

TSAC REPORT

ISSUE 53





TACTICAL PERFORMANCE

Eleiko offers complete strength and tactical performance training solutions.

Our range of the world's finest bars, bumper plates and platforms, supported by Eleiko Education ARMYou, create engaging and effective free weight environments that provide optimal performance training zones for tactical readiness.

Partner with Eleiko to learn to coach, implement and sustain engaging performance programs for military personnel and first responders. ARMYou powered by Eleiko delivers:

- Tactical fitness and performance programs
- Become a Certified ARMYou Performance Trainer (CAPT)
- Long-term tactical solution



LEARN ABOUT OUR COMPLETE STRENGTH SOLUTIONS
ELEIKO.COM / 866 447 9441 / USA@ELEIKO.COM

ELEIKO
RAISE THE BAR

NSCA MISSION

As the worldwide authority on strength and conditioning, we support and disseminate research-based knowledge and its practical application, to improve athletic performance and fitness.

TSAC EDITORIAL REVIEW PANEL

Mark Abel, PHD, CSCS,*D, TSAC-F

Jerry Bean, MS, ATC, LAT, CSCS, TSAC-F

Jon Carlock, MS, CSCS,*D

Patrick Conway, MS, CSCS,*D

Jason Dudley, MS, CSCS,*D, TSAC-F, FMS, RSCC

Stacy Gnacinski, PhD

Jason Hartman, MS, CSCS

Nancy Henderson, DPT, PT, OCS

John Hofman, MS, CSCS,*D, TSAC-F,*D

Jared Hornsby, PHD

Charlie Kornhauser, TSAC-F

Katie Miller, RD, LDN, CSCS

Brian Schilling, PHD, CSCS, FNCSA

Katie Sell, PHD, CSCS

Kevin Serre, PHD, CSCS

Courtney Shinost, DPT, CSCS, NSCA-CPT, RSCC

Stew Smith, CSCS

Tony Soika, MS, CSCS,*D, TSAC-F,*D

Mick Stierli, MS, CSCS

Henry "Hal" Williamson, MA, CSCS, TSAC-F

STAFF

Editor

Rob Orr, PHD, TSAC-F

Assistant Editor

Britt Chandler, MS, CSCS,*D, NSCA-CPT,*D

Publications Director

Keith Cinea, MA, CSCS,*D, NSCA-CPT,*D

Managing Editor

Matthew Sandstead, NSCA-CPT,*D

Publications Coordinator

Cody Urban

CONTACT

NSCA TSAC
1885 Bob Johnson Drive
Colorado Springs, CO 80906
phone: 800-815-6826

TSAC Report email:
tsacreport@nsca.com

Managing Editor:
matthew.sandstead@nsca.com

© 2019 National Strength and Conditioning Association.
Reproduction without permission is prohibited.

ISSN: 2378-7392



TABLE OF CONTENTS

- 04 IMPROVING PHYSICAL READINESS TESTING (PRT) RESULTS FOR U.S. NAVY SAILORS ENROLLED IN THE FITNESS ENHANCEMENT PROGRAM (FEP) USING A 10-WEEK PROGRESSION PLAN**
MANNY ROMERO, CSCS, TSAC-F, AND JOSH HOCKETT, MS, CISSN, CSCS,*D, NSCA-CPT,*D, TSAC-F,*D
- 08 CONSIDERATIONS OF BLOOD FLOW RESTRICTION (BFR) TRAINING – A CASE FOR INJURY PREVENTION AND MAXIMIZING STRENGTH FOR TACTICAL PERSONNEL**
NIC MARTINEZ, PHD, CISSN, CHRIS LILLA, MS, CSCS, AND MIKE RENTERIA, MS, CSCS
- 14 USING SUSPENSION-BASED RESISTANCE TRAINING AS A METHOD OF SHOULDER PREHABILITATION FOR FIREFIGHTERS**
SARAH MROS, CSCS, USAW AND JAY DAWES, PHD, CSCS,*D, NSCA-CPT,*D, TSAC-F, FNCSA
- 20 TSAC – REDUCING THE RISK OF INJURY – ELEMENTS OF INJURY CAUSATION**
ROD POPE, PHD
- 26 TRACKING TRAINING LOAD AND ITS EFFECT ON INJURY RISK AND FITNESS**
DANIEL MAUPIN, DPHTY, ATC, CSCS, AND BEN SCHRAM, DPHTY, PHD, TSAC-F
- 28 SOLDIER MUSCULOSKELETAL INJURIES, RISK FACTORS, AND RECOMMENDATIONS**
ERIC GUTIERREZ, MS, CSCS
- 34 IMPROVING RECOVERY FOR TACTICAL ATHLETES**
KIMBERLY ALLEN, MA, CSCS,*D, TSAC-F,*D
- 38 TSAC REPORT – JANUARY 2019 RESEARCH COLUMN**
BRIAN SCHILLING, PHD, CSCS, AND DUSTIN DUNNICK, MS
- 40 SHOULDER TAPS – A NOVEL TIME-EFFICIENT SCREENING TOOL FOR TACTICAL OPERATORS**
KATHERINE BALFANY, CAITLYN HEREDIA, AND ROBERT LOCKIE, PHD

The statements and comments in *TSAC Report* are those of the individual authors and contributors and not of the National Strength and Conditioning Association (NSCA). The appearance of advertising in this journal does not constitute an endorsement for the quality or value of the product or service advertised, or of the claims made for it by its manufacturer or provide. Neither the Editors of the *TSAC Report*, nor the NSCA, or any other party directly involved in the preparation of the material contained assume any liability or responsibility for the accuracy, completeness, or usefulness, nor shall they be liable for any direct, indirect, incidental, special, consequential, or punitive damages arising out of the use of *TSAC Report*.

IMPROVING PHYSICAL READINESS TESTING (PRT) RESULTS FOR U.S. NAVY SAILORS ENROLLED IN THE FITNESS ENHANCEMENT PROGRAM (FEP) USING A 10-WEEK PROGRESSION PLAN

INTRODUCTION

Maintaining an acceptable level of physical fitness is an increasingly important matter for the entire United States Navy workforce (1,3). Sailors who do not meet the Physical Fitness Assessment (PFA) minimum requirements will be automatically enrolled in the Fitness Enhancement Program (FEP) until they demonstrate the proper criteria needed to remove themselves from the program (3,6,7,8,10). Sailors enrolled in FEP require specialized attention to improve their physical fitness levels up to, or above, the minimum requirements for continued naval career success and lifelong health benefits. Tactical Strength and Conditioning Facilitators® (TSAC-F®) can assist struggling sailors with reaching and sustaining satisfactory or better scores, as determined by their age group and gender. Allowing the fit to become more fit is a laudable and attractive goal for military physical training (PT) programs. However, assuring that those struggling at the other end of the spectrum have the opportunity and support to succeed and contribute to a ready fleet is of equal importance. This article will focus on the requirements that must be met for sailors to pass a PFA, and resources the Command Fitness Leader (CFL) and TSAC-F has at their disposal to assist sailors on FEP. In addition, an example program is provided for the CFL and TSAC-F to help support sailors struggling to meet PFA requirements.

ROLE OF THE CFL AND PFA REQUIREMENTS

CFLs, Assistant CFLs (ACFLs), and the enrolled FEP member must work together to accomplish the goal of meeting and/or exceeding age and gender-specific minimum PFA thresholds (10). CFLs are trained to seek out helpful resources to assist with weight loss and performance enhancement. These resources include, but are not limited to: a registered dietitian (RD), Navy sports medicine personnel, military treatment facilities (MTFs), the Navy's Ship Shape 8-session/8-week lifestyle education program, the Mission Nutrition program, galley/mess hall's Go For Green program guides, Navy Operational Fitness and Fueling Systems, and Operation Supplement Safety (4).

The U.S. Navy assesses personnel via a semi-annual PFA, which includes a medical screen, a body composition assessment (BCA), and a physical readiness test (PRT) (3). PFAs are conducted by the command's designated CFL and, oftentimes, with help from one or more ACFLs. The Navy has become more stringent with the fleet's sailor readiness requirements to be deployment ready. Physical fitness and injury/rehabilitation status are getting a heavy

focus as per the Deputy Chief of Naval Personnel (11). It thus becomes critical for the Navy's fleet to have a fit and ready fleet around the world to meet the operational demands expected of all Navy sailors.

The BCA is used to identify the sailor's estimated body fat percentage. Only CFLs or trained ACFLs are authorized to conduct official BCA measurements (3,6). The components of the BCA include a height and weight measurement, followed by a circumference measurement if the member exceeds the weight for height screen (3,6). Females are to be measured at the neck, waist, and hips, and males are to be measured at the neck and abdomen (6). Sailors will fail the BCA if they exceed the maximum allowable body fat limits of 36% for females and 26% for males (3,6). Members who pass the BCA but are not within the graduated BCA standards for their respective age group will be placed in FEP until they are within the graduated standards (6). Screening tables and chart information can be found under Section 4 in Guide 4 in *The Body Composition Assessment of the Navy Physical Readiness Program Handbook* (6).

The PRT provides Commanding Officers (COs) with a method of assessing the fitness level of the members in their respective commands (7). The components of the PRT include two muscular endurance events (push-ups and curl-ups) and one cardiorespiratory event (3,7,9). The PRT must be administered in the following order: curl-ups, push-ups, and a cardiorespiratory event (3,7,9). All events must be completed on the same day, with 2 – 15 min between each event (3,7,9). Both curl-ups and push-ups are repeated as many times as possible in two minutes and are monitored by the CFL and/or ACFL (7). The 1.5-mi run and/or walk must be completed as quickly as possible and is graded corresponding to the time of completion recorded by the CFL (7). The CO determines whether or not members will be allowed to use the treadmill, stationary bike, or swim option for the PRT (3,5,7,9,10). Other forms of cardio include a 1.5-mi run on a treadmill, 500-yd or 400-m swim, and a 12-min stationary bike test that measures caloric output (3,5,7,9). Event procedures are physically demonstrated and verbally described before each trial. Any sailor who fails to meet those guidelines will forfeit the event and be graded off of the repetitions or time completed (7). Scoring standards can be found in Sections 4 and 5 in Guide 5 in *The Physical Readiness Test of the Navy Physical Readiness Program Handbook* (7).

IMPROVING PHYSICAL READINESS TESTING (PRT) RESULTS FOR U.S. NAVY SAILORS ENROLLED IN THE FITNESS ENHANCEMENT PROGRAM (FEP) USING A 10-WEEK PROGRESSION PLAN

Members must perform and pass all three events to receive an overall score, which is given as a category-level corresponding to the average of points accumulated on PRT events (7). The results of both the BCA and PRT are used to create an overall score for the PFA cycle (3,5,6,7). The PRT is failed when a sailor does not achieve “probationary” or better for any PRT event; provided they were not medically waived (7). Moreover, if a member attempts and fails to complete a cardiorespiratory event, it will be considered a PRT failure (7). A failure of either the BCA or PRT component constitutes a PFA failure (3,8). Members with one or more PFA failures are subject to administrative actions (3,8,10). Those who fail the BCA and/or PRT are automatically enrolled in FEP (2,3,8,10). Participation in FEP is mandatory until the sailor passes the next regularly scheduled PFA cycle with a “good” or better score (3,10). Multiple PFA failures on record will immediately impact a sailor’s advancement ability and, in some cases, will result in being separated from the Navy (3,8,10).

FITNESS ENHANCEMENT PROGRAM (FEP)

FEP is a command-wide program offered to improve fitness and nutrition habits for sailors who struggle to meet PFA standards (10). Moreover, a command member is enrolled into the program in one of two ways: 1) failure of a PFA or 2) voluntary enrollment regardless of PFA scores (3,8,10). Each member enrolled in FEP must select a nutrition option based on the needs of the individual, and is required to track PT sessions and body weight on a weekly basis (10). FEP training sessions are designed and led by CFLs, ACFLs, and/or Morale, Welfare, and Recreation (MWR) Fitness Specialists (10). It is important to note that although MWR Fitness Specialists can assist with programming, the CFL is responsible for administering all aspects of the program (3,10). Although sailors should maintain a year-round level of physical fitness capable of passing a PRT at any given time, adhering to the Navy’s motto of “always ready,” it can help the TSAC-F to have a focused peaking or preparatory program in place for those sailors who may be lacking in one or more areas of testing within the PRT. The TSAC-F should be aware of potential challenges that may prevent the use of a multi-week progression plan. Examples include a member’s change of command, temporary assigned duty (TAD), military-service school schedules, deployments, and shorter underway at-sea periods.

Appendix A is an example of a scalable, 10-week progressive training program designed to help struggling sailors with enhancing their PRT performance and overall PFA score. This example will only highlight one single training session, which can be repeated 2 – 3 times per week. This training program can be used by sailors enrolled in FEP, assuming no orthopedic contraindications have been noted by command medical personnel. CFLs and FEP members should also seek nutritional advice from a RD or the other programs mentioned above to maximize the effectiveness of this program and to improve BCA results if weight management is also an issue for a particular sailor.

APPENDIX A

WARM-UP AND DYNAMIC MOVEMENT PREPARATION

- 1 x 400 m light jog for general warm-up on track
- 10 min of dynamic movement preparation
- 3 – 4 pillar preparation movements of choice for shoulders, core, hips, and glutes
- 2 – 3 central nervous system (CNS) activation movements of choice (e.g., jumps, bounds, quick feet, sprint-starts, etc.)

PRIMARY STRENGTH CIRCUIT 1

- Push-ups (demonstrate and teach proper form each and every time)

SET 1	SET 2	SET 3
Maximum repetitions to failure	75% of repetitions in set 1	75% of repetitions in set 1

2 min rest between sets

PRIMARY STRENGTH CIRCUIT 2

- Curl-ups (demonstrate and teach proper form each and every time)

SET 1	SET 2	SET 3
Maximum repetitions to failure	75% of repetitions in set 1	50% of repetitions in set 1

2 min rest between sets

ASSISTANCE MOVEMENTS

Keep opposing muscles balanced and gross movement efficiency. There should be one minute of rest between all sets.

- Band face-pulls: 3 x 20 with 1-s isometric hold at back
- Bird-dogs: 3 x 10 per side with 2-s isometric hold at top
- Front plank with glute bridge isometric hold, superset: 30 s each x 2 – 3 sets

ENERGY SYSTEM DEVELOPMENT (ESD) CIRCUIT

Assuming the 1.5-mi run is the PRT test modality of choice:

- 4 laps on 400-m track
 - Lap 1: 100% effort, fast walk 1 lap
 - Lap 2: 75% effort, fast walk $\frac{3}{4}$ lap
 - Lap 3: 50% effort, fast walk $\frac{1}{2}$ lap
 - Lap 4: 50% effort, fast walk $\frac{1}{3}$ lap
- 10 min of soft tissue work and flexibility
- Foam rolling/trigger point work
- Proprioceptive neuromuscular facilitation (PNF) stretching/ band stretching/partner stretching

This program can be kept consistent and repeated week to week for about 10 weeks with a frequency of 2 – 3 times per week being ideal with one day of rest between sessions. Because the first set of each exercise/lap is the key to the rest of the sets/repetitions,

as fitness improves, overall repetitions will increase week to week. This can be documented from week to week to assure progression is taking place and to help motivate the sailor. Sailors must be instructed to give a true all-out effort on the first set of each exercise for optimal effectiveness.

Additional exercises and workouts tailored to any one sailor's unique needs can be added in as "homework" or extra help in areas of weakness. Some sailors may be strong in one area (e.g., push-ups and curl-ups) but struggle in another area (e.g., cardiovascular work). Rotation between running, biking, intervals and elliptical options can provide additional choices for the sailor as well. However, most of the time should be spent in the testing modality they will plan to test for in the PRT (bike, run, swim).

REFERENCES

1. Alvar, BA, Sell, K, and Deuster, PA. *NSCA's Essentials of Tactical Strength and Conditioning*. Champaign, IL: Human Kinetics; 1-7, 505-533, 2017.
2. Department of Defense physical fitness and body fat assessment programs procedures. Instruction number 1308.3. Department of Defense, 2002.
3. Office of Chief Naval Operations. OPNAVINST 6110.1J. Physical readiness program. Department of the Navy, 2011.
4. Navy Operational Fitness Series. (n.d). Group Physical Training.
5. Navy Physical Readiness Programs. Operations guide 3: Physical fitness assessment (PFA) checklist. CFL handbook. Department of the Navy, 2016.
6. Navy Physical Readiness Programs. Operations guide 4: Body composition assessment (BCA). CFL handbook. Department of the Navy, 2016.
7. Navy Physical Readiness Programs. Operations guide 5: Physical readiness test (PRT). CFL handbook. Department of the Navy, 2016.
8. Navy Physical Readiness Programs. Operations guide 7: PFA failures, administrative action, administrative separation. CFL handbook. Department of the Navy, 2016.
9. Navy Physical Readiness Programs. Operations guide 10: Alternative cardio options procedures. CFL handbook. Department of the Navy, 2016.
10. Navy Physical Readiness Programs. Operations guide 13: Command fitness guide, command/unit physical training (PT), and fitness enhancement program (FEP). CFL handbook. Department of the Navy, 2016.
11. Navy announces deployability assessment and assignment program. September 26, 2018. Retrieved online October 8, 2018 from https://www.navy.mil/submit/display.asp?story_id=107208.

ABOUT THE AUTHORS

Manny Romero has worked in the sports performance and fitness industry for six years and has worked with hundreds of individuals from military, athletic, and corporate backgrounds. He is a Fitness Instructor for the Navy's Morale, Welfare, and Recreation (MWR) Fitness Department at Naval Air Station North Island (NASNI) in Coronado, CA. His duties include creating and implementing comprehensive strength and conditioning programs for active duty sailors to reduce injury risk and promote tactical readiness. He works closely with his colleagues to promote lifelong wellness for enlisted and retired sailors, Department of Defense patrons, and their families. Romero graduated from San Diego State University with a Bachelor of Science degree in Kinesiology. He holds a Certified Strength and Conditioning Specialist® (CSCS®) and Tactical Strength and Conditioning Facilitator® (TSAC-F®) from the National Strength and Conditioning Association (NSCA). In addition, he is also working on a Master of Science degree in Kinesiology at Point Loma Nazarene University and is expecting to graduate in summer 2019.

