ultimately decreasing impingement. Therefore, tactical athletes that still experience impingement symptoms while keeping the range of motion below 90° of abduction could benefit from strengthening of the rotator cuff (16).

e. Squat

Commonly used bar placements while back squatting are the low- or high-bar position. In a low-bar back squat, the bar is placed along the posterior deltoid and the middle trapezius. This position allows the lifter to utilize a more horizontal torso position and target the hip extensors (glutes and hamstring) more effectively than a high bar squat where the quadriceps are more effectively targeted (22). This low-bar position can cause anterior dislocations and impingement in the shoulder because of the external rotation required at the shoulder and the load being placed directly on the shoulder (6). In the tactical athlete that has instability in the shoulder, this position is even more likely to cause pain and injury. For this reason, in tactical athletes with an unstable shoulder it is recommended to utilize a high bar position or even a safety squat bar. With the high bar position, the bar is placed on top of the upper trapezius and requires a more vertical torso angle. Using this position the tactical athlete can decrease the amount of force that is exerted into the shoulder and will likely be able to squat with less shoulder pain and chance of injury. Another strategy to even further decrease the force into the shoulder is to utilize a safety squat bar. A safety squat bar is a specialized cambered shaped barbell with shoulder support that removes the requirement for external rotation at the shoulder altogether. By completely removing external rotation at the shoulder the tactical athlete with an unstable shoulder will have the least risk and compromise to the shoulder.



FIGURE 1. NINE-POINT ASSESSMENT



FIGURE 2. QUICK GIRD SCREEN



FIGURE 3. SLEEPER STRETCH

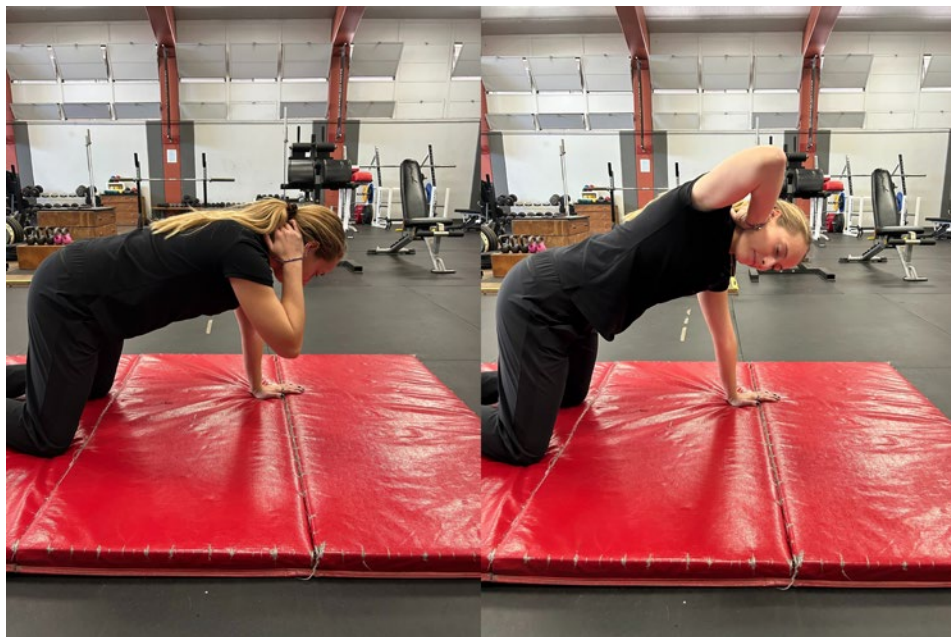


FIGURE 4. T4 ROTATION TEST



FIGURE 5. SIDE-LYING ABDUCTION



FIGURE 6. SIDE-LYING EXTERNAL ROTATION



FIGURE 7. SIDE-LYING HORIZONTAL EXTENSION

CONCLUSION

Shoulder pain in tactical athletes is highly prevalent, often chronic, and multifactorial. Repetitive occupational demands (load carriage, weapon handling, overhead tasks, and high-volume push-ups), combined with historical risk factors such as prior overhead sports participation, traumatic dislocations, GIRD, and congenital or acquired capsular laxity, create predictable patterns of subacromial impingement, rotator cuff tendinopathy, labral pathology, and glenohumeral instability.

Effective management requires a systematic, collaborative approach. Early clinical screening by qualified providers (physical therapists, sports chiropractors, or orthopedic specialists) is essential to rule out red flags and guide decision-making. Strength and conditioning professionals play a critical role in subsequent prehabilitation and rehabilitation by 1) identifying range-of-motion deficits (especially GIRD, thoracic mobility restrictions, and hypermobility), 2) prioritizing rotator cuff and scapular stabilizer strength, and 3) progressively modifying foundational movements (horizontal and vertical pressing and pulling, squatting, and lateral raises—to minimize excessive glenohumeral translation, shear, and impingement while restoring load tolerance.

When historical, occupational, and biomechanical risk factors are systematically addressed through targeted assessment and evidence-informed exercise selection, most tactical athletes with chronic shoulder pain can return to full operational duty with reduced pain, improved resilience, and lower risk of recurrence. A proactive, team-based model that bridges clinic and gym ultimately protects both the individual operator and the mission.

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TSAC REPORT #80 – MILITARY COLUMN – 2026

OVERVIEW

Combat readiness is a multidimensional construct that reflects a military unit's capacity to execute assigned missions under operational conditions. It encompasses physical, cognitive, logistical, and psychological preparedness, and is shaped by both systemic infrastructure and individual performance capabilities (3). The Department of Defense (DoD) defines readiness as “the ability of military forces to fight and meet the demands of assigned missions” (6), underscoring its dynamic, context-dependent nature across domains and operational theaters.

From a performance science perspective, combat readiness is not merely the absence of fatigue or injury but the presence of optimized physiological and neurocognitive states that enable sustained performance under stress. This includes metrics, such as heart rate variability (HRV), cortisol regulation, neurosynchrony, and attentional control, which are increasingly integrated into tactical diagnostics and training protocols (13). As highlighted in recent military literature, readiness training must evolve to address both conventional and asymmetric threats, requiring interdisciplinary approaches that blend clinical diagnostics with operational demands (11). Unlike civilian occupational stress, military-specific combat stressors present unique challenges, including exposure to life-threatening events, witnessing the injury and death of others, and the requirement to take actions that may end another human's life (4,7).

TACTICAL COGNITIVE READINESS OF MILITARY PERSONNEL: THE EFFECT OF TRANSFER OF TRAINING. *INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN ECONOMICS AND MANAGEMENT SCIENCES* 14(1): 263-288, 2025.

ALIM, H, WAHAB, AYA, SUBRAMANIAM, A, AND NOR, NM

BLUF: Applying learned knowledge, skills, and abilities (KSA) from training to real-world operations is critical for improving decision-making, adaptability, and overall mission readiness in complex and unpredictable military environments.

In their 2025 study, Alim et al. (1) present a compelling exploration into the behavioral dimensions of combat readiness. Moving beyond traditional physiological metrics, the authors focus on Tactical Cognitive Readiness (TCR), a soldier's ability to think critically, adapt swiftly, and make sound decisions under operational stress. Their central thesis is clear: cognitive readiness is not merely a product of innate ability or isolated training events, but a direct outcome of how effectively training transfers into real-world performance.

Drawing on a sample of Malaysian Army personnel, the authors employ a quantitative methodology to examine the relationship between training transfer and cognitive readiness. Using structural equation modeling, they reveal a strong positive correlation ($\beta = 0.669$) and a substantial effect size ($f^2 = 0.808$), underscoring the importance of transfer fidelity in shaping operational cognition. These findings suggest that when training environments authentically mirror the complexity and unpredictability of combat scenarios, soldiers are far more likely to exhibit the cognitive agility required in the field.

What distinguishes this study is its emphasis on the behavioral and educational architecture of readiness. The authors argue that KSAs must be embedded in realistic, scenario-based learning environments to ensure effective transfer, aligning with broader trends in tactical performance research concluding that effective training must replicate complex, real-world scenarios (8) to build skill proficiency without overwhelming the individual's mental capacity (9,10), a key factor in performance among military and law enforcement personnel (8,9).

The implications are far-reaching. For military educators and planners, the study offers a roadmap for designing curricula that prioritize cognitive transfer. For readiness assessors, it advocates including behavioral metrics alongside psychophysiological indicators, such as HRV or direct current (DC) potential of brain wave activity (12). And for tactical units operating in asymmetric environments, it reinforces the need for training that cultivates adaptability, situational awareness, and rapid decision-making.

While the study is methodologically sound, its reliance on self-reported data introduces potential bias. Future research would benefit from integrating objective cognitive performance measures, such as EEG coherence or reaction time, and expanding the sample to include multinational forces for broader applicability (5).

Ultimately, Alim et al. contribute a vital piece to the evolving puzzle of combat readiness. By illuminating the role of training transfer in cognitive preparedness, they offer both theoretical insight and practical guidance for enhancing the mental edge of today's tactical operators.

Practitioner Relevance: Understanding how the *transfer of training*, the ability for personnel to apply learned skills and knowledge to real-world contexts, directly impacts tactical cognitive readiness, decision-making, and adaptability under pressure can improve cognitive readiness. Emphasizing the importance of designing, delivering, and evaluating training programs that not only build technical competence but also

ensure skills are retained and effectively transferred to operational environments, contribute to the overall readiness of personnel. Incorporating cognitive readiness into the Tactical, Technical, and Procedures (TTPs) supports the development of evidence-based interventions to enhance human performance, resilience, and mission success in high-stakes settings.