*Josh Hockett is the Director of Tactical Strength and Conditioning for the 57th Rescue Squadron of the 31st Fighter Wing based in Aviano, Italy. He has held this role since January 2019. Prior to this position, he spent over five years as the Director of Food and Fitness Engagement at Bayer Crop Sciences. He received his Bachelor of Science degree in Kinesiology from the University of Wisconsin-Milwaukee and a Master of Science degree in Exercise Science from the University of Wisconsin-La Crosse. He has worked with the University of Wisconsin-Madison Athletics Department via the women's volleyball and hockey teams as well as the men's hockey team. Hockett was the Personal Training Director for Anytime Fitness in Madison, WI for two years prior to his two years as the Strength and Conditioning Coordinator for MizzouRec at the University of Missouri in Columbia, MO. Hockett has worked as the Afloat Fit Boss for the USS Ronald Reagan in San Diego, CA since 2012. He is also an American Natural Bodybuilding Federation (ANBF) professional men's physique competitor and coach. Hockett also holds certifications from the National Strength and Conditioning Association (NSCA) as a Certified Strength and Conditioning Specialist® with Distinction (CSCS,*D®), NSCA-Certified Personal Trainer® with Distinction (NSCA-CPT,*D®), and Tactical Strength and Conditioning Facilitator® with Distinction (TSAC-F,*D®).*



BUILT FOR *PERFORMANCE*

HD Athletic™ stands up to what elite athletes
and elite tactical units dish out.

HAMMERSTRENGTH.COM
866.991.9073

© 2016 Hammer Strength, a division of Brunswick Corporation. All rights reserved. Hammer Strength is a registered trademark of Brunswick Corporation. HD Athletic is a trademark of Brunswick Corporation.

**HAMMER
STRENGTH®**

CONSIDERATIONS OF BLOOD FLOW RESTRICTION (BFR) TRAINING – A CASE FOR INJURY PREVENTION AND MAXIMIZING STRENGTH FOR TACTICAL PERSONNEL

**updated 4/26/2019*

INTRODUCTION

Special Operations Forces (SOF) across the military typically intend to have an extensive and meaningful career. Prior to acceptance into the United States Armed Forces, it is required that particular fitness levels and standards are met, especially at the elite levels. Tactical personnel (i.e., military, police, fire) regularly perform strenuous job-related tasks, and it should be noted that injury prevalence plagues elite soldiers throughout training and during combat operations. Musculoskeletal areas that frequently sustain injury (i.e., impingements, sprains, fractures, strains) involve the neck, back, shoulders, knees, and ankles (5). The majority of these injuries are classified as acute (69.2%), as opposed to being overuse (26.9%) related. However, tactical personnel do commonly incur overuse injuries to the shoulder, including rotator cuff strains, multi-directional instability, and shoulder (labral) tears (6).

According to the injury epidemiology of SOF utilizing self-reported injury histories, physical training was the most reported activity for total injuries. Running and lifting were cited as common injury causes, with running accounting for 23.1% and lifting being linked to 19.2% of injuries. When only “preventable” injuries were included in the analysis, running was the cause of 30.0% and lifting was responsible for 25.0% of injuries (5). However, the repeated high mechanical stress typically used to achieve strength and hypertrophic adaptations may be circumvented through the implementation of low-intensity alternatives to training.

Interestingly, research has shown that low-intensity resistance training demonstrates significant increases in strength and hypertrophy when combined with blood flow restriction (BFR) training (1,2,3,4,8,25). Therefore, the focus of this discussion is on the training programs and associated injuries of tactical personnel, including how to effectively integrate blood flow restriction (BFR) training and technology in order to maximize strength training adaptations, assist with injury prevention and facilitate recovery.

HISTORY/BACKGROUND

Vascular restriction, or BFR, training is a relatively new and innovative concept in fitness and rehabilitation settings. BFR is accomplished by partially restricting venous outflow of an extremity (e.g., applying a pressured cuff to the proximal area of the upper or lower extremities) during low-intensity exercise

(9,21). Precise restriction safely reduces the rate of venous return to the heart as blood passes through the targeted muscle(s). BFR training should not be misinterpreted with training under extreme pressures or ischemic conditions, since proper BFR training utilizes low to moderate pressures and promotes blood pooling in the capillaries within skeletal muscle without arterial occlusion or induced ischemia, which is when arteries are narrowed, and less blood and oxygen can reach the heart (21). Furthermore, BFR training involves moderately restricting venous blood flow back to the heart from the arms or legs, allowing the muscles of the targeted extremities to temporarily “swell” with nutrient rich blood.

The precise physiological occurrences that promote these hypertrophic effects are still being investigated; however, it is purported that vascular restriction combined with low-intensity exercise stimulates numerous factors known to facilitate increases in strength and hypertrophy, including metabolite accumulation (lactic acid, adenosine diphosphate, etc.), increased hormonal responses such as growth hormone (GH) and insulin-like growth factor-1 (IGF-1), and the recruitment rate of fast-twitch muscle fibers (10,24). BFR has been utilized with several exercise modalities (e.g., knee extension, knee flexion, leg press, elbow flexion, bench press) across various populations utilizing low-intensity resistance training, with most reports citing significant increases in muscular strength and hypertrophy (1,2,3,4,25,27,28,29). Increases in strength and hypertrophy have even been observed with BFR when implemented during walk-training, though it can be noted there are significantly greater gains in both strength and hypertrophy when BFR is combined with resistance training as compared to walking (4). Lastly, there is evidence suggesting that BFR in the absence of exercise still results in favorable muscular adaptations, which could be beneficial for expediting recovery if injury occurs (11,12,26).

PHYSIOLOGICAL ADAPTATIONS AND MECHANISMS OF BFR TRAINING

The concept of BFR combined with low-intensity resistance training may differ from the American College of Sports Medicine’s (ACSM) position on prescribed training intensities for inducing muscle hypertrophy, which is stated as 70% 1-repetition maximum (1RM) for 6 – 12 repetitions under normal training conditions (22). Research has demonstrated favorable increases in muscular strength and hypertrophy with reduced training intensities ($\leq 50\%$ 1RM) when combined with BFR (19,25). Remarkably, increases

CONSIDERATIONS OF BLOOD FLOW RESTRICTION (BFR) TRAINING – A CASE FOR INJURY PREVENTION AND MAXIMIZING STRENGTH FOR TACTICAL PERSONNEL

in muscle cross sectional area (CSA) and muscular strength have been observed with BFR training intensities as low as 20% 1RM (1,17,28).

Physiologically, low-intensity BFR training induces a variety of positive adaptations that contribute to the observed hypertrophic and strength increases. Venous restriction demonstrates an increase in muscle cell swelling that appears to be an effect present throughout all related studies (13,14,16,19). BFR training also causes a buildup of metabolites inside the muscle (16,19,24), increases the amount of circulating GH (21,23,24), and increases protein synthesis (7,13,19). All of the aforementioned adaptations most likely work synergistically, contributing to the increases observed in muscle cross sectional area (CSA) and other hypertrophic and strength increases. Metabolic stress or metabolite accumulation is suggested to be the primary factor contributing to the benefits observed with BFR training (15). It is also noted that BFR combined with low-intensity resistance exercise may induce a lower magnitude of mechanical tension accompanied by a linear increase in metabolic stress greater than when combined with moderate- or high-intensity training (4,19,24).

The aforementioned observations support the rationale that positive physiological training adaptations are likely to occur at lower training intensities when accompanied with BFR. It is also likely that the demand for high-intensity resistance training sessions performed throughout a standard strength training program could be effectively reduced by utilizing BFR, thus

decreasing overall stress placed on the tactical athlete during a strength training block.

PRACTICAL INTEGRATION OF BFR TRAINING FOR TACTICAL ATHLETES

After years of BFR research and technological advancements, multiple commercial entities have developed and marketed effective BFR machines and protocols for public use. Performed under conditions involving vascular restriction, BFR technology is most often utilized to strengthen muscle and promote recovery in individuals (18,21). Notably, the features found in some portable BFR training systems offer a handheld, touch-screen device, which utilizes technology that allows for safe and effective integration into tactical strength and conditioning programs.

BFR training is safe to use with a variety of ages, experience levels, conditions, and body types; however, it is recommended that individuals undergo medical examination and/or receive medical clearance prior to starting any new fitness program. The purpose of BFR training is to counter muscle atrophy, and improve strength through a variety of activities, such as resistance training, stretching, cycling, walking, or rehabilitation. Vascular restriction can also be applied to the warm-up, cooldown, and recovery aspects of training. The BFR technology found in cost-effective portable units is gaining traction with practitioners and is currently used in sports, clinics, fitness gyms, aquatics, and military strength and conditioning facilities. When using BFR, intensities should range between 20 – 40% 1RM and last for approximately 10 – 20 minutes. See Table 1 for exercise protocol and recommendations for frequency, intensity, volume, and prescribed pressures. For

Table 1. Standard BFR Protocol for Tactical Athletes

TACTICAL ATHLETES	PRESSURE	INTENSITY	VOLUME	FREQUENCY
Male	Base pressure goal:	As low as 20% 1RM	10 - 20 min	UB <15 min
	20 SKUs* for legs		20 - 30+ reps	LB <20 min
	10 SKUs* for arms		3 - 5 sets	2 - 3 x weekly
			30s rest between sets	3 - 4 x weekly for injury
	Optimal pressure:		60 s between exercise	
	UB - 150 mmHg LB - 200 mmHg			
Female	Base pressure goal:	As low as 20% 1RM	10 - 20 min	UB <15 min
	20 SKUs* for legs		20 - 30+ reps	LB <20 min
	10 SKUs* for arms		3 - 5 sets	2 - 3 x weekly
			30 s rest between sets	3 - 4 x weekly for injury
	Optimal pressure:		60 s between exercise	
	UB - 100 mmHg LB - 150 mmHg			

Note: UB=Upper body. LB=Lower body.

* "SKU" is a standard unit measurement used with KAATSU devices and is approximately equivalent to mmHg.

rehabilitation programs, treatment can follow similar guidelines, but are terminated when there is an improvement in symptoms, achievement of goals, or end of previously planned period.

Portable BFR units utilize air band technology, which is essentially a pressure cuff placed at the proximal ends of either the upper or lower extremities. See Figures 1 – 4 for examples of BFR band placement. The arm bands are smaller than the leg bands, and both inflate with air to the desired pressure set by the BFR technician. It is important to have knowledgeable personnel on staff to ensure proper operation, calibration, and maintenance of exercise equipment. The technician will need to confirm that the BFR unit is set on the targeted extremity (e.g., arms, legs), and at the optimal pressure, which is generally higher in the legs than the arms. The unit should also be set to an equal pressure on both sides of the targeted extremity. Whether performing exercises for the arms or legs, the unit should be checked to ensure proper function and that the color of the user's skin is pink, not pallor. The subject may not feel a pulse under the bands at higher pressures, which is typically an indication for the specialist to reduce the pressure according to manufacturer protocols.

BFR training should never be utilized for upper and lower body exercises concomitantly. Lifting heavy weights, or the use of vascular restriction while undergoing any type of cardiac rehabilitation, is not advised and is considered an unsafe practice or medical contraindication. Vascular restriction bands should be removed immediately if the user experiences a feeling of lightheadedness, uncomfortable tingling, sensation of numbness, and/or presents with paleness. While injuries resulting from BFR training are uncommon, improper operation increases the potential risks and side effects such as dizziness, numbness, subcutaneous hemorrhage, and in rare cases, cerebral anemia, cold feeling, venous thrombus, pulmonary embolism, rhabdomyolysis, and deterioration of ischemic heart disease. It is important that users properly hydrate before, during, and after each training session. Slow movements should be performed, which allows users to work through full ranges of motion unless supervised and instructed otherwise. See ss 5 – 12 for examples of BFR exercises. It is common practice to achieve muscular failure or volitional fatigue within most or all sets, thus a slight tingling in the subject's fingers or toes during training is acceptable. Notably, the subject's musculature may appear larger and vasculature more dilated following BFR training.

CONCLUSION

The innovative technology found in portable BFR training systems can help tactical personnel achieve greater strength and hypertrophic gains, as well as optimize training programs and overall performance. The elite branches of the United States military and those of other tactical personnel are in a unique position to benefit from the versatility offered through current BFR technology.

REFERENCES

1. Abe, T, Hinata, S, Koizumi, K, and Sato, Y. Day-to-day change in muscle strength and MRI-measured skeletal muscle size during 7 days KAATSU resistance training: A case study. *International Journal of KAATSU Training Research* 1(2): 71-76, 2005.
2. Abe, T, Kawamoto, K, Yasuda, T, Kearns, CF, Midorikawa, T, and Sato, Y. Eight days KAATSU-resistance training improved sprint but not jump performance in collegiate male track and field athletes. *International Journal of KAATSU Training Research* 1(1): 19-23, 2005.
3. Abe, T, Kearns, CF, Fujita, S, Sakamaki, M, Sato, Y, and Brechue, WF. Skeletal muscle size and strength are increased following walk training with restricted leg muscle blood flow: Implications for training duration and frequency. *International Journal of KAATSU Training Research*, 5(1): 9-15, 2009.
4. Abe, T, Kearns, CF, and Sato, Y. Muscle size and strength are increased following walk training with restricted venous blood flow from the leg muscle, KAATSU-walk training. *Journal of Applied Physiology* 100(5): 1460-1466, 2006.
5. Abt, JP, Sell, TC, Lovalekar, MT, Keenan, KA, Bozich, AJ, Morgan, JS, et al. Injury epidemiology of U.S. Army Special Operations forces. *Military Medicine* 179(10): 1106-1112, 2014.
6. Chittenden, K, and Morelli, J. Applied periodization in shoulder injury for the tactical athlete – part 1. *TSAC Report* 43: 14-19, 2016.
7. Fujita, S, Abe, T, Drummond, MJ, Cadenas, JG, Dreyer, H, Sato, Y, et al. Blood flow restriction during low-intensity resistance exercise increases S6K1 phosphorylation and muscle protein synthesis. *Journal of Applied Physiology* 103(3): 903-910, 2007.
8. Fujita, S, Brechue, WF, Kurita, K, Sato, Y, and Abe, T. Increased muscle volume and strength following six days of low-intensity resistance training with restricted muscle blood flow. *International Journal of KAATSU Training Research*, 4(1): 1-8, 2008.
9. Hylden, C, Burns, T, Stinner, D, and Owens, J. Blood flow restriction rehabilitation for extremity weakness: a case series. *Journal of Special Operations Medicine* 15(1): 50-56, 2015.
10. Karabulut, M, Abe, T, Sato, Y, and Bembem, M. Overview of neuromuscular adaptations of skeletal muscle to KAATSU Training. *International Journal of KAATSU Training Research* 3(1): 1-9, 2007.
11. Kubota, A, Sakuraba, K, Koh, S, Ogura, Y, and Tamura, Y. Blood flow restriction by low compressive force prevents disuse muscular weakness. *Journal of Science and Medicine in Sport* 14(2): 95-99, 2011.
12. Kubota, A, Sakuraba, K, Sawaki, K, Sumide, T, and Tamura Y. Prevention of disuse muscular weakness by restriction of blood flow. *Medicine and Science in Sports and Exercise* 40(3): 529-534, 2008.
13. Loenneke, JP, Abe, T, Wilson, JM, Ugrinowitsch, C, and Bembem, MG. Blood flow restriction: how does it work? *Frontiers in Physiology* 3: 2012.

CONSIDERATIONS OF BLOOD FLOW RESTRICTION (BFR) TRAINING – A CASE FOR INJURY PREVENTION AND MAXIMIZING STRENGTH FOR TACTICAL PERSONNEL

14. Loenneke, JP, Fahs, C, Rossow, L, Abe, T, and Bembien, MG. The anabolic benefits of venous blood flow restriction training may be induced by muscle cell swelling. *Medical Hypotheses* 78(1): 151-154, 2012.
15. Loenneke, JP, and Pujol, TJ. The use of occlusion training to produce muscle hypertrophy. *Strength and Conditioning Journal* 31(3): 77-84, 2009.
16. Loenneke, JP, Wilson, JM, Marin, PJ, Zourdos, MC, and Bembien, MG. Low intensity blood flow restriction training: a meta-analysis. *European Journal of Applied Physiology* 112(5): 1849-1859, 2012.
17. Madarambe, H, Neya, M, Ochi, E, Nakazato, K, Sato, Y, and Ishii, N. Cross-transfer effects of resistance training with blood flow restriction. *Medicine and Science in Sports and Exercise*, 40(2): 258, 2008.
18. Nakajima, T, Kurano, M, Iida, H, Takano, H, Oonuma, H, Morita, T, et al. Use and safety of KAATSU training: results of a national survey. *International Journal of KAATSU Training Research*, 2(1): 5-13, 2006.
19. Pearson, SJ, and Hussain, SR. A review on the mechanisms of blood-flow restriction resistance training-induced muscle hypertrophy. *Sports Medicine* 45(2): 187-200, 2014.
20. Sato, Y. History and recent progress of KAATSU resistance training. *Clinical Journal of Sport Medicine* 21: 209-213, 2004.
21. Sato, Y. The history and future of KAATSU training. *International Journal of KAATSU Training Research* 1(1): 1-5, 2005.
22. Stand, P. Progression models in resistance training for healthy adults. *Medicine and Science in Sports and Exercise* 41(3): 687-708, 2009.
23. Takano, H, Morita, T, Iida, H, Asada, KI, Kato, M, Uno, K, et al. Hemodynamic and hormonal responses to a short-term low-intensity resistance exercise with the reduction of muscle blood flow. *European Journal of Applied Physiology* 95(1): 65-73, 2005.
24. Takarada, Y, Nakamura, Y, Aruga, S, Onda, T, Miyazaki, S, and Ishii, N. Rapid increase in plasma growth hormone after low-intensity resistance exercise with vascular occlusion. *Journal of Applied Physiology* 88(1): 61-65, 2000.
25. Takarada, Y, Sato, Y, and Ishii, N. Effects of resistance exercise combined with vascular occlusion on muscle function in athletes. *European Journal of Applied Physiology* 86(4): 308-314, 2002.
26. Takarada, Y, Takazawa, H, and Ishii, N. Applications of vascular occlusion diminish disuse atrophy of knee extensor muscles. *Medicine and Science in Sports and Exercise* 32(12): 2035-2039, 2000.
27. Takarada, Y, Takazawa, H, Sato, Y, Takebayashi, S, Tanaka, Y, and Ishii, N. Effects of resistance exercise combined with moderate vascular occlusion on muscular function in humans. *Journal of Applied Physiology* 88(6): 2097-2106, 2000.
28. Yasuda, T, Abe, T, Sato, Y, Midorikawa, T, Kearns, CF, Inoue, K, et al. Muscle fiber cross-sectional area is increased after two weeks of twice daily KAATSU-resistance training. *International Journal of KAATSU Training Research* 1(2): 65-70, 2005.
29. Yasuda, T, Fujita, T, Miyagi, Y, Kubota, Y, Sato, Y, Nakajima, T, and Abe, T. Electromyographic responses of arm and chest muscle during bench press exercise with and without KAATSU. *International Journal of KAATSU Training Research* 2(1): 15-18, 2006.