OPTIMISING COMBAT READINESS: PRACTICAL STRATEGIES FOR INTEGRATING PHYSIOLOGICAL AND PSYCHOLOGICAL RESILIENCE IN SOLDIER TRAINING. IN PROCEEDINGS OF THE HEALTHCARE, 2024.

TORNERO-AGUILERA, JF, STERGIOU, M, RUBIO-ZARAPUZ, A, MARTÍN-RODRÍGUEZ, A, MASSUÇA, LM, CLEMENTE-SUÁREZ, VJ

BLUF: Optimizing combat readiness requires integrating physiological training (fitness, fatigue management, recovery) with psychological resilience (stress inoculation, decision-making under duress, mental health), and realistic, branch-tailored, immersive training systems (e.g., virtual reality, wearables) to bridge the gap between lab-based theory and field-applicable soldier preparation.

The integration of physiological and psychological resilience training represents a fundamental shift in how armed forces prepare personnel for the multifaceted demands of contemporary warfare. Research examining stress in military contexts reveals that 87% of military personnel report experiencing at least some stress as a result of their work (2), underscoring the critical need for comprehensive resilience training approaches.

Tornero-Aguilera and colleagues (2024) present a timely and multidimensional approach to enhancing military performance. Recognizing that modern combat environments demand more than physical strength or tactical skill, the authors argue for a holistic integration of physiological and psychological resilience as the foundation of combat readiness (14).

The study is grounded in the premise that soldiers must be equipped not only to endure physical stressors but also to regulate cognitive and emotional responses under duress. Drawing from psychophysiological research and operational case studies, the authors propose a layered model of readiness that includes cardiovascular efficiency, hormonal regulation, neuromuscular control, and cognitive flexibility. They emphasize that resilience is not a static trait but a trainable capacity, one that can be cultivated through targeted interventions and immersive training environments.

One of the article's key contributions is its operationalization of resilience into actionable training strategies. The authors advocate for the use of wearable technologies to monitor heart rate variability (HRV), cortisol levels, and neuromuscular fatigue in real time. These metrics, they argue, provide a window into the soldier's adaptive capacity and can inform individualized recovery

protocols. In parallel, psychological resilience is addressed through stress inoculation training, mindfulness-based techniques, and cognitive load management, all designed to enhance attentional control and emotional regulation in high-threat scenarios.

Importantly, the authors situate their recommendations within the broader context of asymmetric warfare and hybrid threats, where unpredictability and prolonged exposure to stress are the norm. They call for training environments that replicate the sensory, cognitive, and emotional complexity of real-world missions, arguing that only through such fidelity can readiness be meaningfully developed and sustained.

The authors also touch on the importance of interdisciplinary collaboration, suggesting that optimal readiness programming requires input from exercise physiologists, neuroscientists, behavioral psychologists, and operational commanders. This systems-level thinking aligns with emerging trends in tactical human performance research, where integrated, data-driven models are increasingly replacing siloed approaches.

While the study is primarily conceptual, it is supported by empirical evidence and offers a clear roadmap for implementation. Its relevance extends beyond conventional military units to include special operations forces, law enforcement, and other high-performance tactical teams.

Tornero-Aguilera et al. (14) deliver a compelling argument for rethinking combat readiness through the lens of resilience science. Their work bridges the gap between theory and practice, offering a framework that is both scientifically grounded and operationally viable. For those engaged in optimizing human performance in high-stakes environments, this article serves as both a reference and a call to action.

Practitioner Relevance: Insight into practical, evidence-based strategies for integrating physical conditioning, stress resilience, and cognitive readiness into comprehensive training programs, allowing practitioners to design and implement holistic performance frameworks. These frameworks develop both the physiological capacity and psychological resilience of soldiers, using tools such as biofeedback, immersive simulations, and recovery protocols, to enhance adaptability, decision-making, and sustained performance, in high-stress operational environments.

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NUTRITION RESEARCH COLUMN – JANUARY 2026

– IS IT POSSIBLE FOR VEGETARIANS OR VEGANS TO CONSUME ENOUGH PROTEIN TO SUPPORT OCCUPATIONAL READINESS?

Overview: Tactical and occupational athletes should aim to consume 1.4 – 2.0 g/kg/d of protein, with the optimal “starting” daily target of 1.62 g/kg/d, to sustain a positive nitrogen balance (e.g., a state where protein intake exceeds protein breakdown, supporting muscle growth and development recovery) (1,14,20). Importantly, within this daily protein amount, one must also strive to consume protein servings that contain roughly 6.0 g of essential amino acids (EAA) (28,38) and 2.0 g of leucine (20,30,31) within a 20 – 40 g protein bolus to optimally stimulate muscle protein synthesis (MPS). This can also promote changes in muscle mass and strength through training, which, in turn, may translate into better occupation-specific abilities (i.e., load-carrying ability) (20). This can occur regardless of the sources of protein to establish a foundation. Nevertheless, the growing body of evidence on plant-based proteins suggests that one can certainly obtain favorable outcomes (i.e., comparable to those gained from an animal-based diet) from plant-based sources as long as the amount is matched for EAAs and leucine (3,7,8,12,18,19,21,23,24,25,33,38).

It is clear that tactical and occupational athletes must strive to meet daily protein requirements that exceed the Recommended Dietary Allowances (RDA; 0.8 g/kg/d) (2,3), with an optimal “starting point” of 1.62 g/kg/d as previously suggested by Morton and colleagues (26). Essentially, research has identified a target total daily protein intake to maximize muscle strength and size improvements during extended resistance training in healthy adults (26). Consuming more than this amount does not appear to offer additional benefits in fat-free mass gains (26). However, this does not mean that consuming more protein is unnecessary; evidence suggests that higher intake can be beneficial when in a caloric deficit and aiming to preserve lean or skeletal muscle mass (1,20). In some cases, extra protein may also contribute to additional fat loss. Overall, 1.62 g/kg/day appears to be the optimal nutritional strategy for enhancing training benefits and recovery (26). Any additional protein might provide further benefits depending on individual circumstances (1,20,26). While it may seem feasible to meet this daily protein intake (1.62 g/kg/d) for those who regularly consume animal-based protein, it can be quite challenging for vegetarians (VE) and vegans (VG), which has led to the common myth or misconception that VE/VG cannot consume enough protein to achieve favorable training adaptations (i.e., muscle growth, increased strength, reductions in body fat) (1). The idea that VE and VG could not get enough protein from their diet has mainly been viewed through the lens of the notion that animal protein sources are considered higher-quality proteins

with more essential amino acids (EAA) (10,11,16,17,28,32,39). Research has shown that muscle protein synthesis (MPS) is affected differently by the rate of digestion and absorption, as well as by the EAA content of the protein source (such as whey or casein) (6). Considering this, animal protein sources (i.e., poultry, pork, beef) contain higher amounts of EAAs (up to 42% more), are absorbed more rapidly, raise plasma EAA concentrations more robustly, and, ultimately, induce MPS to a more robust level than plant-based protein sources. Further, the creatine content of animal-based sources is generally higher than that of plant-based sources (5,15). To better illustrate this, consider the work by Tang et al. (36), who showed that whey protein elicited 18% ($p < 0.067$) and 31% ($p < 0.05$) greater MPS responses than soy at rest and post-exercise. Furthermore, Yang et al. noted that a 40.0 g dose of soy protein after exercise was needed to increase MPS, compared to 20.0 and 40.0 g doses of whey protein, resulting in a slightly lower increase in MPS (42). Nevertheless, the overwhelming level of empirical evidence suggests that animal-based protein will undoubtedly trigger the most robust MPS response (2,4,6,9,18,29,35,40,41). However, emerging evidence suggests that plant-based protein sources (e.g., soy) may elicit similar MPS responses and, ultimately, lead to favorable outcomes (e.g., training adaptations) when the individual accounts for the mismatch in EAA content, particularly leucine (1).

WHAT DOES THE SCIENCE SUGGEST ABOUT PLANT-BASED PROTEIN?

Table 1 summarizes several studies comparing the effects of different dietary protein sources on body composition and training adaptations over 1.5 to 9 months. The main question is: “Can one be VE or VG and still gain favorable benefits that would support occupational readiness? For instance, if a tactical athlete is to follow a fully VE or VG-style of eating, can they be sure that the diet will support 1) recovery from heavy training and occupation-specific tasks/responses, 2) recovery from resistance and aerobic training, 3) adaptation from training, and 4) readiness for the occupation? To answer this, practitioners need to consider several examples of how a plant-based dietary regimen compares to an animal-based dietary regimen. First, Hevia-Larrain and colleagues demonstrated that physically active VG who consumed 1.6 g/kg/d of protein from both whole-food sources and soy protein supplementation for 12 weeks experienced body composition and resistance-training adaptations similar to those on a protein-matched omnivore diet (19). These findings suggest that a plant-based diet can support training if protein intake is sufficient

NUTRITION RESEARCH COLUMN - JANUARY 2026 - IS IT POSSIBLE FOR VEGETARIANS OR VEGANS TO CONSUME ENOUGH PROTEIN TO SUPPORT OCCUPATIONAL READINESS?