ABOUT THE AUTHORS

Nic Martinez is an instructor in the Exercise Science Program at the University of South Florida. He is certified through the American College of Sports Medicine (ACSM) as a Certified Exercise Physiologist (ACSM-CEP) and is a Certified Sports Nutritionist from the International Society of Sports Nutrition (CISSN). Additionally, Martinez has served as a human performance coach for professional combat athletes.

Chris Lilla is a Certified Strength and Conditioning Specialist® (CSCS®) through the National Strength and Conditioning Association (NSCA). He is serving as a Fitness and Performance Coach at Life Time Athletic in Tampa, FL. He received his Master's degree from the University of South Florida in Exercise Science with a concentration in Strength and Conditioning.

Mike Renteria serves as the Director of the Human Performance Program for Special Operations Command Central at MacDill Air Force Base. He is a Certified Strength and Conditioning Specialist® (CSCS®) through the National Strength and Conditioning Association (NSCA). He received his Master's degree from the University of South Florida in Exercise Science.



FIGURE 1. ARM BFR – BANDS ARE PLACED AT THE PROXIMAL ENDS OF THE UPPER EXTREMITIES - FRONT



FIGURE 2. ARM BFR – BANDS ARE PLACED AT THE PROXIMAL ENDS OF THE UPPER EXTREMITIES - SIDE



FIGURE 3. LEG BFR – BANDS ARE PLACED AT THE PROXIMAL ENDS OF THE LOWER EXTREMITIES - FRONT



FIGURE 4. LEG BFR – BANDS ARE PLACED AT THE PROXIMAL ENDS OF THE LOWER EXTREMITIES - SIDE



FIGURE 5. GOBLET SQUAT - START



FIGURE 6. GOBLET SQUAT - END



FIGURE 7. PHYSIOBALL LEG CURL - START



FIGURE 8. PHYSIOBALL LEG CURL - END

CONSIDERATIONS OF BLOOD FLOW RESTRICTION (BFR)
TRAINING - A CASE FOR INJURY PREVENTION AND
MAXIMIZING STRENGTH FOR TACTICAL PERSONNEL



FIGURE 9. PUSH-UP - TOP POSITION



FIGURE 10. PUSH-UP - BOTTOM POSITION



FIGURE 11. SUSPENSION CURL - START



FIGURE 12. SUSPENSION CURL - END

SPEED.
POWER.
STRENGTH.

WOODWAY®
BUILT FOR THE BEST BY THE BEST



WOODWAY.COM

USING SUSPENSION-BASED RESISTANCE TRAINING AS A METHOD OF SHOULDER PREHABILITATION FOR FIREFIGHTERS

INTRODUCTION

Firefighting may potentially be one of the most physically demanding occupations in our society (9,16,22). Subsequently, fire departments spend millions of dollars on the treatment of musculoskeletal injury, insurance coverage, rehabilitation, workers compensation, and lost productivity (20). Of these injuries, the shoulder is one of the most common injury sites in this population (4,8). A review of injury reports taken from the Calgary Fire Department between 2007 – 2011 found that shoulder injuries accounted for 13% of all reported musculoskeletal injuries, equating to 107 shoulder sprains and strains over the five-year span. It was also discovered that 32% of these shoulder injuries occurred at the station during physical training activities with the leading causes being from the “bending/lifting/squatting” category (33.6%), followed by the “pushing/pulling” category (29.9%) (8). Furthermore, the National Fire Protection Association (NFPA) found that shoulder injuries account for approximately 8% (2,480) of all annual injuries in United States firefighters (4).

BASIC ANATOMY AND FUNCTIONS OF THE SHOULDER

The shoulder girdle is comprised of three main joints, the glenohumeral (GH) joint, the acromioclavicular (AC) joint, and the sternoclavicular (SC) joint. The GH joint is created by the humeral head resting in the glenoid fossa of the scapula, the AC joint is created by the lateral border of the clavicle and the acromion, and SC joint is formed by the sternal end of the clavicle and the upper portion of the sternum (19). The scapulothoracic articulation is the junction between the posterior thoracic cage and the anterior surface of the scapula (19). Scapulothoracic movement works together with glenohumeral movement to achieve full shoulder range of motion, known as scapulohumeral rhythm (1,19). In general, across the 180 degrees of movement, normal scapulohumeral rhythm involves one degree of scapular upward rotation for every two degrees of humeral flexion/abduction — although this does vary slightly at different degrees (1). Since the GH joint is a ball-and-socket joint, it allows for multidirectional movement and rotation (flexion/extension, external/internal rotation, abduction/adduction, and horizontal abduction/adduction). In a healthy shoulder, the normal range of motion is 180° flexion, 45° extension, 90° external and internal rotation, 180° abduction and adduction, and approximately 30° of horizontal abduction and 120° of horizontal adduction (from a starting point of 90° shoulder abduction) (12).

With a wide range of motion available to this joint, stability can be compromised, making it potentially more prone to injury (e.g.,

dislocation) than other joints (15,23). Stability in the shoulder joint is created by static and dynamic stabilizers (7). The static stabilizers include the glenoid, glenoid labrum, humeral head, joint capsule, and surrounding ligaments (7). The dynamic stabilizers include the surrounding musculature, such as the rotator cuff (supraspinatus, infraspinatus, teres minor, and subscapularis) (7). The global movers include: teres major, biceps tendon, triceps tendon, latissimus dorsi, and deltoid muscle (7). In addition to the main dynamic stabilizers, the scapular stabilizers include the trapezius, rhomboids, levator scapulae, and serratus anterior (6,7). These muscles are responsible for not only moving the shoulder joint through its range of motion, but for decreasing instability and potential injury (7).

MECHANISMS OF SHOULDER INJURIES

Shoulder injuries are typically categorized as either acute or chronic. An acute injury can be defined as an injury of sudden onset caused by high intensity, short duration forces/trauma (10). A chronic injury can be defined as an injury of insidious onset caused by low-intensity, long-duration forces or a recurring acute injury (10). Repetitive overhead activities, strenuous activities with poor movement mechanics, and shoulder instability can often lead to chronic overuse injuries (6). Instability and overloading of the shoulder musculature are both common risk factors for rotator cuff problems, which account for 65 – 70% of all shoulder pain issues (17). Rotator cuff impingement, caused by the narrowing of the subacromial space, is often an effect of glenohumeral instability because of the increased translation of the humeral head in the anterosuperior direction (6). Additionally, glenohumeral muscular imbalance between the rotator cuff muscles and scapular stabilizers may result in excessive excursion of the scapula (abduction/forward rotation of the scapula, characterized by forward rounded shoulders) which can also lead to shoulder impingement (6).

The purpose of this article is to provide a program of suspension-based resistance training exercises for firefighters to train the endurance and stability of the shoulder joint with the purpose of preparing the shoulder complex for the job demands of firefighting and reducing the risk of shoulder injuries.

PREHABILITATION PROGRAM

Prehabilitation was originally used as a preoperative measure to improve postoperative outcomes and enhance recovery through increasing cardiac and respiratory function in the patient (11). With prehabilitation exercises showing positive results in postoperative patient health, the concept of prehabilitation began to spread into

USING SUSPENSION-BASED RESISTANCE TRAINING AS A METHOD OF SHOULDER PREHABILITATION FOR FIREFIGHTERS

other areas of healthcare (21). In the strength and conditioning setting, prehabilitation training is a form of preventative training implemented to decrease the risk of injuries from potential muscle imbalances or repetitive motions, whereas rehabilitation is implemented after an injury has occurred (5,18). Prehabilitation programs can be implemented into the exercise routines of firefighters to allow them to safely meet the physical demands of their job while reducing injury risk. These types of programs should not be used as a rehabilitation program to repair an injury without consulting a physical therapist or physician.

SUSPENSION-BASED RESISTANCE TRAINING

Suspension-based resistance training (SBRT) allows an individual to modify the intensity of an exercise by utilizing their own bodyweight (5,13). Additionally, SBRT may be an ideal modality for implementation of a shoulder prehabilitation program in a firehouse because of its convenience, practicality, and portability. Furthermore, SBRT exercises not only improve the endurance of the targeted muscle groups, but may also aid in developing endurance of the trunk and hip stabilizers (2,3,14). This is due to the need to maintain neuromuscular control and proper body alignment when performing SBRT exercises.

EXERCISES

The following is a series of SBRT exercises that can be used to improve endurance in the shoulder and the muscles surrounding it. To ensure full body conditioning and safety, back hyperextension should be avoided. If back hyperextension is unavoidable and proper form cannot be maintained, reduce the load by increasing the stance angle (13). Figures 1A and 1B display options for exercise modification.



FIGURE 1B. SUSPENSION-BASED ROW MODIFICATION

Scapular Retraction (Figures 2A and 2B)

The purpose of this exercise is to develop muscular endurance in the rhomboids and middle and lower trapezius muscles. These muscles, along with the latissimus dorsi and the levator scapulae make up the superficial musculature of the upper back. Among other roles, the rhomboids and trapezius muscles surround the scapulae and are responsible for scapular retraction, which pulls the scapula towards the spine. The rhomboids are also responsible for scapular elevation and downward rotation, which occurs during scapulohumeral rhythm. Working these muscles will not only increase their endurance, but will aid in training optimal scapular movement patterns needed for overhead lifting. During this exercise, the scapula should be retracted down and back to avoid over activation of scapular elevators.



FIGURE 2A. SCAPULAR RETRACTION FIGURE 2B. SCAPULAR RETRACTION



FIGURE 1A. SUSPENSION-BASED ROW MODIFICATION



FIGURE 3A. PUSH-UP PLUS



FIGURE 3B. PUSH-UP PLUS

Push-Up Plus (Figures 3A and 3B)

The purpose of this exercise is to develop muscular endurance in the serratus anterior muscles. The serratus anterior muscles are responsible for scapular upward rotation and scapular abduction. This exercise trains optimal scapular movement by improving upward rotation of the scapula. This movement is needed to avoid compression stress between the humeral head and the acromion process during humeral elevation.

Rear Deltoid Row (Figures 4A and 4B)

The purpose of this exercise is to develop muscular endurance in the muscles of the upper back and shoulders, specifically the posterior deltoids, trapezius, and rhomboids. The posterior deltoids are responsible for shoulder horizontal abduction while the trapezius and rhomboid muscles act as synergists along with

infraspinatus and teres minor. This movement trains the shoulder dynamic stabilizers, which are needed for safe and efficient upper body movement.



FIGURE 4A. REAR DELTOID ROW



FIGURE 4B. REAR DELTOID ROW

Dual-Arm External Rotation (Figures 5A and 5B)

The purpose of this exercise is to develop muscular endurance in the rotator cuff and deltoids, specifically the infraspinatus with the teres minor acting as a synergist. The muscles of the rotator cuff work together to stabilize the humeral head in the labrum through everyday shoulder movements.



FIGURE 5A. DUAL-ARM EXTERNAL ROTATION



FIGURE 5B. DUAL-ARM EXTERNAL ROTATION

Dual-Arm Internal Rotation (Figures 6A and 6B)

The purpose of this exercise is to develop muscular endurance in the rotator cuff muscles, deltoids, and pectoralis major, specifically the subscapularis with the teres major acting as a synergist. As mentioned previously, the muscles of the rotator cuff are crucial when it comes to shoulder stabilization.

USING SUSPENSION-BASED RESISTANCE TRAINING AS A METHOD OF SHOULDER PREHABILITATION FOR FIREFIGHTERS



FIGURE 6A. DUAL-ARM
INTERNAL ROTATION



FIGURE 6B. DUAL-ARM
INTERNAL ROTATION

I, Y, T Exercise (Figures 7A, 7B, 7C, and 7D)

The purpose of this exercise is to develop muscular endurance in the rhomboids, upper and lower trapezius, deltoids, and rotator cuff muscles. The three different positions in this exercise allows the musculature of the upper, mid, and lower shoulder complex to be activated, building endurance and stability.



FIGURE 7A. I, T, Y EXERCISE



FIGURE 7B. I, T, Y EXERCISE



FIGURE 7C. I, T, Y EXERCISE



FIGURE 7D. I, T, Y EXERCISE

SAMPLE TRAINING PROGRAM

For each exercise, perform 2 or 3 low-intensity sets of 12 – 15 repetitions for 2 or 3 days per week on nonconsecutive days. It is recommended that these exercises are performed before the firefighter's regular routine as part of the warm-up. For further programming guidance, consult with a Tactical Strength and Conditioning Facilitator® (TSAC-F®) or other certified exercise professional.

SUMMARY

With the shoulder continuously proving to be one of the most commonly injured sites, preventative measures need to be taken (4,8). SBRT may help develop the stability and muscular endurance in the shoulder joint needed to decrease the risk of shoulder injuries as a result of the demands of firefighting.

REFERENCES

1. Bryant, C, and Green, D. *ACE's Essentials of Exercise Science for Fitness Professionals*. San Diego, CA: American Council on Exercise; 2012.
2. Byrne, J, Bishop, N, Caines, A, Crane, K, Feaver, A, and Pearcey, G. Effect of using a suspension training system on muscle activation during the performance of a front plank exercise. *Journal of Strength and Conditioning Research* 28(11): 3049-3055, 2014.
3. Calatayud, J, Borreani, S, Colado, J, Martin, F, Rogers, M, Behm, D, and Andersen, L. Muscle activation during push-ups with different suspension training systems. *Journal of Sports Science and Medicine* 13(3): 502-510, 2014.
4. Campbell, R. Patterns of Firefighter Fireground Injuries. *National Fire Protection Association*. 2016. Accessed 2019 from <https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Emergency-responders/ospatterns.pdf>.
5. Dawes, J. *Complete Guide to TRX Suspension Training*. Champaign, IL: Human Kinetics; 2017.
6. Donovan, P, and Paulos, L. Common injuries of the shoulder. Diagnosis and Treatment. *Western Journal of Medicine* 163(4): 351-359, 1995.
7. Felstead, A, and Ricketts, D. Biomechanics of the shoulder and elbow. *Orthopaedics and Trauma* 31(5): 300-305, 2017.
8. Frost, DM, Beach, TAC, Crosby, I, and McGill, SM. Firefighter injuries are not just a fireground problem. *Work* 52(4): 835-842, 2015.
9. Gledhill, N, and Jamnick, VK. Characterization of the physical demands of firefighting. *Canadian Journal of Sport Sciences* 17(3): 207-213, 1992.
10. Knight, KL, Draper, DO. *Therapeutic Modalities: The Art and Science*. Philadelphia: Wolters Kluwer Health/Lippincott Williams and Wilkins; 2013.
11. Le Roy, B, Selvy, M, and Slim, K. The concept of prehabilitation: What the surgeon needs to know? *Journal of Visceral Surgery* 153(2): 111-115, 2016.

12. Lippert, L. *Clinical Kinesiology and Anatomy*. Philadelphia, PA: F. A. Davis Company; 2011.
13. Melrose, D, and Dawes, J. Resistance characteristics of the TRXTM suspension training system at different angles and distances from the hanging point. *Journal of Athletic Enhancement* 4(1): 1-5, 2014.
14. Mok, N, Yeung, E, Cho, J, Hui, S, Liu, K, and Pang, C. Core muscle activity during suspension exercises. *Journal of Science and Medicine in Sport* 18(2): 189-194, 2015.
15. Murray, I, Goudie, E, Petrigliano, F, and Robinson, M. Functional anatomy and biomechanics of shoulder stability in the athlete. *Clinics in Sports Medicine* 32(4): 607-624, 2013.
16. Sheaff, AK, Bennett, A, Hanson, ED, Kim, Y, Hsu, J, Shim, JK, et al. Physiologic determinants of the candidate physical ability test in firefighters. *Journal of Strength and Conditioning Research* 24(11): 3112-3122, 2010.
17. Speed, C. Shoulder pain. *British Medical Journal Clinical Evidence* 9: 1107, 2006.
18. Tenforde, A, Shull, P, and Fredericson, M. Neuromuscular prehabilitation to prevent osteoarthritis after a traumatic joint injury. *Physical Medicine and Rehabilitation Journal* 4(5): 141-144, 2012.
19. Terry, G, and Chopp, T. Functional anatomy of the shoulder. *Journal of Athletic Training* 35(3): 248-255, 2000.
20. *The Economic Consequences of Firefighter Injuries and Their Prevention*. Final Report. 2004. Retrieved 2018 from https://ws680.nist.gov/publication/get_pdf.cfm?pub_id=101312.
21. Valkenet, K, van de Port, IG, Dronkers, J, de Vries, W, Lindeman, E, and Backx, FJ. The effects of preoperative exercise therapy on postoperative outcome: A systematic review. *Clinical Rehabilitation* 25(2): 99-111, 2011.
22. Williams-Bell, F, Villar, R, Sharratt, M, and Hughson, R. Physiological demands of the firefighter candidate physical ability test. *Medicine and Science in Sports and Exercise* 41(3): 653-662, 2009.
23. Zlatkin, MB. In: Barry, B (Ed.), *MRI of the Shoulder*. (2nd ed.) Philadelphia, PA: Lippincott Williams and Wilkins; 2003.