- particularly at 1.62 g/kg/d or within the 1.4 - 2.0 g/kg/d range. Similarly, Candow and team found that supplementing with three equal doses of either soy or whey protein, totaling 1.2 g/kg/day over six weeks, resulted in similar improvements in men and women (8). Both groups saw increases in lean mass (3.1% and 4.7%), 1RM bench press (13.4% and 14%), and hack squat strength (34% and 38.6%) compared to placebo, which showed smaller gains in lean mass (0.5%), 1RM bench press (7.1%), and hack squat (19.7%) (8). Then, findings by Moon and colleagues suggested that consuming 24 g of either rice or whey protein while following a resistance training program (4 days per week, split body, 3 - 4 sets of 6 - 10 repetitions) was sufficient for similar improvements in body mass (0.6% vs. 1.4%), lean mass (0.9% vs. 0.7%), and 1-RM bench press strength (3.6% vs. 2.2%) and leg press (6.9% vs. 8.2%) (25). The common factor across these studies is that the doses were matched for total daily protein intake, and the bolus of protein generally contained sufficient EAA and leucine (i.e., $\approx$ 10 g of EAA and $\approx$ 2.0 g of leucine). This suggests that, so long as the individual is prudent, they can obtain a high-quality protein bolus from either animal- or plant-based sources.

It is worth noting that one study reviewed in Table 1, Volek et al., failed to demonstrate favorable outcomes for the plant-based regimen (40). However, the research team believed that careful planning was not ensured to match, or at least meet a minimum threshold, the amount of EAA and leucine delivered by the plant-based source. To this end, one should focus on the following recommendations: 1) total daily protein intake ranges from approximately 1.4 to 2.0 g/kg/day, 2) the plant protein source provides between approximately 8 to 10 g or more of EAA daily, and 3) the plant protein source supplies about 2.0 g of leucine (3,4,7,8,12,18,19,21,23,24,25,33,37).

EFFECTS OF PORK PROTEIN INGESTION PRIOR TO AND FOLLOWING PERFORMING THE ARMY COMBAT FITNESS TEST ON MARKERS OF CATABOLISM, INFLAMMATION, AND RECOVERY. *NUTRIENTS* 17(12), 2025.

GONZALEZ, DE, HINES, KE, SOWINSKI, RJ, ESTES, L, JOHNSON, SE, CHUN, J, LEE, H, LEON, S, GIL, A, KO, J, BROECKEL, J, BARRINGER, ND, RASMUSSEN, CJ, AND KREIDER, RB

Study BLUF: Findings indicate that both protein quality and dietary creatine availability influence recovery from intense military-style training. At a minimum, plant-based military-style meals ready-to-eat (MREs) should include 6 - 10 g/day of EAA and 2 - 3 g/day of creatine monohydrate to address potential nutritional gaps, especially for military personnel following vegetarian diets.

Study Overview: In a randomized, double-blind, placebo-controlled, and crossover design, the research team explored the impact of ingesting plant-based or pork-based MREs on recovery from the Army Combat Fitness Test (ACFT) and subsequent ACFT performance (13). Twenty-three (n = 23) University Corps of Cadet members participated in the study, which consisted of two four-day testing sequences. Participants completed two ACFTs per study arm, as well as a series of laboratory-based tests. In summary, participants reported to the university laboratory after fasting for 12 hours with a 24-hour urine sample to assess biomarkers of protein turnover (e.g., urinary nitrogen). They also donated blood (to assess biomarkers of inflammation and physiological stress), completed questionnaires (to assess mood states and perceptions of soreness), took cognitive tests (to assess mental fatigue), and ate a pre-exercise meal. After four hours, they performed the ACFT per military standards. They ate three MREs daily and returned to the lab at 0600, fasted, with 24-hour urine samples collected after 24, 48, and 72 hours of recovery. On day 3, they repeated the ACFT four hours after breakfast with an MRE. They resumed training and returned 2 - 3 weeks later to repeat the experiment with an alternate meal regimen. Results showed that three days were enough for participants to reproduce ACFT performance without any hindrance from either dietary regimen. However, those on the pork-based meal regimen reported less muscle soreness, lower urinary urea excretion, lower cortisol levels, and lower depression scores, while exhibiting a higher testosterone-to-cortisol ratio and greater appetite satisfaction over the four consecutive days. In contrast, blood lipid profiles improved more with a plant-based diet. These findings underscore that the animal-based meal regimen may provide slightly more robust MPS and promote better net protein balance, but that, overall, at least acutely, both regimens allowed the cadets to recover and achieve similar performance on the ACFT. However, it is worth noting that longer duration studies may be warranted, as the accumulation of fatigue over a longer duration may start to impact the individual negatively, so the relatively small differences noted in perceived soreness may become more pronounced as one is subject to more and more physical burden with limited recovery resources (e.g., consider the warfighter out in garrison or the first responder having to respond to repeated and extended emergencies with limited recovery time between). Nevertheless, these data suggest that performance is upheld when daily protein is matched.

PRACTITIONER RELEVANCE

So, can a VE or VG tactical or occupational athlete get enough quality protein in their diet? The answer is unequivocally yes. However, it is essential to consider that they may need to increase the total amount of food consumed to ensure they obtain adequate EAA and leucine, comparable to those in animal protein products (5,16,27,42). In some cases, one may obtain 39% less EAA and 37% less branched-chain amino acids than from animal sources with plant-based protein (1). Therefore, one must be careful to account for the EAA content of their chosen protein source. It is also crucial that the individual consume adequate calories and protein, especially during intense training periods, to maintain a positive protein balance and promote training adaptation (34). It is also important to consider the cost of plant-based protein sources. A quick search on popular websites like BodyBuilding.com indicates that plant-based sources tend to be more expensive—plant-based protein powders typically cost between \$29.99 and \$49.99, whereas animal-based powders, such as whey, range from \$26.99 to \$59.99. Considering this, VE/VGs may need to pay more to ensure they can maintain a positive

nitrogen balance and reap the benefits of achieving the 1.62 g/kg/d total daily protein amount. Nevertheless, VE and VG tactical and occupational athletes can fulfill their energy and protein requirements, aiding positive body composition and training improvements, by consuming 1.4 – 2.0 g/kg/day of total protein, which includes 10 – 12 g of EAA and 2 g of leucine per serving to support MPS. During intense training, they usually need 20 – 40% more plant protein than animal protein to achieve comparable levels of EAA and leucine.

This article provides a strong foundation for understanding protein requirements for tactical and occupational athletes, with a balanced discussion of plant-based and animal-based protein sources. However, counterarguments highlight practical challenges, such as the cost and availability of plant-based protein sources, the need for supplementation, and the lack of long-term data on VE/VG diets. These considerations suggest that while VE/VG diets can support occupational readiness, careful planning and supplementation are essential to ensure optimal performance and recovery.

TABLE 1. SUMMARY OF PROTEIN STUDIES

REFERENCE	PARTICIPANTS (AGE)	TRAINING STATUS	DESIGN	DURATION	SUPPLEMENTAL PROTOCOL	DOSE TIMING PROTOCOL	AMINO ACID COMPOSITION (PER SERVING)	EXERCISE PROGRAM	AVERAGE TOTAL CALORIC AND PROTEIN DATA	PRIMARY VARIABLES	KEY FINDINGS	SUMMARY OF KEY FINDINGS
Babault et al.	161 males (18–35 years)	Moderately physically active (2–6 hr/week)	RDBPC	12 weeks	Whey Protein (n = 53): 50 g/d (2x 25 g doses) Pea Protein (n = 53): 50 g/d (2x 25 g doses) Placebo (n = 54): 50 g/d of maltodextrine (2x 25 g doses)	On training days: Taken in the morning and after training; non-training days: Taken in morning and in the afternoon	Whey (25 g protein): EAA content = 9.55; leucine = 2.15 Pea (25 g protein): EAA content = 7.55; leucine = 1.6	RT 3x/week; Elbow flexor & extensor focused; 2–5 sets of 5–15 reps; Training loads based on 1-RM testing every 2 weeks	None Reported: Participants were asked to maintain normal dietary habits throughout study	Muscle thickness (ultrasonography) Strength (isokinetic dynamometer)	Muscle Thickness: Trend toward significance; Whey (+15.3 ± 12.7%); Pea (+13.4 ± 10.8%); Placebo (+10.7 ± 18.6%) Isokinetic strength: ↑ all groups (time effect); data not reported	Both the whey and pea groups experienced non-statistically significant ↑ Bicep thickness, as well as ↑ in isokinetic strength that were comparable.
Banaszek et al.	15 trained men (n = 8) and women (n = 7) (26–50 years)	Trained, HIIT training (3/week for 6 months)	RDB	8 weeks	Whey Protein (n = 7): 48 g/d (2x 24 g doses) Pea Protein (n = 8): 48 g/d (2x 24 g doses)	2 daily doses: Taken =1 hr before and after workout on training days; once in the morning and evening between meals on non-training days	Whey (24 g protein): EAA content = 8.9; leucine = 2.1 Pea (24 g protein): EAA content = 7.7; leucine = 2.0	HIIT 4x/week led by CrossFit trainer; Strength training (60–100% 1-RM) and metabolic conditioning sessions; Performed WOD	Whey: Calories: 2287.8 ± 704.8 kcal; P: 1.8 ± 0.3 g/kg/d Pea: Calories: 1888.1 ± 295.8 kcal; P: 1.7 ± 0.4 g/kg/d	Body comp (BIA) Muscle thickness (ultrasonography) 1-RM Strength (Squat, Deadlift) Isometric Mid-thigh Pull (IMTP) performance WOD performance	No difference (p>0.05) in BM: Whey (10.23%), Pea (10.76%); or BF%: Whey (10.45%), Pea (13.13%) No differences (p>0.05) in muscle thickness for rectus femoris: Whey (10.39%), Pea (13.12%); or vastus lateralis: Whey (13.3%), Pea (12.6%) 1-RM Squat: Whey (+4 kg, 13.7%); Pea (+6.2 kg, 16.2%); 1-RM Deadlift: Whey (+5.1 kg, 15.2%); Pea (+5.1 kg, 13.9%) No difference (p>0.05) noted for IMTP peak force: Whey (10.03%), Pea (10.08%); or IMTP RFD: Whey (13.4%), Pea (11.6%) No improvements (p>0.05) in WOD1 performance: Whey (10.22%), Pea (13.05%); WOD2 performance: Whey (12.62%), Pea (12.17%)	Both the whey and pea groups experienced similar strength, WOD performance, body composition, and muscular adaptations.
Brown et al.	27 healthy, trained, college-aged males (19–25 years)	Experienced weightlifters (≥ 1 year)	RDBPC	9 weeks	Whey Protein (n = 9): 3x 11 g whey protein bar/d + self-selected diet Soy Protein (n = 9): 3x 11 g soy protein bar/d + self-selected diet Placebo (n = 9): no protein bar, followed self-selected diet	No dose timing reported; participants were instructed to consume 3 bars per day and record time of day consumed	Not reported	RT 2x/week; Whole-body strength training; 3 sets of 4–6 reps, 14 exercise	None Reported: Participants were asked to maintain normal dietary habits throughout study	Body comp (hydrostatic weighing)	Lean mass: Whey (1±2.0%); Soy (1±1.8%); Placebo: (1±0.15%)	Both the whey and soy groups experienced similar ↑ in lean mass.