Jay Dawes is an Associate Professor of strength and conditioning and the Coordinator for Athletic Performance at the University of Colorado Colorado Springs. He has worked as a strength/performance coach, personal trainer, educator, and post-rehabilitation specialist for over 15 years, and continues to act as a performance consultant for the Colorado State Patrol. Dawes earned his PhD in the School of Applied Health and Psychology Department at Oklahoma State University. He is certified by the National Strength and Conditioning Association (NSCA) as a Certified Strength and Conditioning Specialist® with Distinction (CSCS,*D*), NSCA-Certified Personal Trainer® with Distinction (NSCA-CPT,*D*), and Tactical Strength and Conditioning Facilitator® (TSAC-F®). He is also certified with the American College of Sports Medicine (ACSM) as a Health Fitness Specialist, United States of America Weightlifting (USAW) as a Club Coach, and the Australian Strength and Conditioning Association (ASCA) as a Level 2 Strength and Conditioning Coach. Additionally, Dawes is recognized as a Fellow of the NSCA since 2009. He is currently the Secretary-Treasurer for the NSCA Board of Directors and is the NSCA Board Liaison for the TSAC Program.

ABOUT THE AUTHORS

Sarah Mros is a master's student at the University of Colorado at Colorado Springs. She is working towards a degree in strength and conditioning and athletic training. She received her Bachelor's degree in Health and Fitness Promotion from the State University of New York in Canton, New York. She is certified with the American College of Sports Medicine (ACSM) as a Personal Trainer, the National Strength and Conditioning Association (NSCA) as a Certified Strength and Conditioning Specialist® (CSCS®), and United States of America Weightlifting (USAW) as a Level 1 Coach.



HYPERVOLT

Featuring Quiet Glide™ Technology



The Hypervolt is a cordless state-of-the-art vibration massage device that relaxes sore stiff muscles, increases circulation and range of motion, and improves the overall health of the body's soft tissue.

Benefits

- Helps relieve muscle stiffness and soreness
- Increases range of motion
- Promotes circulation
- Lightweight, easy-to-use for self-myofascial release

Included Applicators



Innovation by
HYPERICE

TSAC – REDUCING THE RISK OF INJURY – ELEMENTS OF INJURY CAUSATION

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

BASIC PRINCIPLES FOR REDUCING RISKS OF INJURY IN TACTICAL PERSONNEL

It is valuable to revisit basic principles when considering how to reduce risks of injury in tactical populations. The contexts in which tactical personnel operate can often differ substantially from the relatively controlled occupational settings in which personnel in many other jobs work, demanding creative thinking regarding how to reduce risks of injury. Going back to basic principles provides building blocks and structure for that sort of thinking when working with personnel who operate and sometimes must train in harsh and unpredictable environments, where hazards may not be readily eliminated or avoided.

An initial consideration is how and why injuries occur – the causes of injury. Put simply and consistent with the writings of various experts in the field (5), an “injury” is damage to the body which occurs because the amount of energy applied to the body exceeds the body’s capacity to cope with it, or resist it. For example, a bone breaks because it hits hard ground at speed with bodyweight behind it, so that the mechanical energy applied to the bone exceeds its capacity to withstand it. Three elements of injury causation are widely discussed in the safety and injury risk management literature using varying nomenclature and are present in every instance in which an injury occurs – these are “hazards,” “errors” and “other contributing factors” (3,5). Each of these elements will be discussed here individually. Efforts to control one or more of these elements have the potential to reduce risks of injury (likelihoods and severity or consequences) to personnel (sometimes known as “hosts”) (4). All elements should be considered where possible. It should also be noted that more than one of each of these elements may contribute to an injury. Injury causation is complex and multifactorial and rarely reflects a simple sequence of events which happen one after the other (5). Rather, many factors (including hazards, errors, and other factors) may contribute, with some of these factors existing well before the injury occurs, some occurring around the time of injury, and their influences often being non-sequential, interactive, and simultaneous.

Consistent with the overview provided by Pryor (3), “hazards” are potential sources of damage to the body (i.e., injuries), because of their ability to apply energy to the body in some circumstances. Within this definition of hazards, the words “potential” and “in some circumstances” should be noted. Importantly, unless the potential of hazards is activated through some sort of error (or

failure) in their management or control, or when navigating them (errors including but not limited to neglect or lack of detection of the hazard), hazards will not cause harm. Examples of hazards in the tactical population include ground surfaces or equipment that can exert damaging forces on the body, fires that can apply burning heat to the body, and weapons. When thinking about reducing injury risks, it is worth noting that a hazard which might damage one person might not damage another who is better prepared or able to resist or avoid it (e.g., through physical conditioning, use of protective equipment, or anticipation or detection and then taking defensive or evasive action). Hazards are also known as “agents” that cause injury (3,4).

“Errors” are missing or inappropriate responses by systems or people (3,5). They can be intentional or non-intentional and are sometimes also called “failures of controls,” “holes in defences,” or similar (3,5). An error that leads to injury might be made by the injured person (e.g., they stepped in a hole), by another person (e.g., the tactical facilitator did not notice the hole and fill it before the training session or forgot to warn participants of it), or by a “system” (e.g., the tactical facilitator sent an email to the relevant grounds maintenance team, asking them to fill the hole, but the email was redirected by the computer system into a junk email folder so that the alert never arrived and the hole was never filled; or a warning light did not come on when it was supposed to at a railway crossing; or a machine did not stop as it was supposed to when someone’s hand got stuck in it). If errors do not occur, then hazards will not be enabled to cause injuries. For example, if a hole in the ground was filled prior to personnel using the area, or if personnel identified or were made aware of the hole and stepped over it or avoided it, no one would step into it and have impact, twisting, or tripping forces applied to their foot and body by the hole, perhaps causing injury.

“Other contributing factors” are factors other than hazards or errors which make errors more likely or make hazards more potent or more difficult to resist, and again are widely discussed in the safety and injury risk management literature (3,5). For example, stress, fatigue, or operational tempo might reduce attentional capacity and reaction times and make human error more likely. Peer pressure might make inappropriate risk-taking more likely. Poor visibility or operating at greater speed might reduce the amount of time someone has to avoid a hole in the ground, meaning that they step into it at high speed and damaging force is therefore applied to the ankle. Lower levels of physical conditioning might mean that someone is less able to resist the damaging forces applied by a load to their back as they participate in a team lift activity. Lack of protective knee and elbow pads might reduce the body surface area over which

TSAC – REDUCING THE RISK OF INJURY – ELEMENTS OF INJURY CAUSATION

TABLE 1. EXAMPLE OF MODIFIED HADDON'S MATRIX USED TO DOCUMENT FACTORS CONTRIBUTING TO INJURY CAUSATION IN A TACTICAL TRAINING CONTEXT

	System Responses and Errors	Injured Person	Other Person(s)	Hazard(s) and Their Carriers
	Responses and missing or inappropriate responses in a technological, activity, or activity support "system" which make hazards less or more likely to exist or damage a body.	Characteristics or equipment which make them resistant or prone to injury, behavior (including errors – missing or inappropriate responses), skill level, experience, preparation level, etc.	Characteristics or equipment which make them hazardous, behaviour (including errors – missing or inappropriate responses), skill level, experience, preparation level, etc.	Potential sources of damage to the body and the means by which they are brought to, or formed in, the context.
Before Injury or Exposure to Risk Occurs (Primary Proactive)	Requests for grading and rolling of training areas to reduce rocks are not addressed in timely fashion by contractors – seems to be a funding issue.	Trainees injured – low skill level, poor control of going to ground, land little experience with rocky ground. Poorly prepared for this also – could do with more teaching on strategies and skills to deal with the hazards.	Only one instructor to ~30 trainees – hard to control trainee technique. Poor venue selection and preparation. Inexperienced with trainees – expect too much too soon.	Training area run down – very rocky and poorly maintained – possibly not the best venue available. Erosion increases rock prevalence. Loads carried too heavy – need to consider skill level and conditioning.
Before Injury Occurs, but After Exposure to Risk has Occurred (Primary Reactive)	Fault correction often delayed due to a low instructor to trainee ratio.	Lack of knee/ elbow pads. Pack loads worn during much of fire and movement make impacts with rocks heavier, more damaging. Trainees do not prop and drop properly to slow descent – heavier impact results.	Often injury occurs as trainee being pushed beyond capacity to perform by instructor or peers. Instructors not heeding signs of fatigue.	Rocks on training area. Pack loads place strain on back as land when going to ground. Slippery if raining, increasing impact forces when going to ground.
After Injury has Occurred (Secondary/Tertiary)	First aid provision are often delayed due to a low instructor to trainee ratio, such that the instructors cannot afford the time. Medical is manned well below establishment, so injured personnel often wait some time before initial medical care and rehab can be provided.	Tend to avoid reporting injuries and usually try to persist with activity, thereby aggravating injury – worried about back squadding or discharge.	Instructors inexperienced with trainees and tend to push them even when injured, increasing injury severity.	Rocky ground makes medical vehicle access difficult and hard to find comfortable area to rest injured persons and apply first aid.

TABLE 1. EXAMPLE OF MODIFIED HADDON’S MATRIX USED TO DOCUMENT FACTORS CONTRIBUTING TO INJURY CAUSATION IN A TACTICAL TRAINING CONTEXT (CONTINUED)

ENVIRONMENT/ CONTEXT		
Physical Environment/Context	Social Environment/Context	Operating Context
Visibility, temperature, ground surface characteristics, sea state, equipment condition, and inbuilt protection, etc.	Stress, peer influence, regulations, team membership effects, quality, and quantity of supervision, finances, sense of urgency, sleep deprivation, etc.	Work:rest ratios and phasing, fatigue, recovery status, sleep deprivation, time-of-day, sequence of skill development, speed and load, etc.
Planning inadequate – no modification of activity to compensate for poor visibility conditions or slippery surface, if present.	Only one instructor to ~30 trainees – hard to control technique of going to ground. Instructors often tired due to low manning levels and so less attentive. Trainees under stress, increasing likelihood of injury.	Simulation activity usually follows other strenuous field activity, so trainees are often pre-fatigued.
Activity most injurious when conducted at night – dark, cannot see rocks, and if raining, ground is slippery – more likely to land hard when going to ground or tripping/slipping.	Fault correction delayed because of low instructor to student ratio. Sense of urgency is promoted during lessons, increasing speed and forces and hence injury risk.	Trainees often pre-fatigued. Night timing of some activities increases risk. Loads and speed increase impact forces.
Difficult to assess injuries properly at night in the dark.	First aid often delayed because of low instructor to student ratio. Fear of back squadding, so trainees tend not to report injuries or persist with treatment. Peers and instructors reinforce this ethos. Medical reinforces this by giving long periods on limited duties.	Remote location delays access to full medical care.

pressure from rocky ground is spread during a crawling activity, increasing the potency of the rocks to cause skin damage and bruising. Inadequate quality-assurance processes during procurement of personal protective equipment might lead to equipment failure that exposes personnel to hazards. Inadequate systems maintenance may mean alarms and safety controls do not work when required.

Factors that comprise the three elements of injury causation for particular injury types occurring in a specific injury context can be documented in a modified Haddon’s matrix (Table 1), once they are identified (4).

This matrix considers such factors in terms of where they contribute in the pre-injury, injury event, and post-injury phases — the latter to influence the severity or consequences of injury. These factors, comprising hazards, errors and other contributing factors, can be identified in a number of different ways, guided by the structure provided by the modified Haddon’s matrix. These ways may include brainstorming with subject matter experts —

often experienced tactical operators or strength and conditioning facilitators accustomed to operating in the respective contexts. Safety and healthcare professionals may also contribute usefully, and both injury records of the organization and previously published reports about the types of injuries and contexts of interest might also be valuable. Direct observation of the activities and venues in which the injuries tend to occur might also be of benefit (1,2).

In order to identify some of the less obvious factors contributing to injury causation, it is also good practice to conduct “root cause analysis,” using a “systems” approach. In its simplest form, this means asking “why,” repeatedly, and looking further afield in the organization and systems within which the injuries are occurring than just the immediate proximity of the injuries. For example: “why does a particular hazard exist?,” “why are personnel fatigued?,” “why were personnel operating under conditions of poor visibility?,” “why did a system fail?,” and “why did a person make an error?” Often, asking these questions will highlight additional factors, sometimes further removed from the

TSAC – REDUCING THE RISK OF INJURY – ELEMENTS OF INJURY CAUSATION

TABLE 2. EXAMPLE OF MODIFIED HADDON'S MATRIX USED TO DOCUMENT POTENTIAL COUNTERMEASURES FOR FACTORS CONTRIBUTING TO INJURY CAUSATION IN A TACTICAL TRAINING CONTEXT

	System Responses and Errors	Injured Person	Other Person(s)	Hazard(s) and Their Carriers
	Responses and missing or inappropriate responses in a technological, activity, or activity support “system” which make hazards less or more likely to exist or damage a body.	Characteristics or equipment which make them resistant or prone to injury, behaviour (including errors – missing or inappropriate responses), skill level, experience, preparation level, etc.	Characteristics or equipment which make them hazardous, behaviour (including errors – missing or inappropriate responses), skill level, experience, preparation level, etc.	Potential sources of damage to the body and the means by which they are brought to, or formed in, the context.
Before Injury or Exposure to Risk Occurs (Primary Proactive)	Discuss grading, rolling, and sand provision for training areas with contractors – decide on a manageable, regular maintenance program/ requirement.	Prior to simulation, spend more time learning and practicing correct going-to-ground technique and building strength for this. Include modifications to accommodate rocky ground and carriage of load, if unavoidable.	Conduct training for instructors on skill development stages, practice, etc., slowing lessons to enable fault correction, training area selection and preparation. Develop criteria for training areas to be used.	Specify in standard operating procedures (SOPs) training areas to be used and preparation to be conducted. Arrange upgrade of designated areas – clear rocks, lay sand, build levy banks, grade and roll drop loads before going to ground.
Before Injury Occurs, but After Exposure to Risk has Occurred (Primary Reactive)	Use injury stats and specific case scenarios (of problems) to support a bid to increase staff numbers. Spend more time developing going-to-ground skills before simulation activities to reduce need for technique correction.	Provide trainees knee/ elbow pads and instruct on use. Drop loads before going-to-ground commences, or minimize load. Provide trainees with more practice on going to ground safely before simulation activity.	Conduct training for instructors on observing, recognizing and responding to signs of fatigue or injury in trainees and on skill development stages and safe progression.	See cell above.
After Injury has Occurred (Secondary/Tertiary)	Use injury stats and specific case scenarios (of delays) to support a bid to increase medical staffing, employing civilians if necessary.	Review medical care and limited duty allocations’ duration and ensure best sport medical practice. Brief trainees and instructors on consequences (injury severity) of not reporting early and benefits of early reporting.	See cell above.	Review vehicle access to designated training areas – grade/clear to provide ready access and clear a site and lay sand/cement/wooden platform in one part of each training area for patient care (near vehicle access).

TABLE 2. EXAMPLE OF MODIFIED HADDON'S MATRIX USED TO DOCUMENT POTENTIAL COUNTERMEASURES FOR FACTORS CONTRIBUTING TO INJURY CAUSATION IN A TACTICAL TRAINING CONTEXT (CONTINUED)

ENVIRONMENT/ CONTEXT		
Physical Environment/Context	Social Environment/Context	Operating Context
Visibility, temperature, ground surface characteristics, sea state, equipment condition, and inbuilt protection, etc.	Stress, peer influence, regulations, SOPs, team membership effects, quality and quantity of supervision, finances, sense of urgency, sleep deprivation, etc.	Work:rest ratios and phasing, fatigue, recovery status, sleep deprivation, time of day, sequence of skill development, speed, and load, etc.
SOPs: specify activity modifications to occur if poor visibility/slippery ground conditions to reduce injury risk (e.g., slow speed, use night vision goggles, smaller steps/movements, etc.).	Bid for more staff justified by injury stats. More practice of going to ground prior to simulation activity so instructor fatigue and trainee stress less of an issue (skill automated). Psychologists to review trainees support.	Review training program and ensure high workload activities do not precede simulation, and that adequate recovery time is provided prior to each such session.
SOPs: specify times of day at which activity to be conducted – only at night if essential to training outcomes and if at night, avoid rocky sites. Lay sand on training areas to reduce slippage and impact.	Bid for more staff. Practice going to ground more. Only intro sense of urgency as skill level increases. Seek medical support on-site to conduct first aid for high-risk activities (e.g., night).	See cell above. SOPs: minimize night activities and avoid rocky ground at night. Avoid speed until skill level high. Drop packs before going to ground or minimize load.
Minimize night activities. Battery or solar power operated floodlight to be taken to/provided at training site patient care area for every night training session unless precluded by training objectives.	Review medical care and limited duties duration and ensure best sport med practice. Brief trainees and instructors on consequences (injury severity) of not reporting early and benefits of early reporting.	Use less remote training areas if possible. Seek medical support on-site for high-risk activities (e.g., night) so immediately available, with vehicle.

immediate injury context, which have contributed in important and preventable ways to the injuries occurring. It might also suggest some actions that could be taken to reduce injury risks (likelihoods and severity or consequences).