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IS IT POSSIBLE FOR VEGETARIANS OR VEGANS TO CONSUME ENOUGH PROTEIN TO SUPPORT OCCUPATIONAL READINESS?

TABLE 1. SUMMARY OF PROTEIN STUDIES

REFERENCE	PARTICIPANTS (AGE)	TRAINING STATUS	DESIGN	DURATION	SUPPLEMENTAL PROTOCOL	DOSE TIMING PROTOCOL	AMINO ACID COMPOSITION (PER SERVING)	EXERCISE PROGRAM	AVERAGE TOTAL CALORIC AND PROTEIN DATA	PRIMARY VARIABLES	KEY FINDINGS	SUMMARY OF KEY FINDINGS
Candow et al.	27 males (n = 9) and females (n = 18) (18–35 years)	Not participating in resistance training	RDBPC	6 weeks	Whey Protein (n = 9): 1.2 g/kg/d whey protein + 0.3 g/kg/d sucrose Soy Protein (n = 9): 1.2 g/kg/d Soy protein + 0.3 g/kg/d sucrose Placebo (n = 9): 1.2 g/kg/d of maltodextrine + 0.3 g/kg/d sucrose	3 equal daily doses; Taken ~30 min before and after training sessions, and before bed	Not reported	Supervised RT 4x/week; Whole-body, free weights routine consisting of 8-9 different exercises; 4-5 sets of 6-12 reps at 60-90% 1-RM; Training volume was matched	Whey: Calories: 3129 ± 591 kcal, P:1.9 ± 1.3 g/kg/d Soy: Calories: 3015 ± 657 kcal, P:1.8 ± 1.4 g/kg/d Placebo: Calories: 3120 ± 387 kcal, P:1.7 ± 1.3 g/kg/d	Body comp (DEXA) 1-RM Strength (Bench press and hack squat) Myofibrillar protein catabolism (3-MEH)	Lean mass: Whey (+2.5 kg, 14.7%); Soy (+1.7 kg, 13.1%); Placebo: (+0.3 kg, 10.5%) 1-RM Squat strength: Whey (+26.7 kg, 138.6%); Soy (+23.7 kg, 134%); Placebo: (+14.1 kg, 119.7%) 1-RM Bench strength: Whey (+8.2 kg, 114%); Soy (+7.6 kg, 113.4%); Placebo: (+4.0 kg, 17%) 3-MEH: Whey (124.0%); Soy (130.0%); Placebo (142.0%) = No differences between groups	Both the whey and soy groups experienced ↑ Lean mass and ↑ 1-RM Strength that was not statistically different. No differences were noted for 3-MEH, although significant increases were found.
DeNysschen et al.	28 overweight males (21–50 years)	Generally sedentary, overweight individuals with moderate hypercholesterolemia	RDBPC	12 weeks	Whey Protein (n = 10): 26.6 g whey protein supplement Soy Protein (n = 9): 25.8 g soy protein supplement Placebo (n = 9): 25 g complex carbs	Protein supplement take ~60 min within workout on training days, and around same time on "off" days. Participants were instructed to maintain 1.2 g/kg/d protein intake	Not reported	Supervised RT 3x/week, 4 block periodized plan; Split body, focused to improve strength and lean body mass; Block 1: 2-3 sets of 8-10 reps; Block 2: 3-4 sets of 8-10 reps; Block 3: 3 sets of 10-12 reps; Block 4: 4 sets of 10-12 reps	Whey: Calories: 2405 ± 136 kcal, P:1.2 ± 0.3 g/kg/d Soy: Calories: 2283 ± 291 kcal, P:1.1 ± 0.3 g/kg/d Placebo: Calories: 2026 ± 125 kcal, P:1.0 ± 0.2 g/kg/d	Body comp (4-site skinfolds, waist-to-hip) 1-RM Strength Anthropometrics	Lean mass: Whey (+1.2 kg, 11.7%); Soy (+1.8 kg, 12.5%); Placebo: (+2.4 kg, 13.4%) BF%: Whey (11.7%); Soy (11.5%); Placebo: (12.5%) 1-RM Bench strength: Whey (+17.4 kg, 121.4%); Soy (+18.2 kg, 121.8%); Placebo: (+17.5 kg, 121.4%); note, all other major muscle group strength metrics increased Waist-to-hip ratio: Whey (1.22%); Soy (1.11%); Placebo: (1.11%)	All groups experienced similar ↑ lean mass and muscle strength metrics, as well as improvements in BF% and waist-to-hip ratios
Hartman et al.	57 healthy males (18–30 years)	Not participating in resistance training	RPC	12 weeks	Milk Protein (n = 18): 17.5g milk protein/d Soy Protein (n = 19): 17.5 soy protein/d Placebo (n = 19): isoelectric maltodextrin solution	Under supervision one 17.5g protein or placebo drink was consumed immediately post and 1hr post exercise	Not reported	Supervised RT 5x/week; Whole-body split routine; push, pull, and lower body; 2-4 sets of 10-12 or 4-6 reps, 80% 1-RM	Milk: Calories: 3128 ± 246 kcal, P:1.66 ± 0.16 g/kg/d Soy: Calories: 3009 ± 181 kcal, P:1.5 ± 0.1 g/kg/d Placebo: Calories: 3176 ± 214 kcal, P:1.56 ± 0.13 g/kg/d	Body comp (DEXA) 1-RM Strength (Leg press) Muscle fiber size	Lean mass: Milk (+3.9 kg, 16.2%); Soy (+2.8 kg, 14.4%); Placebo: (+2.4 kg, 13.7%) 1-RM Leg press: Milk (+191 kg, 1102%); Soy (+210 kg, 198%); Placebo: (+184 kg, 187%) All groups increased in fiber CSA; data reported in figures	All groups experienced ↑ lean mass, muscle strength metrics, and muscle CSA. The Whey group experienced the greatest increases in lean mass and 1-RM strength metrics (p<0.05) compared to the other groups.
Hevia-Larrain et al.	38 untrained young males (18–35 years)	Physically active, not resistance trained	Parallel (2 groups)	12 weeks	Habitual Omnivores (n = 19): 1.6 g/kg/d total protein intake (supplemental whey protein administered to augment habitual intake) Habitual Vegans (n = 19): 1.6 g/kg/d total protein intake (supplemental soy protein administered to augment habitual intake)	Supplemental protein was consumed 2x per day at breakfast and in the evening. Protein doses were individually tailored to ensure 1.6 g/kg/d total protein intake was maintained during the study.	Whey: EAA content = 48.2; leucine = 9.6 Soy: EAA content = 37.3; leucine = 7.2; *based on g/100g, unclear what the exact doses were as these were individualized	Supervised RT 2x/week; Focus: Leg press (incline) and leg-extension exercises; Week 1-4: 2 sets of 12-15 reps; Week 5-8: 3 sets of 10-12 reps; Week 8-12: 4 sets of 8-10 reps	Whey: Calories: 2175 ± 429 kcal, P:1.71 ± 0.14 g/kg/d, Total EAA: 54 ± 7 g/d, leucine: 11 ± 2 g/d Soy: Calories: 2353 ± 431 kcal, P:1.70 ± 0.19 g/kg/d, Total EAA: 43 ± 5 g/d, leucine: 9 ± 1 g/d	Leg muscle mass Muscle mass & BF% (DEXA) Muscle CSA size (ultrasound and biopsy) 1-RM Strength (Leg press)	Whole-body lean mass: Whey (+1.5 kg, 12.6%); Soy (+1.9 kg, 13.3%); Leg lean mass: Whey (+1.2 kg, 16.3%); Soy (+1.2 kg, 16.3%) BF(kg.%): Whey (+0.6 kg, 14.4%); Soy (-0.1 kg, 13.4%) Muscle CSA rectus femoris: Whey (+0.7 cm2, 18.0%); Soy (+1.0 cm2, 11.6%); Muscle CSA vastus lateralis: Whey (+2.8 cm2, 112.6%); Soy (+2.2 cm2, 110.2%) 1-RM leg press: Whey (+122 kg, 146.7%); Soy (+96 kg, 137.2%)	Both the omnivor and vegan groups experienced similar ↑ in whole-body and leg lean mass, Muscle CSA, an 1-RM lower body strength, as well as ↑ in BF%
Joy et al.	24 healthy males (18–30 years)	Resistanced trained individuals (RT 3x per week for 6 month and 1 year experience with RT)	RDB	8 weeks	Whey Protein (n = 12): 48 g/d whey protein isolate Rice Protein (n = 12): 48 g/d rice protein isolate	Taken post resistance exercise session	Whey (48 g protein): EAA content = 25.1; leucine = 5.5 Rice (48 g protein): EAA content = 17.4; leucine = 3.8	Non-linear RT program 3x/week; Focus: All major muscle groups; upper and lower body split; Hypertrophy: 3 sets of 8-12 reps; Strength: 3 sets of 2-5 reps	None Reported: Participants were given a meal plan by dietitian	Body comp (DEXA) Muscle Thickness 1-RM Strength (Bench press and leg press) Power (Wingate)	Lean mass: Whey (+3.2 kg, 15.3%); Rice (+2.5 kg, 14.3%); BF (kg.%): Whey (+0.7 kg, 14.3%); Rice (-2.2 kg, 12.4%) Muscle thickness quadriceps: Whey (+0.3 cm, 16.25%); Rice (+0.2 cm, 14%); Muscle thickness biceps: Whey (+0.5 cm, 115.9%); Rice (+0.5 cm, 113.9%) 1-RM bench press: Whey (+9 kg, 110.1%); Rice (+9.6 kg, 111.2%); 1-RM leg press: Whey (+80.2 kg, 138.3%); Rice (+66.8 kg, 130.4%) Wingate peak power: Whey (+997.9 watts, 114.2%); Rice (+115.5 watts, 118.3%)	Both the whey and rice groups experienced similar ↑ in lean mass, muscle thickness, 1-RM strength, and wingate peak power, as well as reductions in BF%

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Lynch et al.	48 non-active males and females (18–35 years)	Not participating in resistance training	Pro-spective, two group parallel arm RDB	12 weeks	Whey Protein Isolate (n = 26): 19 g/d, 10 g EAA and ~1.8 g leucine Soy Protein Isolate (n = 22): 26 g/d, 10 g EAA and ~1.8 g leucine	Taken immediately post-workout on training days, or consumed between meals on non-training days	Whey (19 g protein): EAA content = 9.5; leucine = 1.9 Soy (26 g protein): EAA content = 9.2; leucine = 1.9	Supervised RT 3+/- week: Whole-body progressive resistance training; Week 1-6: 3 sets of 10 reps at 60-70% 1-RM; Week 7-12: 4 sets of 8 reps at 70-80% 1-RM	Whey: Calories: 2173 ± 351 kcal, P:1.3 ± 0.2 g/kg/d Soy: Calories: 2331 ± 357 kcal, P: 1.4 ± 0.4 g/kg/d	Body mass Body comp (DEXA) Muscle thickness (ultrasonography) Knee flexion and extension torque (isokinetic dynamometer)	Lean mass: Whey (+1.5 kg, 13.4%); Soy (+1.1 kg, 12.5%) BF%: Whey (-1.7 kg, 15.4%); Soy (-1.1 kg, 13.6%) Muscle thickness vastus lateralis: Whey (+0.2 cm, 18.7%); Soy (+0.1 cm, 14.5%); Muscle thickness vastus intermedius: Whey (+0.0 cm, 0.0%); Soy (+0.5 cm, 16.3%) Peak torque extensions: Whey (+40.2 Nm, 132.3%); Soy (+28.4 Nm, 121.5%); Peak torque flexions: Whey (+20.4 Nm, 133.7%); Soy (+16.3, 125.3%)	Both the whey and soy groups experienced similar ↑ in lean mass and peak torque for extensions and flexions, as well as reductions in BF%
Mobley et al.	75 healthy, untrained males (19–23 years)	Not participating in resistance training	RDBPC	12 weeks	Whey Protein Concentrate (WPC) (n = 17): 26.3 g 2x per day, ~3.0 g leucine Whey Protein Hydrolysate (WPH) (n = 14): 25.4 g 2x per day, ~3.0 g leucine Soy Protein Concentrate (WPC) (n = 15): 39.2 g 2x per day, ~3.0 g leucine Leucine (LEU) (n = 14): 2.3 g 2x per day, ~3.0 g leucine Placebo (PLA) (n = 15): maltodextrin, 0.4 g 2x per day, ~0.015 g leucine	On training days individually-packaged treatments were taken immediately post-training and 30-min prior to bedtime; on the non-training days, treatments were taken between a meal and 30-min prior to bedtime	WPC: EAA content = 12.6; Leucine = 2.8 WPH: EAA content = 13.3; Leucine = 2.9 SPC: EAA content = 14.3; Leucine = 2.9 Leucine: EAA content = 3.0; Leucine = 2.9	Supervised RT 3+/- week: Undulating periodization training model, focus: strength and hypertrophy; Mon or Tues: 4 sets of 10 reps, Wed or Thurs: 6 sets of 4 reps, Fri or Sun: 5 sets of 6 reps; Progressive overload: 50-90% 1-RM, increasing over the 12 week period	WPC: Calories: 2347 ± 147 kcal, P: 1.8 ± 0.1 g/kg/d WPH: Calories: 2614 ± 150 kcal, P: 1.95 ± 0.1 g/kg/d SPC: Calories: 2536 ± 144 kcal, P: 2.1 ± 0.1 g/kg/d LEU: Calories: 2395 ± 149 kcal, P: 1.4 ± 0.1 g/kg/d PLA: Calories: 2784 ± 234 kcal, P: 1.3 ± 0.1 g/kg/d	3- RM Strength Body mass Body comp (DEXA)	3-RM strength bench press: WPC (+14 kg, 120.6%), WPH (+16 kg, 121.9%), SPC (+17 kg, 126.2%), LEU (+14 kg, 120.6%), PLA (+13 kg, 119.7%) 3-RM strength squat: WPC (+35 kg, 141.2%), WPH (+37 kg, 144.6%), SPC (+36 kg, 143.9%), LEU (+27 kg, 131.8%), PLA (+41 kg, 158.6%) Muscle mass: WPC (+2.1 kg, 15.6%), WPH (+1.9 kg, 15.1%), SPC (+2.6 kg, 16.9%), LEU (+1.9 kg, 15.2%), PLA (+2.4 kg, 16.6%) Muscle thickness vastus lateralis: WPC (+0.5 cm, 120.0%), WPH (+0.3 cm, 112.0%), SPC (+0.4 cm, 115.4%), LEU (+0.4 cm, 116.7%), PLA (+0.4 cm, 117.4%)	All groups experienced similar ↑ lean mass, muscle thickness, and 3-RM muscle strength metrics
Moon et al.	24 healthy, trained males (18–50 years)	Resisted trained individuals (1 year experience with RT; >1.0x and >1.5x body weight for the bench press and leg press, respectively)	RDB	8 weeks	Whey Protein (n = 12): 24 g/d Rice Protein (n = 12): 24 g/d	On training days: Supplement taken within 60-min post workout session; non-training days, taken with 60-min of bedtime	Whey Protein (24 g protein): EAA content = 11.3; Leucine = 2.5 Rice Protein (24 g protein): EAA content = 9.3; Leucine = 2.1	RT 4+/-week; Linear periodized, split-body, two upper and lower body sessions per week; Week 1-6: 3 sets of 10 reps at 10-RM load, Week 7-10: 4 sets of 6 reps to failure; Last set was performed to failure per exercise	Whey: Calories: 2752 ± 855 kcal, P: 1.85 ± 0.43 g/kg/d Rice: Calories: 2625 ± 881 kcal, P: 1.61 ± 0.73 g/kg/d	Body comp (DEXA) 1-RM Muscular strength Muscular Endurance (RTF) Anaerobic Capacity (Wingate)	Body mass: Whey (+12 kg, 11.4%), Rice (+0.5 kg, 10.6%); Lean mass: Whey (+11 kg, 11.7%), Rice (+0.7 kg, 10.9%); Fat-free mass: Whey (+11 kg, 11.7%), Rice (+0.6 kg, 10.9%) 1-RM bench press: Whey (+2.6 kg, 12.2%), Rice (+4.1 kg, 13.6%); 1-RM leg press: Whey (+27 kg, 18.2%), Rice (+24 kg, 16.9%) RTF bench press: Whey (12.8%), Rice (18.5%); RTF leg press: Whey (8.5%), Rice (18.6%) Wingate peak power: Whey (+0.2 watts/kg, 12.1%), Rice (No Change)	All groups experienced similar ↑ in body mass, lean mass, fat-free mass, and 1-RM strength with no difference between the protein source.
Reidy et al.	67 healthy males (18–35 years)	Recreationally active, but not engaged in any regular exercise-training program	RDBPC	12 weeks	Whey Protein (n = 22): 22g/d whey protein isolate Soy Protein (n = 23): 22g/d soy-dairy protein blend Placebo (n = 23): isocaloric maltodextrin	On training days, immediately post workout, treatments were taken under supervision; on non-training days, the supplement was taken between meals	Whey Protein (26.2 g protein): EAA content = 10.8; Leucine = 2.3 Soy Protein (25.2 g protein): EAA content = 9.8; Leucine = 2.0	Supervised RT 3+/- week: Whole-body program; 3-4 sets of 10 reps at 60-80% 1-RM; Last set was performed to failure per exercise	Whey: Calories: 2585 ± 192 kcal, P: 1.59 ± 0.1 g/kg/d Soy: Calories: 2365 ± 195 kcal, P: 1.61 ± 0.1 g/kg/d	Body comp (DEXA) 1-RM Strength (Chest press, knee extension, squat) Muscle thickness	Lean mass: Whey (+2.4 kg, 14.2%), Soy (+2.5 kg, 14.4%), Placebo (+2.2 kg, 3.9%); BF%: Whey (18.9%), Soy (16.8%), Placebo (14.1%) 1-RM strength bench press: Whey (+34 kg), Soy (+36 kg), Placebo (+38 kg); 1-RM strength squat: Whey (+100 kg), Soy (+90 kg), Placebo (+94) Muscle thickness thigh: Whey (+0.56 cm, 112.4%), Soy (+0.50 cm, 111.9%), Placebo (+0.54 cm, 112.9%)	All groups experienced similar ↑ in lean mass, muscle thickness and strength.