Once factors contributing to injuries are identified and documented, ways to address these factors in order to reduce injury risks can be considered. A modified Haddon's matrix or Haddon's list of ten countermeasure strategies can again be used to brainstorm, document and structure these ideas regarding ways to reduce injury risks (4). If using the matrix, it will be evident from the matrix which elements of injury causation have been well addressed (associated matrix cells will be full of ideas) and which require further consideration (associated matrix cells will be relatively empty). Table 2 provides an example of using Haddon's matrix in a tactical training context and Runyan provides an example of using Haddon's list of ten countermeasure strategies in a children's playground context (4). Once the ideas are

documented, an action plan can be drawn up and responsibilities assigned for specific listed actions that can be reasonably and practically implemented and could be expected to lead to an adequate reduction in injury risk to justify cost and effort.

Expectations of success in injury risk reduction from taking any particular action can be gauged from advice of experienced personnel, from review of reports of the effects of such interventions, or from consideration of the mechanisms by which such interventions might act to reduce injury risks (see, for example, Haddon's list of ten preventive strategies) (4). Further monitoring should then occur as steps are taken to reduce injury risks, in order to ensure the actions taken do in fact reduce injury risks and do not inadvertently cause harm. A good example of such harm arising from well-intended and well-informed efforts to reduce injury risks can be found in the anterior cruciate ligament (ACL) injuries that occurred after rubber matting was laid on a military obstacle course in an effort to reduce impact forces

and risk of slipping after personnel landed from jumps while also ensuring the ground surface was even — in order to limit the risk of personnel developing stress fractures or rolling their ankles and so spraining ligaments (1,2). Those reports (1,2) also provide a good example of how the processes described above can be employed to effectively identify and counter causes of specific injury types in a tactical forces training context, and Runyan (4) provides a further worked example of identifying factors that contribute to injury causation, as well as potential countermeasures, in the context of a children's playground.

In summary, it must be acknowledged that, in the contexts in which tactical personnel must frequently operate and train, elimination, complete avoidance, full control, and fail-proof protection from hazards are often not realistic or viable options. However, by considering all elements of injury causation, as discussed in this article, it often remains feasible to identify viable ways to intervene effectively in order to reduce injury risks.

REFERENCES

1. Pope, R. Case report: Injury surveillance and systematic investigation identify a rubber matting hazard for ACL rupture on an obstacle course. *Military Medicine* 167(4): 359-362, 2002.
2. Pope, R. Rubber matting on an obstacle course causes ACL ruptures and its removal eliminates them. *Military Medicine* 167(4): 355-358, 2002.
3. Pryor, P. Hazard as a concept. In: HaSPA (Health and Safety Professionals Alliance). *The Core Body of Knowledge for Generalist OHS Professionals*. Tullamarine, VIC. Safety Institute of Australia, 2012.
4. Runyan, C. Introduction: Back to the future—Revisiting Haddon's conceptualization of injury epidemiology and prevention. *Epidemiologic Reviews* 25(1): 60-64, 2003.
5. Toft, Y, Dell, G, Klockner, K and Hutton, A. Models of causation: Safety. In: HaSPA (Health and Safety Professionals Alliance). *The Core Body of Knowledge for Generalist OHS Professionals*. Tullamarine, VIC. Safety Institute of Australia, 2012.

ABOUT THE AUTHOR

Rod Pope is currently a Professor of Physiotherapy at Charles Sturt University and co-leads the Tactical Research Unit, headquartered at Bond University in Australia. Pope provided clinical physiotherapy, rehabilitation, and injury prevention services at the Australian Army Recruit Training Centre before establishing and leading the Australian Defence Injury Prevention Program, at the request of the Defence Health Service Branch. In this role, he worked closely with senior military physical training instructors to optimize physical training practices. As part of this work and more recently in his university roles, Pope has conducted and supervised wide-ranging research and consultancy projects on preventing injuries and enhancing performance during physical activity in tactical training and operational contexts. Very much a practitioner researcher, Pope's research invariably stems from questions about practice in the field and aims to usefully inform this practice.

TRACKING TRAINING LOAD AND ITS EFFECT ON INJURY RISK AND FITNESS

Fitness is a vital component for tactical personnel, and tactical facilitators play a pivotal role in developing this component to enhance occupational performance. However, when compared to working with professional athletes, tactical facilitators in tactical environments can have additional challenges to work around, such as scheduling due to the unpredictable nature of the job, as well as poor prior training history especially in recruits. These challenges then can lead to uncertainty for tactical facilitators deciding when to implement higher-intensity training days, or when to effectively progress personnel with no training histories. While developing fitness is a necessary component, improper application of training doses, either during a single session or over time, can lead to higher injury rates and diminishing returns in fitness. Recent research in elite sport has found that by monitoring training load, injuries may be able to be minimized while ensuring fitness is still developed (4).

Tracking training load originally started as a method to reduce preventable injuries associated with overtraining. As further research has found that higher workloads did not necessarily lead to higher increases in fitness, this concept developed into creating a workload management method that aims to concurrently increase fitness while minimizing injury risk (4). For example, a study of Australian Football League players found that those who completed a high training load significantly increased their 2-km time trial compared to those completing a very high, moderate, or low training load (6). Similarly, it has been shown that high three-week running distances (73.721 – 86.662 km) are likely to increase injury risk (2). These studies provide evidence that tracking training load can be used to predict injury risk and possible fitness changes. The aim of this article is to provide those working with tactical populations an introduction into tracking training load to mitigate injury risk while concurrently optimizing fitness.

TRACKING TRAINING LOAD

The International Olympic Committee consensus statement defines training load as a cumulative amount of stress on an individual from single, or multiple, training sessions over time (7). These stresses can be measured both externally, such as distance run, or internally, such as heart rate. Utilizing both measures allows practitioners to measure the work completed via external loads, as well as how the individual is adapting both physiologically and psychologically via internal loads (7). Measuring both external and internal loads is necessary, because when using only external load, individual response is not measured and the individual may not be adapting to the external load (4). These values can then be measured as cumulative loads over a set time (such as a weekly or bi-weekly total loads), weekly changes in load, or

using more advanced methods such as acute:chronic workload ratios (ACWR) (4).

EXTERNAL TRAINING LOAD

Measuring external training load is an attempt to define the total work completed. Global Positioning Systems (GPS) units have commonly been used in sport given the variety of information they provide, such as distance at various speeds, acceleration, and other variables (1). However, tactical populations, specifically military, may have security concerns regarding the use of these devices. Therefore, other simpler ways to track external training load could include total distance run, number of sprints, or total weight lifted. Given that load carriage is a vital component for tactical personnel, this activity may also potentially be a useful measure of training load, though to date, research has not been performed to validate this method. These methods may be easier for practitioners to implement in larger units and may be more applicable to tactical personnel. More information regarding external load tracking can be found in papers by Gabbett et al. and Bourdon et al. (1,4).

INTERNAL TRAINING LOAD

Internal training load is a measure of how an individual is physiologically or psychologically responding to their workload. Tracking internal training has been performed previously by utilizing heart rate (physiological), however this can require tactical personnel to either wear fitness watches or heart rate monitors, as well as computer software to collect and maintain all the data. An alternative could be to monitor the individual's rating of perceived exertion (RPE) (psychological). This requires utilizing a modified RPE scale that subjectively measures an individual's perceived intensity of a training session. This score is then multiplied by the session duration to calculate sRPE. For example, if an individual completes a 60-min session at an intensity of six, the sRPE will be 360 (60 x 6) arbitrary units, or AU. While sRPE is defined as a psychological measure, it previously been reported as having a high correlation to heart rate ($r=0.89$) and blood lactate concentration ($r=0.86$), both of which are physiological measures (1,5).

APPLICATION

There are numerous ways to track training load and methods can vary depending on population, activities performed, access to resources and practitioner experience. Because little to no research has been performed in tactical populations, there are no benchmarks for which to aim, or gold standard methods to implement. Tactical facilitators should use their experience and knowledge for choosing appropriate variables to track. Although there is a lack of research in tactical populations, elite sport has

reported values that may be attributable, such as the total three-week running distance mentioned earlier (2). Internal training loads >1,245 AU over a week, as measured by sRPE and >8651 AU over four weeks were associated with higher risk of injury in rugby union players (3). Utilizing total distance and sRPE may be initial strategies for tactical facilitators to introduce for monitoring training loads. Tactical facilitators can track these variables and create specific baselines as they gather and analyze more information. As more research is performed in this area, guidelines can be introduced to help direct practitioners who can then further adjust these recommendations to fit their program and desired outcomes.

CONCLUSION

Tracking training load has been utilized to mitigate injury risk and maintain fitness in elite sports. Given the impacts injury and fitness can have on tactical personnel, it is vital to implement strategies that work to accomplish these goals. However, the results from elite sports will likely not be directly transferrable as considerable differences exist between the sporting and tactical populations. It is also important to note that tactical personnel are likely to undergo significant loads, both external and internal, as a function of their occupational tasks. While tracking loading during physical training sessions may be an effective means to reduce injury risk, including day-to-day tasks may increase the reliability of this method. The framework outlined in the research reviewed above may be applicable in the tactical environment, however research is needed to establish the reliability and validity of methods for tracking training load in tactical populations.

REFERENCES

1. Bourdon, PC, Cardinale, M, Murray, A, Gastin, P, Kellmann, M, Varley, MC, et al. Monitoring athlete training loads: consensus statement. *International Journal of Sports Physiology and Performance* 12(2): 161-170, 2017.
2. Colby, MJ, Dawson, B, Heasman, J, Rogalski, B, and Gabbett, TJ. Accelerometer and GPS-derived running loads and injury risk in elite Australian footballers. *Journal of Strength and Conditioning Research* 28(8): 2244-2252, 2014.
3. Cross, MJ, Williams, S, Trewartha, G, Kemp, SP, and Stokes, KA. The influence of in-season training loads on injury risk in professional rugby union. *International Journal of Sports Physiology and Performance* 11(3): 350-355, 2016.
4. Gabbett, TJ. The training-injury prevention paradox: Should athletes be training smarter and harder? *British Journal of Sports Medicine* 50(5): 273-280, 2016.
5. Gabbett, TJ, and Domrow, N. Relationships between training load, injury, and fitness in sub-elite collision sport athletes. *Journal of Sports Sciences* 25(13): 1507-1519, 2007.
6. Harrison, PW, and Johnston, RD. Relationship between training load, fitness, and injury over an Australian rules football preseason. *Journal of Strength and Conditioning Research* 31(10): 2686-2693, 2017.

7. Soligard, T, Schwellnus, M, Alonso, J-M, Bahr, R, Clarsen, B, Dijkstra, HP, et al. How much is too much? (Part 1) International Olympic Committee consensus statement on load in sport and risk of injury. *British Journal of Sports Medicine* 50(17): 1030-1041, 2016.

ABOUT THE AUTHORS

Daniel Maupin has a background in athletic training and physical therapy. During his Doctor of Physiotherapy Degree at Bond University, he was introduced to working with tactical populations and completed his research project in this area. Tactical populations sparked his interest due to their similarities in sports, both being very physically demanding and requiring high levels of fitness, while tactical populations having a more varied skillset and unpredictable occupation. This led him to pursue a PhD studying training load and its effects on fitness and injury risks in tactical populations.

Ben Schram is the research and data coordinator for the Tactical Research Unit at Bond University. His research interest is focused on maximizing the health and wellbeing of tactical personnel. His previous military training with the Australian Army has allowed him unique insight into the complex demands of tactical personnel, facilitating a greater understanding of the current body of tactical research. His research focus has been in injury epidemiology, injury minimization strategies, validating fitness standards, deconstructing the physical and physiological demands of tactical occupations, and creating strategies to maximize performance of occupational tasks.

SOLDIER MUSCULOSKELETAL INJURIES, RISK FACTORS, AND RECOMMENDATIONS

Soldiers must be physically prepared to meet a broad range of challenges. Mission accomplishment and the soldier's own life, depend on their ability to march over rugged country under fighting load, drive fast moving vehicles over rough terrain, assault, run and crawl long distances, jump in and out of craters and trenches, jump over obstacles, lift and carry heavy objects, and go long periods without rest. These movements occur in all planes and at a broad range of intensities, and according to Field Manual 7-22 Army Physical Readiness Training, these warfighting activities require "superb physical conditioning," (39).

Soldiers must be trained and physically ready to execute the aforementioned activities, which are requisite tasks for the warfighter. The Army's physical fitness program, Physical Readiness Training (PRT), incorporates training activities that directly support its wartime missions (39). Commanders develop their unit's PRT programs with activities that have a nexus to the unit's essential tasks.

The purpose of PRT is to improve physical fitness, progressively train soldiers, develop soldier self-confidence and discipline, and prevent injury (20,39). In mid-2018, 22.9% of non-deployable soldiers were unable to perform their duties due to a limited-duty profile lasting more than 14 days (3). Limited-duty profiles are highly associated with musculoskeletal injuries (MSK-I) and are a result of, or exasperated by, PRT (6,22). The incidence of MSK-I is well-documented in the Army, but MSK-I continues to be a concern (8). Research has postulated that a majority of MSK-I are preventable suggesting the cycle of injury can be broken (1,32). Understanding common soldier injuries and associated risk factors may help in doing so.

Common injuries among soldiers include sprains, strains, and stress fractures. With regards to location, injuries are common to the lower extremities and the lumbo-pelvic hip complex (7,14). This is indicative of the stresses imposed on soldiers by the movements and activities listed above.

Factors that exhibit a strong association with musculoskeletal injuries among military populations include, but are not limited to: age (2,28), anthropometrics (8,35), fitness (muscular and cardiorespiratory) (11,23,31), gender (17,21) inadequate or excessive physical activity (15,18,19,42), prior injury (18,19,30,42) and smoking (4,15,18). Understanding injury risk factors can provide perspective for leaders that evaluate their soldiers' injury risk. For example, poor fitness is a well-cited risk factor that may result in greater perceived stress, fatigue, and altered biomechanics during PRT (15,23). Thus, a soldier with poor fitness may be at a greater risk of injury with efforts to improve physical fitness

levels, when those efforts are accompanied with inadequate rest, PRT programming, or coaching. Additionally, a soldier recovering from injury that is placed on a rehabilitative PRT program may experience a decline in physical activity. Both soldiers become susceptible to greater risk through compounding risk factors (e.g., poor fitness, inadequate/excessive physical activity, and prior injury).

Rank and age are risk factors that should be considered together. Lower ranking soldiers are at increased risk for injury (24,42). There is certainly an interplay between rank and age, as younger soldiers generally have less time in service and lower rank. Lower ranking soldiers also exhibit less control over the type, quantity, and frequency of PRT and typically execute the most physically demanding tasks, while senior non-commissioned officers (NCO) and officers assume supervisory roles. Conversely, older age is a risk factor as well, which may be a cumulative result of greater exposure (i.e., time in service), general reductions in physical activity, and the natural loss of muscle-mass associated with aging (9,16).

Smoking is perhaps the most binary risk factor (i.e., soldiers either smoke or they do not). Although binary, smoking is arguably the most difficult risk factor to modify due to its psychosocial implications and tobacco's addictive properties. Smoking's long-term negative health effects are well known and affect more than just longevity. Smoking reduces bone density and the body's ability to heal after injury, partly due to hypoxia and impaired blood flow (2,5). PRT is a process of repeated damage (microtrauma) to tissues, that over time and with proper recovery, increase the tissue damage threshold and result in specific adaptations. Soldiers who smoke will recover from PRT and injuries at a slower rate when compared to non-smokers, and may experience a reduced healing capability lasting weeks to years, even after smoking ceases (35).

Anthropometrics are measurements that can be used to assess injury risk. For example, high body mass index (BMI) ($>25 \text{ kg/m}^2$) could be considered a risk factor due to a greater amount of weight (i.e., more weight per unit of height) leading to greater physiological strain and impact forces while training (27). Conversely, extremely low BMI ($<19 \text{ kg/m}^2$) could also put soldiers at increased risk; potentially due to less available muscle mass to assist in force production and shock attenuation during high-impact physical activity (27). Body fat percentage may also serve as marker of injury risk. Cowan et al. found that recruits not meeting the Army's body fat regulations were found to be at an elevated risk for injury during initial training when compared to their weight-qualified peers, both of whom passed a qualifying

fitness assessment (8). Additionally, abdominal circumference is a practical measurement to couple with BMI and body fat percentage. This measure was found to be superior to BMI in estimating injury risk among United States Air Force trainees (26). Using multiple anthropometric measures may provide a more valid assessment of MSK-I risk than using one alone.

For each risk factor there are potential protective factors. For example, a BMI $<18 \text{ kg/m}^2$, or $>25 \text{ kg/m}^2$ can put a soldier at greater risk for injury (27). Therefore, a BMI of $19 - 24 \text{ kg/m}^2$ is considered a protective factor. There are also protective factors that exist outside of soldiers' control, such as: unit injury surveillance (15,32,33), leadership knowledge and involvement (6,41), training-load monitoring (12,13), adequate sleep and nutrition (40), and potentially movement screening, including pre-injury and return to duty (RTD) screening (10,29,36). Risk and protective factors can be considered as training moderators. When considered as moderators, risk and protective factors are third variables that moderate the relationship between PRT and physical readiness. Physical readiness can be viewed as a spectrum, with injury (the lack of readiness) at one end and performance (high readiness) at the other. Figure 1 shows the relationship between training and physical readiness, moderated by various protective and risk factors. If risk factors outweigh protective factors, the soldier may steer towards injury. Oppositely, if protective factors outweigh the risk factors, a soldier's performance may increase. A balance of risk and protective factors would lead to a marginal or insufficient level of physical readiness. Understanding training moderators can assist unit injury prevention efforts.