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Thomson et al.	83 older adults (50-79 years)	Physically active, not resistance trained	RDBPC	12 weeks	Milk Protein (n = 34): 27 g/d dairy based protein + 1.2 g/kg/d dietary protein Soy Protein (n = 26): 27 g/d soy based protein + 1.2 g/kg/d dietary protein Usual protein intake group (Placebo) (n = 23): <1.2 g/kg/d dietary protein	Treatments were taken immediately post-workout on training days, and on non training days between meals, dietary protein was evenly distributed across all meals	Not reported	RT 3x/week; Progressive overload, whole-body program, five exercises; 1-3 sets of 8-12 reps	Milk Protein: Calories: 2003 ± 344 kcals, P: 1.42 ± 0.14 g/kg/d Soy Protein: Calories: 1993 ± 311 kcals, P: 1.45 ± 0.14 g/kg/d Placebo: Calories: 1912 ± 255 kcals, P: 1.08 ± 0.05 g/kg/d	Strength (isokinetic dynamometer) Body comp (DEXA) Physical function (8-RM)	Isometric knee extensor strength: Milk (+25.5 Nm, ↑17.6%), Soy (+18.4 Nm, ↑12.1%), Placebo (+30.5 Nm, ↑22.2%); Handgrip strength: Milk (+1.0 kg, ↑2.8%), Soy (+1.6 kg, ↑4.9%), Placebo (+2.0 kg, ↑5.8%) 8-RM Leg press s: Milk (+65.2 kg, ↑74.4%), Soy (+47.4 kg, ↑46.9%), Placebo (+66.3 kg, ↑73.8%); 8-RM bench press: Milk (+17.4 kg, ↑50.7%), Soy (+17.4 kg, ↑46.7%), Placebo (+13.3 kg, ↑44.4%) Lean mass: Milk (+1.0 kg, ↑1.9%), Soy (+1.4 kg, ↑2.8%), Placebo (+0.8 kg, ↑1.7%); BF%: Milk (↓2.2%), Soy (↓3.0%), Placebo (↓2.0%)	All groups experienced similar in lean mass, isometric strength, and 8-RM physical function.
Volek et al.	63 untrained males and females (18-35 years)	Not participating in resistance training	RDBPC	9 months	Whey Protein (n = 19): 22 g/kg/d whey protein, 1.4 g/kg/d protein intake Soy Protein (n = 22): 22 g/kg/d soy protein, 1.4 g/kg/d protein intake Placebo (n = 22): carbohydrate group	Treatments were taken immediately post-workout on training days, and with breakfast on non-training days	Whey Protein (22 g protein): EAA content = 9.6; Leucine = 2.2 Soy Protein (22 g protein): EAA content = 6.7; Leucine = 1.4	RT 3 x/week; Whole-body, progressive, nonlinear, periodized; 3-5 sets of 3-15 reps (depending on focus); Intensity: Light = 12-15 reps; Moderate = 8-10 reps; Heavy = 3-6 reps	Whey: Calories: 2109 ± 77 kcals, P: 1.37 ± 0.27 g/kg/d Soy: Calories: 2044 ± 72 kcals, P: 1.36 ± 0.16 g/kg/d Placebo: Calories: 2004 ± 111 kcals, P: 1.36 ± 0.11 g/kg/d	Body comp (DEXA) 1-RM Strength (Bench press and squat)	Body mass: Whey (+3.1 kg, ↑4.1%), Soy (+2.2 kg, ↑3.1%), Placebo (+1.8 kg, ↑2.5%); Lean mass: Whey (+3.3 kg, ↑6.4%), Soy (+1.8 kg, ↑3.7%), Placebo (+2.3 kg, ↑4.6%) Body mass: Whey (↑1.5%), Soy (↑0.6%), Placebo (↑1.2%) 1-RM bench press: Whey (+20.1 kg, ↑38.7%), Soy (+15.9 kg, ↑35.3%), Placebo (+16.0 kg, ↑35.6%); 1-RM squat: Whey (+35.8 kg, ↑43.1%), Soy (+39.8 kg, ↑66.3%), Placebo (+43.7 kg, ↑61.5%)	The whey group experienced greater ↑ in lean body mass. All groups experienced similar ↑ in 1-RM strength.

Data in Key Findings represent change from baseline percentages and are denoted with either a ↑ = increase; ↓ = Lesser or decrease. EAA = essential amino acids, DEXA = dual x-ray absorptiometry, R = randomized, DB, Double-blind, PC, Placebo-controlled, HIFT = high-intensity functional training, BF% = body fat percentage, mCSA = muscle cross-sectional area; 1-RM = one repetition maximum; RCT = Randomized Clinical Trial; IMTP = Isometric Mid-thigh Pull (IMTP) performance; BIA = bioelectrical impedance analysis; WOD = workout of the day; DEXA = dual energy X-ray absorptiometry; 3-RM = three repetition maximum; 8-RM = eight repetition maximum; RTF = repetitions to fatigue at 80% 1-RM; 3-MEH = urinary 3-methylhistidine

Adapted from Kerksick et al.

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EMBEDDING STRENGTH AND CONDITIONING IN HIGH SCHOOL JROTC – A 16-WEEK MODEL FOR TACTICAL READINESS, SAFETY, AND SELF-EFFICACY

Tactical facilitators working in high school environments often inherit Junior Reserve Officers' Training Corps (JROTC) physical training practices that vary widely from unit to unit. Today, JROTC is one of the nation's largest youth development programs, serving nearly half a million students annually, between ages 14 – 18 (10). While JROTC's core purpose is to instill military values, a sizeable subset of cadets later pursues ROTC or enlistment, where physical readiness becomes a determinant of opportunity and early success (e.g., scholarship competitiveness, successful progression through initial military training). The Army's Holistic Health and Fitness (H2F) doctrine frames physical readiness as a multi-domain, trainable system. In parallel, Army fitness testing has evolved from the Army Physical Fitness test to the Army Combat Fitness Test (ACFT) and recently to the Army Fitness Test (AFT), which tests strength, power, muscular endurance, and aerobic capacity (12,13). This evolution makes a compelling case for structured, school-feasible strength and conditioning (S&C) for those involved in JROTC.

This article translates current tactical and youth training literature into a 16-week JROTC S&C model that can be delivered during class periods or after school. The model integrates H2F principles, youth resistance training consensus recommendations, and mitigates injury risk while deliberately promoting cadet self-efficacy through building experience and competency, a key driver of adherence and performance under pressure (2,5,6,12).

WHY JROTC S&C – AND WHY NOW

Many cadets choose ROTC or enlistment after graduation, making the JROTC years a logical time to develop foundational physical literacy that supports later training demands. Evidence shows that JROTC physical activity is highly variable and often less structured than traditional physical education, with cadets engaging in significantly lower levels of moderate-to-vigorous physical activity during class sessions (9). JROTC programs may conduct physical training before school, during class, or after school, but these sessions frequently emphasize drill and leadership over systematic development of fitness qualities (14). This inconsistency underscores the need for a standardized, progressive model that prepares cadets for the physical demands of ROTC participation.

At the same time, lessons from military cohorts suggest that nontraditional, mixed modality programs that emphasize strength, power, task-specific capacity, and load management can outperform generic calisthenics for developing the qualities that

predict operational performance – without increasing injury risk when progressed appropriately (5,11). Injury prevention reviews in military populations consistently highlight the importance of controlling training loads, using progressive overload within a linear periodization program, and tracking simple readiness indicators to reduce preventable injuries during training cycles (5,7). Integrating these insights into JROTC enables S&C personnel to raise the floor of physical readiness while protecting time, energy, and morale throughout the school year. When these cadets graduate, they will be more prepared to meet the physical demands of a ROTC program.

GUIDING PRINCIPLES FOR A SCHOOL-FEASIBLE JROTC MODEL

A practical JROTC S&C framework must respect school constraints while addressing the gaps in current physical training practices. The NSCA's updated youth position paper and international consensus state that, under qualified supervision with appropriate progressions, adolescents benefit from resistance training through improvements in strength, motor skills, bone health, and injury resilience, with low adverse event rates (6). These benefits extend beyond the musculoskeletal system because well-coached training creates “mastery experiences” that build task-specific confidence, a central mechanism in Bandura's self-efficacy theory and a robust predictor of adherence to physical activity (2,4).

From a tactical perspective, the strongest case for a structured program is risk management. Training-related injuries remain among the most common and costly issues across initial military training (7). However, risk can be mitigated through simple guardrails: avoid sudden spikes, cap weekly volume increases, standardize technique instruction, and log basic indicators like session rating of perceived exertion (sRPE), localized soreness, and modifications. These steps enable coaches to identify problems early and adjust before minor issues become major ones (5,10).

IMPLEMENTING THE 16-WEEK PLAN: SCREENING, TEACHING, AND BASELINES

Before week one, facilitators should explain to cadets that the program seeks to teach correct movement patterns, build strength and endurance gradually, and improve their confidence engaging in physical training. At the onset of the program, a brief technique screen doubles as a teaching session focused on the hip hinge, squat, push, pull, and carry. The objective is not to “grade” cadets

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on day one but to establish a common language of positions, bracing, and spotting that will anchor every session thereafter. Baseline tests should be school-appropriate proxies for Army-relevant domains: a one-mile run (or 12-minute walk/run distance), hand-release push-ups (or plank time), farmer carry distance, and a 3-rep maximum hex bar deadlift (or sandbag/kettlebell deadlift, dependent on cadet readiness) (12). Each cadet records a 0 – 100 confidence rating (“How confident are you that you can improve this test?”) for the major tasks; these ratings become both a coaching compass and a motivational lever during the semester (2,4).

COACHING STANDARDS, SAFETY, AND SIMPLE MONITORING

The coach-to-cadet ratio should target 1:15 or better with stations that promote quality over throughout. Technical terms are introduced and reintroduced in ordinary language and reinforced with tactile and visual cues. Session RPE (0 – 10), soreness ratings, and short notes on modifications are captured on a simple paper or digital log. Weekly changes in total volume and running mileage are limited to roughly 5 – 10%, and a “drop week” or reduced load week is scheduled after illness, school travel, or exam periods to avoid unloading–reloading spikes (1,3). A minimalist injury surveillance line list – what happened, where, when, how severe, and what modification followed – keeps the facilitator grounded, supports a continuous improvement mindset, and fosters communication between coaches and rehabilitation professionals. Together, these practices operationalize H2F’s focus on monitoring and align with injury prevention recommendations in military populations (5,7,13).

THE 16-WEEK MODEL

The plan comprises four mesocycles, each four weeks long, progressing from movement competency to strength, and then to power and speed, before consolidating adaptations and tapering into assessments. Frequency is three to four training days per week, with two to three resistance sessions and two conditioning sessions; some weeks combine these elements on the same day in shorter blocks to fit class periods. Two pathways run in parallel: a full equipment path using trap bars, kettlebells, medicine balls, and sleds; and an equipment light path using sandbags, dumbbells, bands, and partner carries. Progression begins linearly and transitions to an undulating model to expose cadets to distinct training emphases while honoring recovery and school constraints (1,11).

WEEKS 1–4: TECHNIQUE AND CAPACITY

The first mesocycle is a teaching block with submaximal volumes integrating progressive overload. Each resistance session opens with a five-minute movement prep – hip hinging with a dowel, squat patterning to a box, scapular setting for rows and push-ups – and then reinforces a primary pattern, a secondary pattern, a row or pull variation, and a loaded carry. Conditioning alternates

between short intervals – ten repeats of 100 – 150 meters at a comfortable but purposeful pace with one-to-one walk/jog recovery – and conversational pace/tempo runs of fifteen to twenty minutes punctuated by short strides. The coaching goal is consistent, repeatable technique: neutral spine and bracing on hinges and squats, vertical forearms and full-range push-ups, and dynamic torso control during carries. This technique-first emphasis is consistent with youth S&C safety statements and with H2F’s “teach–train–test” logic; though at the JROTC level, the testing metric comes later to ensure proficiency (6,13).

WEEKS 5–8: STRENGTH EMPHASIS AND TRANSITION

The second mesocycle introduces heavier sets and a first taste of power while preserving the movement menu. One “strength” day uses trap bar or sandbag deadlifts for four sets of five repetitions at a moderate-to-hard effort (RPE 6 – 7), weighted or elevated push-ups for four sets of six to ten repetitions, pull-ups with band assistance or suspension rows for four sets of six to ten repetitions, and longer farmer carries for four sets of 30 to 50 meters. A second day emphasizes volume with goblet squats (three sets of eight to ten repetitions), dumbbell bench or tempo push-ups (three sets of eight to twelve repetitions), row variations (three sets of eight to twelve repetitions), and sled pushes or drags for four repeats of 20 to 30 meters; equipment light groups substitute loaded carries and sandbag drags. A third session introduces low-amplitude power: medicine ball chest passes and scoop tosses for six sets of two to three throws, bodyweight jump squats for three sets of six, and technique-focused pull-ups. Conditioning features 200 – 400 meter repeats. For example, six to ten repeats of 200 meters at around one-mile race pace plus ten to fifteen seconds with one-to-one recovery, and a 25- to 30-minute easy run or bike. Around weeks six to eight, facilitators collect submaximal three to five repetition deadlifts, an 800-meter time trial, and a brief technique rubric to mark progress while avoiding maximal fatigue. This test battery aligns with H2F’s training logic and minimizes the risk of unaccustomed intensity spikes that can elevate injury risk (1,5,13).

WEEKS 9–12: POWER AND SPEED EMPHASIS

The third mesocycle converts strength into greater speed and power while maintaining one heavy day for neural drive. A heavy day features deadlifts for five sets of three at RPE 7 – 8, weighted push-ups for four sets of five to eight, and weighted pull-ups, if able, for five sets of three to five (otherwise exercises will be progressed relative to those completed in weeks 5 – 8). A power day anchors medicine ball throw series (eight sets of two to three throws), kettlebell swings (four sets of eight), and contrast sets pairing two or three heavy deadlift triples with two or three low-rep jump sets. A third day organizes single-leg strength and trunk control (split squats for three sets of eight to ten, single-arm rows for three sets of eight to twelve, press variations for three sets of eight to ten) and longer carries. Conditioning shifts to faster 200 – 300-meter intervals with fuller recoveries and a separate

threshold session built from two sets of eight to ten minutes at a “comfortably hard” effort separated by easy movement. The coaching focus is efficient stretch-shortening mechanics and posture under load or during fast movements. This undulating emphasis on strength, power, and endurance matches what systematic reviews in military cohorts have identified as effective for multiple performance domains (9).

WEEKS 13–16: CONSOLIDATION AND ASSESSMENT

The final mesocycle consolidates adaptations and tapers into testing. Strength maintenance sessions keep intensity but reduce volume (e.g., deadlifts three sets of three to four at RPE 7), while power sessions preserve low-volume throws and jumps to maintain rate of force development without inducing fatigue. A movement quality session prioritizes mobility, light accessories, and technique rehearsal. Conditioning in weeks 13 and 14 includes sharpening intervals, followed by a light volume week 15 and a test week 16. The endline assessments mirror baselines: a one-mile run (or 12-minute distance), hand-release push-ups, a submaximal three- to five-rep hinge or a repetition-target test at a fixed load, a simple carry-drag circuit time, and repeat self-efficacy ratings for major tasks. Facilitators compare baseline and end-assessment confidence and performance metrics and ask cadets to reflect on how specific coaching cues helped them move better or feel safer—an explicit attempt to leverage mastery experiences and credible feedback to consolidate self-efficacy improvements (2,13).

EQUIPMENT LIGHT DELIVERY WITHOUT COMPROMISE

Many schools lack sleds, bumper plates, or even racks. Sandbags and dumbbells substitute effectively for deadlifts and loaded squats; straps or ropes connect to sandbags for drags; rings or TRX straps enable horizontal pulls; a variety of carries and ground-to-shoulder sandbag lifts create robust, transferable stimuli. For medicine ball work, schools can use taped alternatives to commercial medicine balls when budgets are constrained. The youth training literature supports the safety and efficacy of such modalities in novice populations when coaching and progression are sound, and the military S&C evidence base underscores that nontraditional formats can meaningfully improve strength, power, and occupationally relevant performance (5,6,11).