Age, fitness, physical activity, rank, smoking, and anthropometrics are just a few potential MSK-I risk factors for soldiers. Some risk factors are intrinsic and out of a soldier's control (e.g., age and gender), others are extrinsic and actionable by the soldier (e.g., smoking.) Regardless, both have a negative effect on the relationship between physical training and readiness.

Risk from PRT should consist of residual and secondary risk (i.e., the risk remaining and the resultant risks of control measure implementation). To minimize injury incidence, commanders and leaders can implement measures to reduce intrinsic risk factors, while maximizing protective factors and best controlling for external risk — these efforts will weight protective factors and create a training moderator imbalance that promotes performance over injury. The following are recommendations at the company, supervisory, and soldier levels.

COMPANY LEVEL

Affecting injury requires command emphasis, so the command must make injury prevention and reduction a priority. With a significant number of soldiers non-deployable due to limited-duty profiles, injury poses a substantial threat to readiness (3). A few options available to commanders are: to seek expertise, conduct injury surveillance and task and demand analyses, educate

soldiers on common injuries and risk factors, and implement movement screening.

The statistics adage “you can't manage what you don't measure” is a poignant reminder that commanders must play an active role in injury mitigation within their formations. Although, the command is not alone in this endeavor. Commanders should seek available expertise to assist in their injury prevention and reduction efforts. The brigade physical therapist and physician assistant are good resources and can assist in implementing injury surveillance programs. The injury surveillance program may help define the unit's unique risk and allow for comparison at future time points. At a minimum, the system could document the number of limited-duty profiles divided by the number of soldiers in the unit at the specified time period. Additional information to track is injury severity, mechanism of injury, and total duty days lost (38). After injury data is collected and analyzed, commanders can implement focused intervention efforts and educate soldiers on current injury trends. Furthermore, commanders can utilize available strength and conditioning professionals at military fitness centers and health facilities. These professionals can assist in PRT programming, movement instruction and training, movement screening, and gait analysis. Commanders can utilize the skills of these professionals to assist in implementing a unit movement screening program to identify dysfunction and asymmetries in soldiers that can translate into injury during PRT. Also, injured soldiers cleared for normal duty can be screened in efforts to reduce the likelihood of reinjury.

Commanders can also conduct unit task and demand analyses to determine the critical movement patterns required for successful mission accomplishment. Identifying and training for those movements can translate to lower injury risk during tactical operations and routine duty. This is important because movement profiles and fitness levels will vary significantly across different military occupations and units (e.g., a light infantryman versus a heavy-wheeled mechanic) (32,37). By doing so, commanders are taking active injury prevention efforts that guide unit PRT and balance the physical rigors of military operations and the physical readiness and health of the soldier. The task and demand analysis may also help in providing limits for PRT, such as weekly marching mileage. For example, a unit with a mission set that requires marching long distances under load will prioritize loaded marching (i.e., the task) in the PRT program. The unit can then train to meet the unique and specific demands of this task. As the unit's injury incidence and/or performance changes over time (determined through surveillance, load monitoring, and testing), the unit can adjust weekly marching mileage and load, until the desired performance level is reached. In reality, the training environment is much more complex as units have multiple tasks that comprise the mission set, so the challenge lies in task prioritization, measurement, and the appropriate adjustments to safely meet the demands.

Finally, the command should educate subordinate leaders and soldiers. The command can inform soldiers of trends and injury incidence based on the unit's aggregated injury data. Also, if available, the unit's health professionals (e.g., brigade physical therapist and physician assistant) may provide briefings to soldiers on injury risk factors and common injuries and their mechanisms. Requiring subordinate leaders to include injury risk reassessment during performance counseling may ensure injury prevention efforts stay relevant. Also, setting collective company goals (e.g., <5% of soldiers on a limited-duty profile) can create a nexus between the organization and the individual soldier and serve as a metric of unit success.

SUPERVISORY LEVEL

Like the commander, supervisors (e.g., platoon leaders/sergeants and squad/team leaders) must understand risk factors and common injuries, leverage available expertise, and educate and counsel their soldiers. Although, it is at this level that PRT programs are effectively implemented and monitored. Supervisors can: monitor training load, identify individual soldier risk, and support command initiatives (e.g., movement screening and surveillance).

PRT is typically planned and conducted at the platoon level and led by the platoon's NCOs; it is here that training-load can be monitored. Management requires measurement. There is strong evidence that a relationship exists between training load and injury (12). Common MSK-Is can result from inappropriate PRT programming and the subsequent overloading of tissues. Injury surveillance and the task and demand analysis will help to frame the PRT program, while training load monitoring will assist in measuring it. Monitoring training load can produce a useful, quantitative variable that provides insight when compared with other measurements, such as fitness test scores and injury incidence rates. Over time, training load monitoring will create data points that can be compared with the aforementioned variables and produce reference points. These reference points can be used to paint a picture of the PRT program's effectiveness at any given time point. Training load is computed as a product of session frequency, duration, repetitions, distance, and intensity, but may also include other subjective and objective internal and external measures (e.g., heart rate and perceived effort) (12,34). Supervisors may benefit from consulting with strength and conditioning professionals when deciding how to manage training load. Load monitoring is common practice in professional and collegiate sports organizations and it should be no different for soldiers.

Supervisors can target injury risk as soon as soldiers arrive to the unit. By understanding modifiable risk factors, supervisors can screen incoming soldiers and develop effective intervention points. For example, tobacco cessation, optimal anthropometrics, and fitness level can be discussed during initial counseling and any deficiencies can be noted along with an initial plan to reduce

risk. With the support of health professionals, supervisors can screen soldiers for movement dysfunction and asymmetries prior to participating in the unit's PRT program. They can also use routine performance counseling to reassess injury risk or review current recovery efforts for injured soldiers. Similar to collective company goals, platoons can establish performance-focused goals to promote physical readiness and injury prevention. The emphasis on injury prevention and reduction by the command and supervisors can foster a climate of high physical readiness that becomes apparent at the soldier level.

SOLDIER

The individual soldier serves as the first line of defense against injury. Commanders and supervisors play a significant role in injury prevention, but all is for naught unless the individual soldier takes action to lower their individual MSK-I risk. Lower ranking soldiers exert the least amount of control over the type, frequency, and duration of PRT. Although, they exhibit the most control over modifiable injury risk factors. Soldiers should be familiar with injury risk factors and common injuries, practice effective goal setting, and differentiate between health and performance objectives.

High body fat, BMI, abdominal circumference, inadequate/excessive physical activity, smoking, and poor fitness are all risk factors that a soldier can easily understand and modify. If the culture and climate of the unit emphasizes high readiness and promotes injury prevention efforts, individual soldiers may be more inclined to adapt to ideal ranges and avoid risky behaviors (e.g., smoking).

Soldiers are encouraged to have individual professional and personal goals, many of which tend to be fitness related. Soldiers should practice systematic goal setting that aims to create an equilibrium between supporting unit readiness and individual performance goals. Soldiers seeking fitness goals outside of unit PRT can consult with available strength and conditioning professionals and physical therapists. Discussing goals with first-line supervisors during counseling will create congruence between personal goals and unit readiness.

Finally, with the high incidence of MSK-I in the military, soldiers are likely to experience an injury during their time in service. Prior injuries put soldiers at increased risk for re-injury (21,22,33). Once injured, soldiers (with supervisor support) must ensure they are fully recovered before RTD. If soldiers are not fully rehabilitated prior to RTD, the cycle of injury is likely to resume. The cycle can be broken if soldiers and supervisors differentiate between health objectives (e.g., pain-free movement, achieving full range of motion) and performance objectives (e.g., maximum strength and power) (25). Health objectives promote proper and effective movement while performance objectives enhance those movements and are inherently riskier. Again, health professionals can aid in identifying these objectives, but understanding them is key.

SOLDIER MUSCULOSKELETAL INJURIES, RISK FACTORS, AND RECOMMENDATIONS

The warfighting activities mentioned in this introduction create a robust movement profile that, when coupled with high levels of injury risk and low protective factors, can result in greater injury incidence and decreased readiness. Seeking available expertise,

implementing injury surveillance, task and demand analyses, risk factor education, training load monitoring, and effective goal setting are a few methods that commanders, supervisors, and soldiers can utilize in the fight against MSK-I.

FIGURE 1. TRAINING MODERATORS

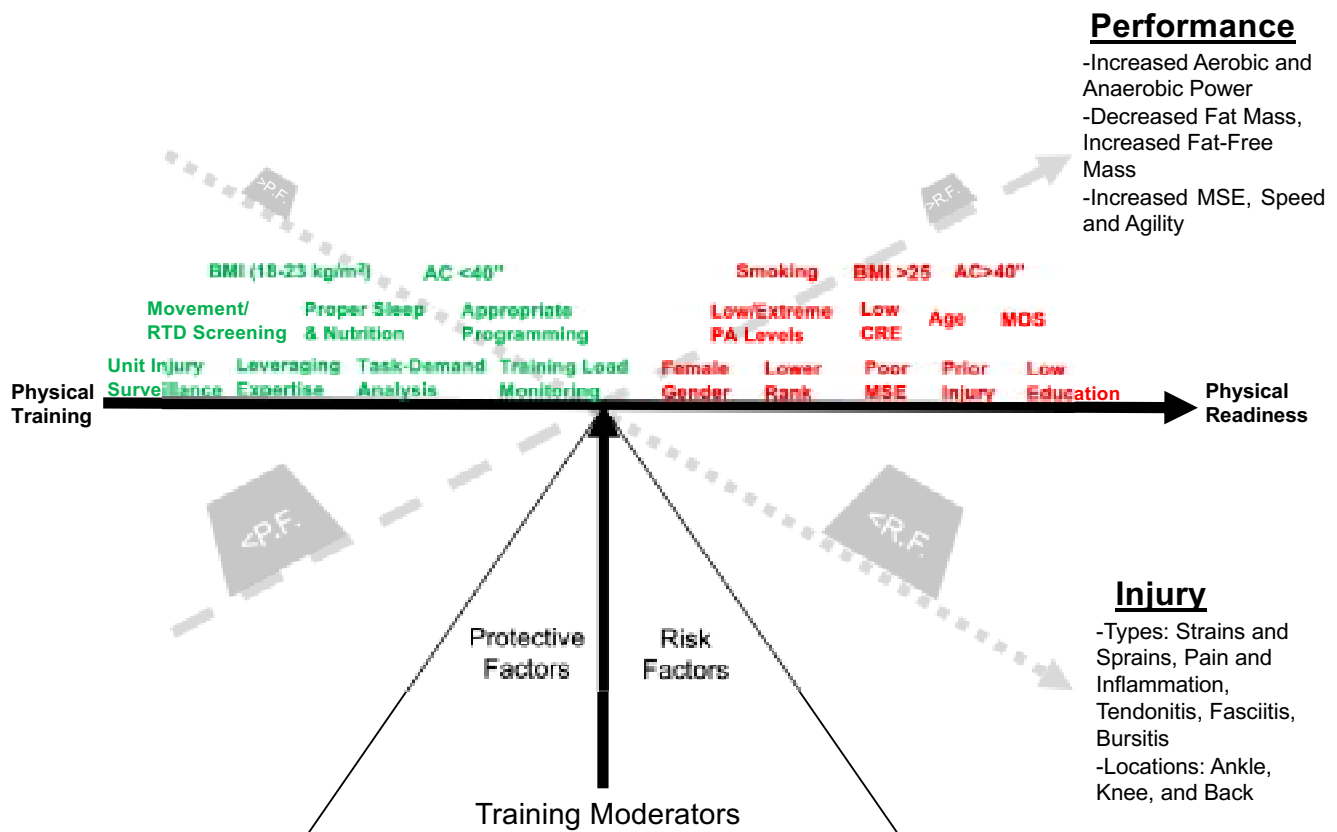


Figure 1. Conceptual model of the physical training and physical readiness relationship moderated by protective and risk factors. **AC** – Abdominal Circumference; **BMI** – Body Mass Index; **CRE** – Cardiorespiratory Endurance; **MSE** – Muscular Strength & Endurance; **PA** – Physical Activity

REFERENCES

1. Abt, JP, Sell, TC, Lovalekar, M, Keenan, K, Bozich, A, Morgan, J, et al. Injury epidemiology of U.S. Army Special Operations Forces. *Military Medicine* 179(10): 1106-1112, 2014.
2. Anderson, MK, Grier, T, Canham-Chervak, M, Bushman, TT, and Jones, BH. Occupation and other risk factors for injury among enlisted US Army Soldiers. *Public Health* 129(5): 531-538, 2015.
3. Bedingfield, M. U.S. Army Non-Deployable Report - July 2018. Washington D.C., Army Dot; 2018 September 13, 2008.
4. Bedno, SA, Cowan, DN, Urban, N, and Niebuhr, DW. Effect of pre-accession physical fitness on training injuries among US Army recruits. *Journal of Prevention Assessment and Rehabilitation* 44(4): 509-515, 2013.
5. Bedno, SA, Jackson, R, Feng, XS, Walton, IL, Boivin, MR, and Cowan, DN. Meta-analysis of cigarette smoking and musculoskeletal injuries in military training. *Medicine and Science in Sports and Exercise* 49(11): 2191-2197, 2017.
6. Bullock, SH, Jones, BH, Gilchrist, J, and Marshall, SW. Prevention of physical training-related injuries recommendations for the military and other active populations based on expedited systematic reviews. *American Journal of Preventative Medicine* 38(1): S156-S181, 2010.
7. Cameron, KL. *Musculoskeletal Injuries in the Military*. New York, NY: Springer; 43-61, 105-229, 2016.

8. Cowan, DN, Bedno, SA, Urban, N, Yi, B, and Niebuhr, DW. Musculoskeletal injuries among overweight army trainees: Incidence and health care utilization. *Occupational Medicine-Oxford* 61(4): 247-252, 2011.
9. Cruz-Jentoft, AJ. Sarcopenia. Chichester, West Sussex: John Wiley and Sons; 2012.
10. De La Motte, SJ, Gribbin, TC, Lisman, P, Beutler, AI, and Deuster, P. The interrelationship of common clinical movement screens: Establishing population-specific norms in a large cohort of military applicants. *Journal of Athletic Training* 51(11): 897-904, 2016.
11. De La Motte, SJ, Gribbin, TC, Lisman, P, Murphy, K, and Deuster, PA. A Systematic review of the association between physical fitness and musculoskeletal injury and risk: Part 2—Muscular endurance and muscular strength. *Journal of Strength and Conditioning Research* 31(11): 3218-3234, 2017.
12. Eckard, TG, Padua, DA, Hearn, DW, Pexa, BS, and Frank, BS. The relationship between training load and injury in athletes: A systematic review. *Sports Medicine* 48(8): 1929-1961, 2018.
13. Esmaeili, A, Hopkins, WG, Stewart, AM, Elias, GP, Lazarus, BH, and Aughey, RJ. The individual and combined effects of multiple factors on the risk of soft tissue non-contact injuries in elite team sport athletes. *Frontier Physiology* 9(1280): 2018.
14. Gefen, A, and Epstein, Y. The mechanobiology and mechanophysiology of military-related injuries [e-book]: Cham: Springer International Publishing; 2016.
15. Grier, T, Canham-Chervak, M, McNulty, V, and Jones, BH. Extreme conditioning programs and injury risk in a US Army Brigade Combat Team. *US Army Medical Department Journal* 36-47, 2013.
16. Hallal, PC, Andersen, LB, Bull, FC, Guthold, R, Haskell, W, and Ekelund, U. Global physical activity levels: surveillance progress, pitfalls, and prospects. *The Lancet* 380(9838): 247-257, 2012.
17. Holsteen, KK, Choi, YS, Bedno, SA, Nelson, DA, and Kurina, LM. Gender differences in limited duty time for lower limb injury. *Occupational Medicine-Oxford* 68(1): 18-25, 2018.
18. Knapik, JJ, Graham, B, Cobbs, J, Thompson, D, Steelman, R, and Jones, BH. A prospective investigation of injury incidence and injury risk factors among Army recruits in military police training. *BMC Musculoskeletal Disorders* 1432, 2013.
19. Knapik, JJ, Graham, B, Cobbs, J, Thompson, D, Steelman, R, and Jones, BH. A prospective investigation of injury incidence and risk factors among army recruits in combat engineer training. *Journal of Occupational Medicine and Toxicology* 8(1): 5, 2013.
20. Knapik, JJ, Rieger, W, Palkoska, F, Van Camp, S, and Darakjy, S. United States Army physical readiness training: Rationale and evaluation of the physical training doctrine. *Journal of Strength and Conditioning Research* 23(4): 1353-1362, 2009.
21. Kucera, KL, Marshall, SW, Wolf, SH, Padua, DA, Cameron, KL, and Beutler, AI. Association of injury history and incident injury in cadet basic military training. *Medicine and Science in Sports and Exercise* 48(6): 1053-1061, 2016.
22. Lauder, TD, Baker, SP, Smith, GS, and Lincoln, AE. Sports and physical training injury hospitalizations in the army. *American Journal of Preventative Medicine* 18(3): 118-128, 2000.
23. Lisman, PJ, De La Motte, SJ, Gribbin, TC, Jaffin, DP, Murphy, K, and Deuster, PA. A systematic review of the association between physical fitness and musculoskeletal injury and risk: Part 1—Cardiorespiratory endurance. *Journal of Strength and Conditioning Research* 31(6): 1744-1757, 2017.
24. Loring, K, Bedno, S, Hauret, K, Jones, B, Kao, T-C, and Mallon, T. Injuries from participation in sports, exercise, and recreational activities among active duty service members - Analysis of the April 2008 Status of Forces Survey of Active Duty Member. Retrieved October 25, 2018 from <http://www.dtic.mil/dtic/tr/fulltext/u2/a560733.pdf>.
25. McGill, SP. Core training: Evidence translating to better performance and injury prevention. *Strength and Conditioning Journal* 32(3): 33-46, 2010.
26. Nye, NS, Carnahan, DH, Jackson, JC, Covey, CJ, Zarzabal, LA, Chao, SY, et al. Abdominal circumference is superior to body mass index in estimating musculoskeletal injury risk. *Medicine and Science in Sports and Exercise* 46(10): 1951-1959, 2014.
27. Pratt, DJ. Mechanisms of shock attenuation via the lower extremity during running. *Clinical Biomechanics* 4(1): 51-57, 1989.
28. Reynolds, K, Cosio-Lima, L, Bovill, M, Tharion, W, Williams, J, and Hodges, T. A comparison of injuries, limited-duty days, and injury risk factors in infantry, artillery, construction engineers, and special forces soldiers. *Military Medicine* 174(7): 702-708, 2009.
29. Rhon, DI, Teyhen, DS, Shaffer, SW, Goffar, SL, Kiesel, K, and Plisky, PP. Developing predictive models for return to work using the military power, performance and prevention (MP3) musculoskeletal injury risk algorithm: A study protocol for an injury risk assessment programme. *Injury Prevention* 24(1): 81, 2018.
30. Seay, JF, Shing, T, Wilburn, K, Westrick, R, and Kardouni, JR. Lower-extremity injury increases risk of first-time low back pain in the US Army. *Medicine and Science in Sports and Exercise* 50(5): 987-994, 2018.
31. Sefton, JM, Lohse, KR, and Mcadam, JS. Prediction of injuries and injury types in Army basic training, infantry, armor, and cavalry trainees using a common fitness screen. *Journal of Athletic Training* 51(11): 849-857, 2016.
32. Sell, TC, Abt, JP, Crawford, K, Lovalekar, M, Nagai, T, Deluzio, JB, et al. Warrior model for human performance and injury prevention: Eagle tactical athlete program (ETAP) Part I. *Journal of Special Operations Medicine* 10(4): 2-21, 2010.
33. Sell, TC, Abt, JP, Nagai, T, Deluzio, JB, Lovalekar, M, Wirt, MD, and Lephart, SM. The eagle tactical athlete program reduces musculoskeletal injuries in the 101st Airborne Division (Air Assault). *Military Medicine* 181(3): 250-257, 2016.
34. Soligard, T, Schwellnus, M, Alonso, J-M, Bahr, R, Clarsen, B, Dijkstra, HP, et al. How much is too much? (Part 1) International Olympic Committee consensus statement on load in sport and risk of injury. *British Journal of Sports Medicine* 50(17): 1030, 2016.

SOLDIER MUSCULOSKELETAL INJURIES, RISK FACTORS, AND RECOMMENDATIONS

35. Taanila, H, Suni, JH, Kannus, P, Pihlajamäki, H, Ruohola, JP, Viskari, J, and Parkkari, J. Risk factors of acute and overuse musculoskeletal injuries among young conscripts: a population-based cohort study. *BMC Musculoskeletal Disorders* 16:104, 2015.

36. Teyhen, D, Bergeron, MF, Deuster, P, Baumgartner, N, Beutler, AI, De La Motte, SJ, et al. Consortium for health and military performance and American College of Sports Medicine Summit: Utility of Functional Movement Assessment in identifying musculoskeletal injury risk. *Current Sports Medicine Reports* 13(1): 52-63, 2014.

37. Teyhen, D, Shaffer, S, Butler, R, Goffar, S, Kiesel, K, Rhon, D, et al. Application of athletic movement tests that predict injury risk in a military population: Development of normative data. *Military Medicine* 181(10): 1324-1334, 2016.

38. United States Army. U.S. Technical Bulletin: Prevention and control of musculoskeletal injuries associated with physical training. Retrieved October 25, 2018 from <https://adp.army.mil>.

39. United States Army. U.S. Field Manual 7-22: Army Physical Readiness Training. Retrieved October 15, 2018 from <https://armypubs.us.army.mil/doctrine/index.html>.

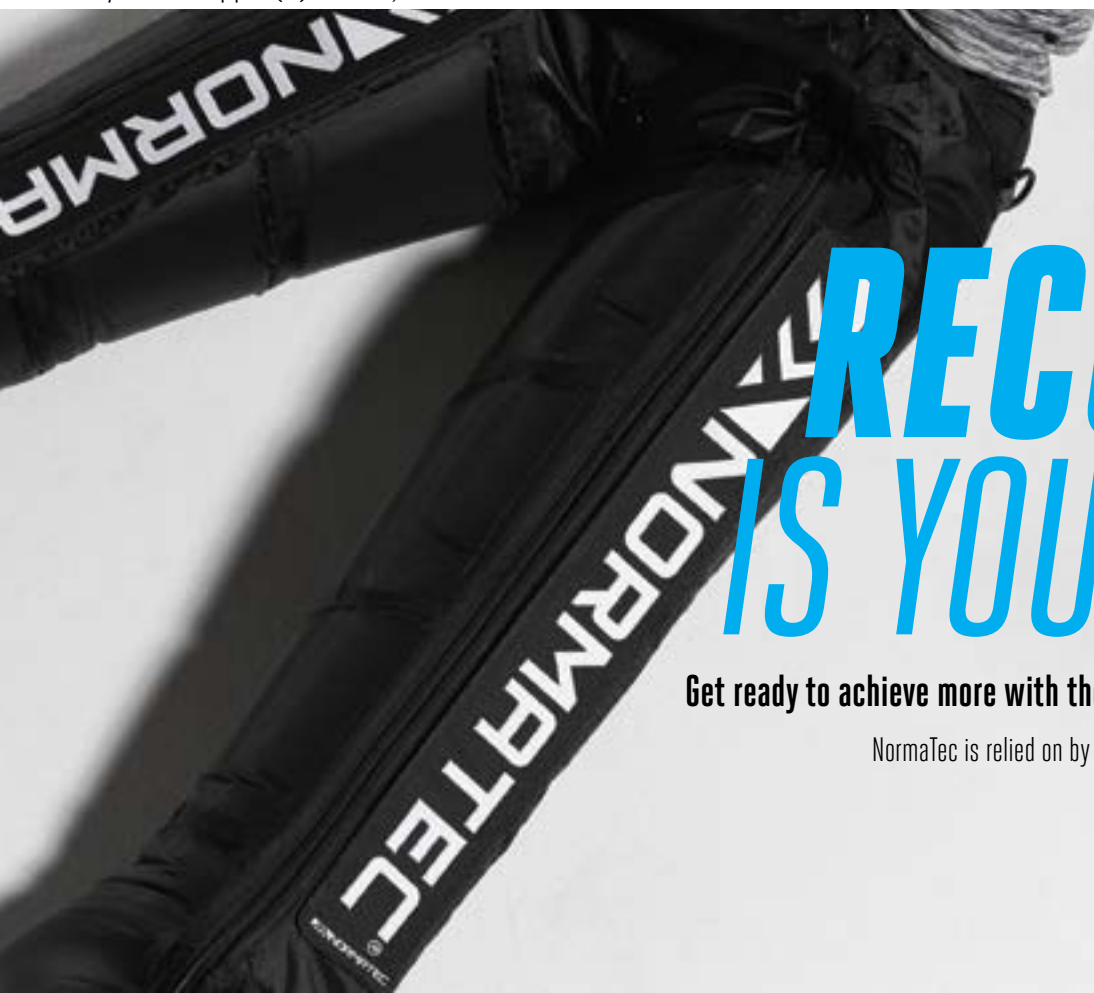
40. United States Army. U.S. The performance triad guide sleep, activity, and nutrition. Retrieved September 18, 2018 from <http://www.columbia.edu/cgi-bin/cul/resolve?clio11668629>.

41. Wardle, SL. Mitigating the risk of musculoskeletal injury: A systematic review of the most effective injury prevention strategies for military personnel. *Journal of Science Medicine and Sport* 20 Suppl 4(11): S3-S10, 2017.

42. Wilkinson, DM, Blacker, SD, Richmond, VL, Horner, FE, Rayson, MP, Spiess, A, and Knapik, JJ. Injuries and injury risk factors among British army infantry soldiers during predeployment training. *Injury Prevention* 17(6): 381-387, 2011.

ABOUT THE AUTHOR

Eric Gutierrez is a United States Army officer currently assigned to the United States Army Student Detachment, where he is pursuing a Master of Education degree in Applied Physiology from Teachers College, Columbia University. Gutierrez holds a Master of Science degree in Exercise Science from California University of Pennsylvania and a Bachelor's degree from the University of Texas at San Antonio. He previously served as the commander of a combat engineer company in the 4th Brigade, 25th Infantry Combat Team (Airborne), stationed in Anchorage, AK.



RECOVERY IS YOUR EDGE

Get ready to achieve more with the Normatec PULSE recovery massage.

Normatec is relied on by 97% of pro teams to keep athletes at their prime.

IMPROVING RECOVERY FOR TACTICAL ATHLETES

Recovery is arguably one of the most important topics tactical facilitators need to be aware of in order to keep tactical personnel ready for duty and minimize fatigue. Not just the physical aspects regarding fatigue, but overall recovery of the mind and body. The demands of training, daily stress of the job or life events, and lack of sleep are all factors that impact the recovery of tactical athletes. The purpose of this article is to help provide recommendations of overall recovery modalities for tactical athletes.

ESSENTIAL RECOVERY METHODS

Most former athletes may remember a high school strength coach encouraging them to drink chocolate milk after their workouts or the gallon-sized milk jug of water that everyone carried around the day of a game or big match up. Likewise, there were the dreaded ice baths in the training center that were obligatory, rain or shine. Recovery methods for athletes have progressed over the last 5 – 10 years, but it is important for tactical athletes to remember some of the simpler modalities for recovery.

NUTRITION

Diet and exercise interrelate regardless of training purpose, be it developing strength, building lean muscle mass, losing weight, or weight management. Nutrition is also a key factor in muscle recovery. Eating more protein is one suggestion most trainers and coaches will initially make. There has been an extensive amount of evidence supporting that increasing the intake of protein and amino acids will help restore muscle fibers and aid in recovery (2,13).

Protein plays a significant role in increasing muscle glycogen re-synthetization during recovery (1). One common form of consuming additional protein intake is through supplementation. Today, there are protein supplements sold in just about every grocery store and gas station. While these are convenient, they can be filled with unwanted sugars and other additives (11). Protein powder supplements are typically available in bulk at vitamin shops or other fitness-focused nutrition stores and can also be purchased online (8).

Some things to consider before purchasing from one of these sources is the credibility of the company, if the products are certified (e.g., National Sanitation Foundation [NSF], United States Pharmacopeia [USP], and Good Manufacturing Practice [GMP]), and the overall reviews of the products. Product consumers are more likely to share views, experiences, and side effects that are relatable. A common question associated with protein supplementation is which kind or brand is best and most effective. Inherently it is typically thought that the more expensive the protein is, the better the quality of the supplement. However, according to Rindom et al., the recovery and regain of muscle strength, as well as anaerobic or aerobic performance,

is not influenced by the quality of the protein supplement that is consumed (7).

There are other ways to increase protein consumption other than through supplementation. Protein is found in a variety of foods, such as meats, fish, eggs, and other dairy products. Some plant-based protein sources, like legumes and nuts, lack important amino acids. Although when paired with other foods they become complete proteins (11). An example of this would be black beans and rice or peanut butter on whole-grain bread, which will make a complete protein.

It is important to remember that protein is just one small component when it comes to supplementation for recovery. Omegas, anti-inflammatories, and hydration supplements can also aid in different aspects of recovery. Though there are numerous varieties of protein powders and drinks, and now gel capsules, these supplements are just an alternative for increasing protein intake rather than through eating high-protein foods.

REST

Sleep is an essential part of the recovery process, as it provides several important psychological and physiological functions. Sleep deprivation can be detrimental to the muscle recovery process, resulting in reduced muscle glycogen repletion, decreased muscle damage repair, alterations in cognitive function, and an increase in mental fatigue (4).

Human bodies detect environmental and internal changes through the central and peripheral nervous systems. The autonomic nervous system, forming part of the peripheral nervous system, is comprised of two divisions: sympathetic and parasympathetic systems. The sympathetic response term which many may be familiar with is the “fight-or-flight” reaction to a situation or stimulus. When at rest, the parasympathetic nervous system should take precedence, initiating a state of recovery for the body; many may recognize this as a “rest-and-digest” response. This phase is crucial for restoring muscle fibers and energy sources through digesting and synthesizing glycogen. Without this rest component, the body may have a difficult time recovering. Prolonged periods of increased stress or stimulation, whether from overtraining or lack of sleep, may lead to the body switching priority from overall recovery to sustainment under extreme levels of fatigue. This potentially leads to a physical breakdown and may see the body work against positive changes in training or performance.

As tactical facilitators, providing tactical athletes with recommendations to improve their quality of sleep is imperative. Tactical athletes may experience prolonged periods of stress or stimulation that are not always avoidable. One relatively easy way

to improve sleep is by creating a conducive sleeping environment (10). The ideal room would be dark, cool, and comfortable, and while that may be unfeasible at times, it is a good goal to aim for. Also, consideration should be given to taking short naps in order to make-up for any loss of sleep (10). Guidance on avoiding the use of electronics or personal devices while laying down may also be of use. General advice would be to cease electronic device use at least one hour prior to bedtime, in order to allow for 30 – 60 min of a relaxing wind-down period (10). Other recommendations would be to avoid caffeine after lunch and limit alcohol use in the late evening.

Rest for the body is important, regardless of the form of training or sport that is being participated in. Even the best athletes can only function at a percentage of their highest potential if they have been deprived of adequate rest or sleep (10). The concept behind overtraining stems from the notion that athletes only progress to a certain point before they start tapering off due to a lack of recovery generated during periods of rest. The risk of overtraining can also be heightened for tactical athletes as well due to the lack of rest and inadequate sleep that they commonly experience (13).

RESTORING

Changes to nutrition and rest regimens are more common practices that typically can be easily implemented with little or no additional cost or burden. This third grouping of recovery combines all aspects of restoring mind, body, and soul. It encompasses methods, such as holistic practices, which approach recovery from a different perspective. Common forms of this recovery method use body and mind techniques, such as performing yoga or tai chi, movement therapy, and even chiropractic or acupuncture care. For some, this may include electromagnetic therapy, meditation, or listening to music.

Regardless of which modality of recovery is chosen, it is important to take into consideration the individual responses that can occur depending on the individual. Tactical athletes especially, may deviate from the norm due to the elevated stress and stimuli they are exposed to daily. It should be remembered that, just because one method of recovery may work for some, it does not mean that it would have the same effect on others.

THE QUICK FIX

Changes to habits do not come rapidly. In reality, it takes time and discipline to adopt new routines. Training programs, diet changes, and overall availability of resources can all hinder efforts in changing recovery practices. Different jobs, mission tasks, locations, and day-to-day responsibilities will all play a part in how a tactical athlete will recover. Each day is different, but the importance of being adequately recuperated and fit for duty will not change. These three simple adjustments can help speed up the process of recovery, improve the feeling of wellbeing, and increase readiness for action.

1. **Drink Water:** Water is necessary in order to metabolize food. Generally, a healthy person needs 100 ml of water to be able to metabolize 100 calories (6). Water intake requirements depend upon the environment and physical activity level of the individual. Typical adequate intake of water per day for males is 2.5 liters, and for females is two liters (14). Proper hydration helps to rid the body of toxins, aid in digestion, and prevent dehydration (9). Be aware, however, that excessive water intake can have a deleterious effect and can lead to hyponatremia, or the diluting of body electrolytes (5).
2. **Make Sleep a Priority:** The importance of adequate rest should not be underestimated. Eight hours of sleep should be the target, even if that may be difficult to meet due to job or lifestyle demands (10). Insufficient rest limits the body's opportunity to recover, which in turn may increase the risk of injury.
3. **More Protein, More Power:** Research supports the supposition that increased amounts of dietary protein aides in muscle recovery (1,8,10,11,12). Whether it is through supplementation or other food sources, ensuring sufficient protein dietary intake may aid in recovery.

KEY POINTS

There are numerous ways to optimize recovery. In essence, identifying the approach that works best for the specific individual is the key. A lot of time and money can be spent on trying the newest and greatest supplements, but there is no guarantee that they will work. Simple changes to daily habits may be what is missing. Sufficient sleep and protein intake through foods or supplements may aid in optimizing recovery and may help improve overall quality of life.

REFERENCES

1. Betts, JA, and Williams, C. Short-term recovery from prolonged exercise: Exploring the potential for protein ingestion to accentuate the benefits of carbohydrate supplements. *Sports Medicine* 40(11): 941-959, 2010.
2. Brown, MA, Stevenson, EJ, and Howatson, G. Whey protein hydrolysate supplementation accelerates recovery from exercise-induced muscle damage in females. *Applied Physiology, Nutrition and Metabolism* 43(4): 324-330, 2018.
3. Gandy, J. Water intake: Validity of population assessment and recommendations. *European Journal of Nutrition Suppl* 2: 11-16, 2015.
4. Nédélec, M, Halson, S, Abaidia, AE, Ahmaidi, S, and Dupont G. Stress, sleep and recovery in elite soccer: A critical review of the literature. *Sports Medicine* 45(10): 1387-1400, 2015.
5. Noakes, TD, Goodwin, N, Rayner, BL, Branken, T, and Taylor, RKN. Water intoxication: A possible complication during endurance exercise. *Medicine and Science in Sports Exercise* 7: 370-375, 1985.