MONITORING, RISK MANAGEMENT, AND COMMUNICATION

Training-related injuries remain among the most common and costly issues across initial military training (8). In youth training, injury risk is elevated when poor movement mechanics are present, trainees are not supervised when necessary, pre-requisite competencies are not demonstrated, and immaturity is seen relative to safety practices (6). However, risk can be mitigated through simple guardrails: avoid sudden spikes in training volume or intensity, standardize technique instruction, and instruction on how to use and implement basic log indicators like session

rating of perceived exertion (sRPE). These steps enable coaches to identify problems early and adjust before minor issues become major ones (5,11). Coaches may plan de-emphasis weeks after exam periods, holidays, or illness clusters to allow cadets to gradually build back into higher-volume training. Coaches may choose to track attendance, session RPE, localized soreness, and any modifications, along with notes explaining the reasons for these changes. If soreness spikes two to three points above an athlete’s normal for the same movement, the facilitator reduces load that day and inspects technique at the next session. The same goes for reports of unilateral pain or sudden changes in movement patterns. These simple heuristics operationalize the injury prevention principles identified in tactical populations (5,7).

ADMINISTRATIVE ALIGNMENT AND SUSTAINABILITY

For unit leaders, the most persuasive argument for embedding S&C is alignment: the program mirrors H2F principles while giving cadets a low-risk, high-yield introduction to the kinds of movements and capacities they will need later. As the AFT continues to standardize Army fitness assessment, collaboration with nearby ROTC programs to share testing procedures or pacing strategies can smooth the JROTC-to-ROTC transition. Over time, prospective tracking of injury incidents, simple performance metrics, attendance, and self-efficacy will help provide a feedback loop that helps instructors refine the program and communicate its impact to administrators and parents (1,2,14).

TAKEHOME MESSAGE FOR TACTICAL FACILITATORS

A 16-week JROTC S&C plan that respects school constraints can move the needle on readiness and confidence without inflating risk. The plan begins by teaching movement, adds strength carefully, then converts strength to speed and endurance while monitoring load. It embeds simple tools—RPE, soreness, attendance, brief technique rubrics, and self-efficacy ratings—to keep cadets safe and engaged. The literature supports the safety and utility of supervised youth resistance training and the performance value of mixed-modality programs in tactical populations. H2F provides the doctrine; the AFT maintains the impetus; strength and conditioning coaches provide the craftsmanship that makes it real in classrooms and gyms. With clear coaching language, modest equipment, and thoughtful progression, high school units can build a durable, transferable foundation that serves cadets now and years ahead (2,5,6,9,12,13,14).

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TABLE 1. ASSESSMENT PROTOCOL

ASSESSMENT TYPE	BASELINE (WEEK 0)	WEEK 16 (POST)
1-mile run or 12-minute walk/run distance	Record time or distance	Repeat test
Hand-release push-ups or plank time	Record reps or time	Repeat test
Farmer carry distance	Record max distance	Repeat test
Submaximal 3- to 5-rep deadlift or fixed-load rep test (hex bar, sandbag, kettlebell)	Record chosen test and reps or load lifted	Record reps or load lifted
Carry-drag circuit time	Not performed	Record completion time
Self-efficacy ratings (0 – 100)	Rate confidence for each task	Repeat ratings

TABLE 2. JROTC SAMPLE PROGRAM OUTLINE

MESOCYCLE	WEEK	FOCUS	EXAMPLE RESISTANCE SESSION	EXAMPLE CONDITIONING SESSION
Weeks 1 – 4	Week 1	Technique and Capacity	Movement prep (hinge, squat, scapular setting); KB/sandbag deadlifts (3 x 8–10 at RPE 5–6); push-up progressions; TRX/ring rows (3 x 8–12); farmer carries (3 x 20–40 m)	10 x 100–150 m intervals at comfortable pace w/ 1:1 walk/jog recovery; 15–20 min tempo run with short strides
Weeks 5 – 8	Week 5	Strength and Transition	Trap-bar/sandbag deadlifts (4 x 5 at RPE 6–7); weighted/elevated push-ups (4 x 6–10); band-assisted pull-ups or ring rows (4 x 6–10); farmer carries (4 x 30–50 m)	6–10 x 200 m intervals at one-mile pace +10–15 s w/ 1:1 recovery; 25–30 min easy run or bike
Weeks 9 – 12	Week 9	Power and Speed	Deadlifts (5 x 3 at RPE 7–8); weighted push-ups (4 x 5–8); weighted pull-ups (5 x 3–5); med-ball throws (8 x 2–3); KB swings (4 x 8); contrast sets (deadlift + jump)	200–300 m intervals w/ full recovery; threshold session: 2 x 8–10 min at comfortably hard effort
Weeks 13 – 16	Week 13	Consolidation and Assessment	Deadlifts (3 x 3–4 at RPE 7); low-volume throws and jumps; movement-quality session (mobility, light accessories, technique rehearsal)	Sharpening intervals; prep for Week 16 testing (e.g., 1-mile run, push-ups/plank, carry-drag circuit)

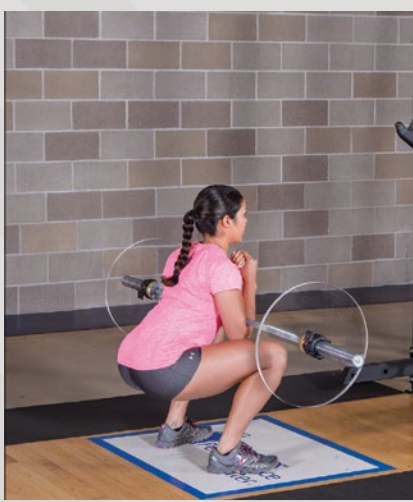
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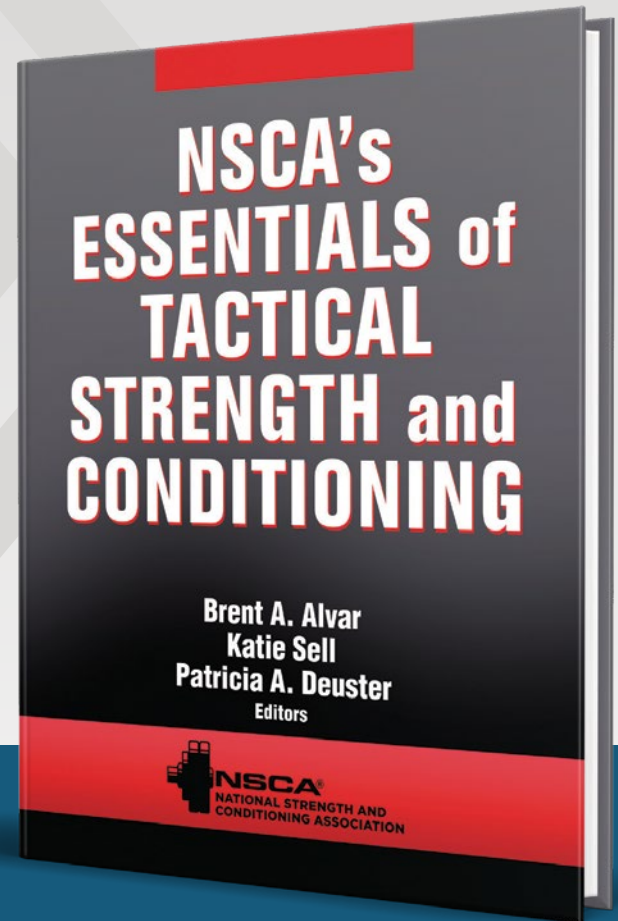
ABOUT THE AUTHORS

Cason Kelly is a PhD student in Health Science: Exercise and Sport Science at Liberty University and an Instructor and Field Experience Coordinator in the Department of Health and Human Performance at Tarleton State University. His research explores interprofessional education and the integration of field experiences in strength and conditioning to enhance collaborative practice. A Certified Strength and Conditioning Specialist® (CSCS®) through the National Strength and Conditioning Association (NSCA), Kelly has experience coaching athletes, Olympic weightlifters, and active professionals. He is also engaged in the tactical strength and conditioning community, supporting initiatives to improve the health and performance of first responders and military personnel. Kelly is committed to preparing students for success through experiential learning and evidence-based training.

Craig Hermans is a Professional Assistant Professor in the Department of Health and Human Performance at Tarleton State University. He brings over 30 years of experience in strength and conditioning, including 12 years in tactical settings with military and law enforcement and 15 years in higher education. His research focuses on the physiological effects of stress on first responders, performance under pressure, and the long-term impact of tactical conditioning on health and readiness. Hermans has worked extensively with athletes, first responders, and tactical professionals, designing evidence-based programs to enhance performance and reduce injury risk. At Tarleton State University, he teaches courses such as tactical strength and conditioning and contributes to research on stress adaptation, recovery, and performance optimization.



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DEPTH PUSH-UP

Purpose:
To develop explosive upper body power.

Start:
Start in a push-up position, with the hands on a medicine ball and elbows extended.

Action:
The medicine ball is kept and dropped the hands slightly and above slightly the medicine ball immediately and ending the elbow.

Common Tasks for Structural Firefighters

Figure 01: Structural firefighter carrying equipment.

Figure 02: Structural firefighter completing a kneeling hose pull.

Figure 03: Structural firefighter performing a hose hold.

Figure 04: Structural firefighter performing an upright hose pull.

Figure 05: Structural firefighter performing a star climb with a hose bundle.

Figure 06: Structural firefighter performing a victim drag.

Figure 07: Structural firefighter gaining access through a scuttle hatch for roof operations.

Figure 08: Structural firefighter performing a forcible entry using a sledgehammer.

the medicine ball is kept and dropped the hands slightly and above slightly the medicine ball immediately and ending the elbow.

vertical height during must be higher than

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