6. Porth, C. *Essentials of Pathophysiology: Concepts of Altered Health States*. Lippincott Williams and Wilkins; 2011.
7. Rindom, E, Nielsen, M, Kececi, K, Jensen, M, Vissing, K, and Farup, J. Effect of protein quality on recovery after intense resistance training. *European Journal of Applied Physiology* 116(11/12): 2225-2236, 2016.
8. Samal, JRK, and Samal, IR. Protein supplements: Pros and cons. *Journal of Dietary Supplements* 15(3): 365-371, 2018.
9. Shaheen, NA, Alqahtani, AA, Assiri, H, Alkhodair, R, and Hussein, MA. Public knowledge of dehydration and fluid intake practices: Variation by participants' characteristics. *BMC Public Health* 18(1): 2018.
10. Simpson, NS, Gibbs, EL, and Matheson, GO. Optimizing sleep to maximize performance: Implications and recommendations for elite athletes. *Scandinavian Journal of Medicine and Science in Sports* 27(3): 266-274, 2017.
11. The Best Sources of Healthy Protein. *Consumer Reports on Health* 30(9): 8-9, 2018.
12. Waldron, M, Whelan, K, Jeffries, O, Burt, D, Howe, L, and Patterson, SD. The effects of acute branched-chain amino acid supplementation on recovery from a single bout of hypertrophy exercise in resistance-trained athletes. *Applied Physiology, Nutrition and Metabolism* 42(6): 630-636, 2017.
13. Wheeler, AR, and Wenke, JC. Military fractures: Overtraining, accidents, casualties, and fragility. *Clinical Reviews in Bone and Mineral Metabolism* 16(4): 103-115, 2018.

ABOUT THE AUTHOR

Kimberly Allen is a doctoral student at the University of Southern Mississippi. She is a Certified Strength and Conditioning Specialist® with Distinction (CSCS,*D®) and a Tactical Strength and Conditioning Facilitator® with Distinction (TSAC-F,*D®) with the National Strength and Conditioning Association (NSCA). Allen is a graduate of the University of Alabama, where she received her Master's degree in Human Performance. Her undergraduate studies were completed at the University of Montevallo, where she started her research journey and developed a true passion for the field. She has worked in the fitness industry for over 10 years, and has been an active member of the NSCA for six years. She has been published in the *Journal of Strength and Conditioning Research* and has written several articles for the *TSAC Report*. She has also been awarded the NSCA's Women's Scholarship twice, and received the Alumni of the Year Award by the University of Montevallo.



**LEARN
FROM
THE BEST**

www.barcainnovationhub.com/nsca

Certified online courses



**BARÇA
INNOVATION HUB**
Universitas



NSCA
NATIONAL STRENGTH AND
CONDITIONING ASSOCIATION
CEU APPROVED

PERFORM BETTER!

FACILITY DESIGN

FROM CONCEPT TO COMPLETION, LET US
HELP MAKE YOUR FACILITY A REALITY



FREE 3D DESIGN

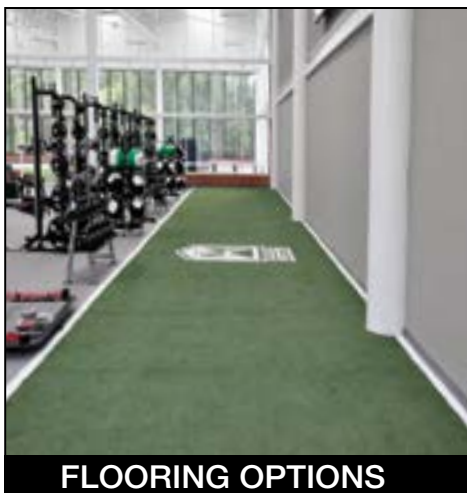


FREE CONSULTATION

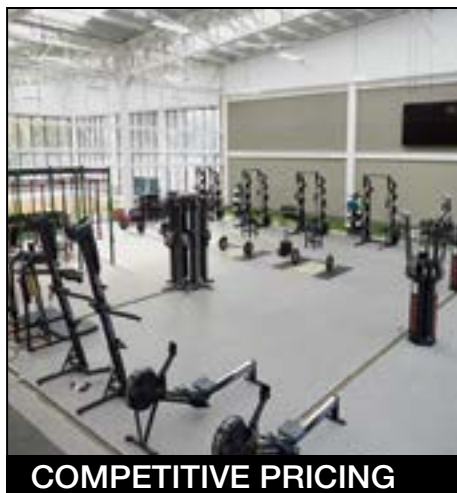


PROJECT COORDINATION

Let us be your “One-Stop Shop” for all your facility needs.



FLOORING OPTIONS



COMPETITIVE PRICING



FINANCING OPTIONS

For more information on designing your facility, call or visit us at

800-556-7464 ■ PERFORMBETTER.COM

TSAC REPORT – JANUARY 2019 RESEARCH COLUMN

PHYSICAL AND PHYSIOLOGICAL PERFORMANCE DETERMINANTS OF A FIREFIGHTING SIMULATION TEST. *JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL MEDICINE* 60(7): 637-643, 2018. SIDDALL, AG, STEVENSON, RD, TURNER, PJ, AND BILZON, JL.

A recent study published in the *Journal of Occupational and Environmental Medicine* examined how physical and anthropometric variables attributed to the success of firefighters in the United Kingdom (UK) during a firefighting simulation test (FFST). The FFST was previously validated by the UK Fire and Rescue service for occupational readiness. Sixty-eight operational firefighters (63 males, 5 females) participated in the study with an average age of 41 years.

Data collection took place in two sessions separated by at least seven days. Day one consisted of collecting body mass and height, in addition to estimating body fat percentage using bioelectrical impedance. Participants then performed a maximal aerobic fitness test to record VO_2max . The test consisted of running on a treadmill at a self-selected speed with the treadmill incline increasing 3% every three minutes until participants could not continue. Day one ended with a demonstration of all the aspects of the FFST. The FFST was a continuous circuit totaling 1025 m and consisting of three tasks: 25-kg barrel carried 200 m, charged hose reel dragged 75 m followed by a 55-kg dummy dragged 50 m, and a hose run simulating setting up a 100-m water relay using four lengths of 25-m hoses (13 kg each). During the FFST, participants wore full personal protective clothing consisting of helmet, shirt, tunic, leggings, boots, and gloves (~8.2 kg). A self-contained breathing apparatus (12.1 kg) was worn during the first two tasks and removed for the hose run. On day two, participants completed the FFST at a maximal effort. Time-to-completion and perceived exertion (Borg scale) were recorded during the FFST.

Absolute VO_2max combined with estimated fat mass was the strongest predictor of FFST performance, explaining nearly 59% of the variance ($R^2=0.585$). Thus, firefighters with higher aerobic fitness and lower fat mass were predicated to have the lowest FFST times. Furthermore, participants with the lowest 20% fat mass performed better on the FFST than the average of all participants, as well as those in the top 20% of fat mass. The researchers suggested that fat mass is a better predictor of firefighter task performance than is total body mass. Unfortunately, due to the sex differences in body composition, data derived from a mostly male sample may not be applicable to female firefighters. It is possible the small sample of female firefighters may not have influenced the results. Future studies may need to examine if absolute body fat would be a better

predictor in females than percentage of body fat. Tactical facilitators who work with firefighters should monitor fat mass and aim to keep it low, but within healthy limits. If individuals already have low fat mass, it can be beneficial to train to add more lean mass without risking a loss of performance.

PHYSICAL FITNESS CHARACTERISTICS OF HIGH VS. LOW PERFORMERS ON AN OCCUPATIONALLY SPECIFIC PHYSICAL AGILITY TEST FOR PATROL OFFICERS. *THE JOURNAL OF STRENGTH AND CONDITIONING RESEARCH* 31(10): 2808-2815, 2017. DAWES, JJ, LINDSAY, K, BERO, J, ELDER, C, KORNHAUSER, C, AND HOLMES, R.

The Journal of Strength and Conditioning Research recently published a study examining whether there was a difference in performance on physical ability tests (PAT) by patrol officers. PATs are frequently used for assessing both recruits and officers on physical performance and designed to replicate job-tasks essential to police work. The researchers analyzed the physical characteristics of the officers with high versus low PAT performance. Furthermore, they investigated which fitness test best predicted PAT performance. Sample data from 495 officers (476 males; 19 females) from a single agency were used. The average male age was 39.5 years and the average female age was 37.7 years.

Fitness assessment tests included: vertical jump height, one-minute push-ups, one-minute sit-ups, legs/lower back isometric strength, hand grip strength, a 20-m beep test, and a PAT obstacle course. Legs/lower back isometric strength was assessed using a leg/back chain dynamometer adjusted so the participant's knees were bent approximately 110 – 120°. The PAT course consisted of performing a series of simulated job-related tasks as quickly as possible. The PAT begins with participants in a chair with a seatbelt. Once the test starts, participants unbuckle the seat belt and run 30 m in a zig-zag pattern, then repeat the pattern ending back at the chair. This is followed by maneuvering through 10 rings placed on flat ground. After running through the rings, a simulated body drag is performed with a 54.6-kg bag over 6.1 m, immediately followed by an 18.2-kg crate carry for 6.1 m. Next, officers take a ball out of a bucket, cross over a simulated interstate barrier and place the ball in another bucket. Another ball is then taken, and the officer must crawl through a 1.83-m long, 10.97-m square opening, and place the ball in another bucket. Officers then sprint up and over a ramp (7.9-m long with the middle being 1.5-m tall) five times, retrieving and returning a ball each trip through. After the ramp, a sled is pushed 7.32 m out, and then pushed back. After the sled, officers ran back through each station in reverse order, ending when they return to the starting

chair and buckle the seatbelt. The PAT had a 5-min time limit, which was not surpassed by any officers in the study.

An analysis of all the tests and their relationship to PAT performance, the beep test, vertical jump, and one-minute sit-up test were the best predictors. Based on a regression analysis ($267.24 - 1.26 [\text{vertical jump } \{\text{cm}\}] - 0.664 [\text{beep test } \{\text{s}\}] - 0.48 [\text{sit-ups}]$), PAT time decreased by 1.25 s for every inch achieved in the vertical jump test. Additionally, PAT time decreased by two-thirds of a second for each second of the beep test and decreased by 0.5 s for every sit-up completed. Officers who had high PAT performance (high=182.8 s; low=217.1 s) scored significantly better in the beep test (high=52.1 s; low=24.1 s), vertical jump (high=48.2 cm; low=45.7 cm), push-up (high=47.2 repetitions; low=30.3 repetitions), and sit-up test (high=41.0 repetitions; low=27.9 repetitions). Based on these results, tactical facilitators working with police officers should focus on increasing lower body power to increase PAT performance. Push-ups and sit-ups performance should also be monitored. The results of this study can be used to monitor potential PAT performance prior to testing as well as tracking progress between testing periods. It is yet unclear how these data can be applied to females since they were a small part of the sample in this study.

EFFECT OF WHEY PROTEIN SUPPLEMENTATION ON PHYSICAL PERFORMANCE AND BODY COMPOSITION IN ARMY INITIAL ENTRY TRAINING SOLDIERS.

NUTRIENTS 10(9): 1248, 2018.

MCADAM, JS, MCGINNIS, KD, BECK, DT, HAUN, CT, ROMERO, MA, MUMFORD, PW, ET AL.

A 2018 study in the journal *Nutrients* investigated the effect whey protein supplementation had on physical performance and body composition in United States (U.S.) Army soldiers during Army Initial Entry Training. Sixty-nine male U.S. Army soldiers (age=19 $\pm$ 1 years) were supplemented with either whey protein (WP) or carbohydrate (CHO) for eight weeks. Those in the WP group were given a whey protein supplement twice daily (77 g/day). The CHO group was given a calorie-matched carbohydrate supplement twice daily (127 g/day). All supplementations were administered after the morning physical fitness training and before bedtime. Physical performance was evaluated using the Army Physical Fitness Test during week two and eight. The Army Physical Fitness Test includes: 2-min push-up test, 2-min sit-up test, and a 2-mi run. Body composition was estimated using the 7-site skinfold measurements during weeks one and nine.

Dietary intake, consumed only at the dining facility, was monitored in both groups during the eight weeks to determine if total caloric consumption and macronutrient intake would differ between the groups. Both groups showed an increase in total calories (WP: pre=2825 $\pm$ 611 kcal, post=3516 $\pm$ 681 kcal; CHO: pre=2624 $\pm$ 740 kcal, post=3348 $\pm$ 542 kcal) and fat consumed (WP: pre=98 $\pm$ 27 g, post=115 $\pm$ 31 g; CHO: pre=90 $\pm$ 31 g, post=106 $\pm$ 23 g) over the eight-week period. Additionally, the WP group increased protein

(pre=122 $\pm$ 25 g, post=201 $\pm$ 29 g) and carbohydrate (pre=371 $\pm$ 84, post=430 $\pm$ 97) consumption during the intervention, while the CHO group only increased carbohydrate (pre=349 $\pm$ 95, post=495 $\pm$ 85) consumption. Therefore, both groups increased total calories, fat, and carbohydrate consumption during the intervention, but only the WP group increased protein consumption. Prior to testing, both supplement groups had similar height (WP=173 $\pm$ 6 cm, CHO=173 $\pm$ 5 cm) and weight (WP=73.4 $\pm$ 12.7 kg, CHO=72.3 $\pm$ 10.9 kg). Post testing, height and weight did not significantly differ between the groups, however, both groups showed a significant decrease in fat mass (WP=-4.5 kg; CHO=-2.7 kg).

Physical performance post-testing showed the WP group averaged nearly seven more push-ups compared to the CHO group (WP=53 $\pm$ 12 repetitions; CHO=46 $\pm$ 9 repetitions). However, there was no significant difference between the two groups in sit-up performance (WP=60 $\pm$ 11 repetitions; CHO=61 $\pm$ 9 repetitions) or 2-mi run times (WP=14:41 $\pm$ 1.9s; CHO=14:32 $\pm$ 1.1s). Whey protein did not lead to any differences in body composition but did lead to an increase in total protein consumption when compared to the CHO group. It is possible that total protein intake was the main contributing factor to the improvements in push-up performance. The consumption of a whey protein supplement may just serve as a convenient method to increase total protein during training. Tactical facilitators working with Army personnel, especially those about to participate in Army Initial Entry Training, should understand how protein consumption, either with whey protein supplementation or food sources, prior to and during training might ensure optimal performance. Based on these data, consuming 2.8 $\pm$ 0.5 g/kg/day may serve to increase some performance measures without having a negative effect on body composition.

ABOUT THE AUTHORS

Brian Schilling is a Professor and the Chair of Kinesiology and Nutrition Sciences at the University of Nevada, Las Vegas. His research interest is tactical strength and conditioning, and he teaches both research methods and scientific communication courses. He has a background as an American football and weightlifting athlete, and worked as a strength and conditioning coach before pursuing his PhD. In addition, Schilling has published extensively in the field of strength and conditioning.

Dustin Dunnick is a doctoral student at the University of Nevada, Las Vegas. His research interest involves tactical strength and conditioning and pulmonary function. His athletic background includes competing in American football, powerlifting, weightlifting, and track and field. His research in the area of strength and conditioning has been published in textbooks and peer-reviewed journals.

SHOULDER TAPS – A NOVEL TIME-EFFICIENT SCREENING TOOL FOR TACTICAL OPERATORS

INTRODUCTION

Tactical operators, including law enforcement officers, firefighters and military personnel, perform various tasks that can require pushing, pulling, lifting, carrying, dragging, jumping, running, crawling, climbing, and fighting (1,5,36). These movements may be performed with additional loads of anywhere between 10 – 50 kg, depending on the operator, role, and mission (2,33). Posture is challenged in walking or standing tasks when loaded, and certain tasks can put a tactical operator into problematic positions, which could potentially lead to an increased risk of incurring an injury (39). In military populations, injuries are directly associated with lost duty days, missed training, early attrition from service, and diminished performance in combat operations (31). As an example, Nindl et al. noted that in 2001, the Department for Veteran affairs paid out over \$5.5 billion to service members with musculoskeletal disabilities (30). Injuries seen in first responders (e.g., police officers, firefighters) may be associated with a higher employee turnover rate, increased absence from work, shortened career span, and a reduction in quality of work performance (15).

Practitioners often use various screening assessments to evaluate risk factors that may contribute to increased injury rates in tactical populations (6,13,21,23,31). Screening is commonplace for assessing movement, and can aid practitioners in distinguishing movement mechanics that could predispose an individual to injury (e.g., knee valgus during a drop landing) (25). A majority of screens have an established grading criteria, which provides a quantitative value for movement of the individual (11,35). However, while screening is primarily used to discover faulty movement patterns, practitioners should exercise caution when correlating or making predictions of screening outcomes with injury occurrence or performance (13,22,23). Nevertheless, screening is a quick and efficient means to begin to help a practitioner understand the capacity of an individual's movement.

The Functional Movement Screen™ (FMS™) is commonly utilized as a tool for identifying movement limitations that may be associated with musculoskeletal injuries (3,6,7,29,31). Furthermore, the FMS has garnered attention as a comprehensive screening tool in tactical populations (3,4,7,31,34). It is both a qualitative and quantitative assessment of fundamental movement patterns intended to identify potential functional limitations and asymmetries of an individual (31). Several studies have linked the outcomes of the FMS to injury risk (3,7,23,31). However, this does not suggest that it serves primarily as a predictive tool for injury risk or performance outcomes (24). Nonetheless, there are several advantages to using the FMS, specifically that it provides practitioners with a way to evaluate movement throughout the kinetic chain and identify deficits and weaknesses relative to select movements (10).

A limitation to the FMS is the amount of time needed to complete the movement screen, which may not be efficient for a practitioner. This is especially true for those working with tactical operators, as these individuals are often very time-poor (4,14). Another drawback to using the FMS is that the operator will generally need to perform all seven movements and associated clearing tests to effectively evaluate movement limitations. This is such an issue that in recent times researchers have isolated individual tests (i.e., the overhead deep squat) to use as a movement assessment (6,9,25,38). It can be advantageous for practitioners to isolate tests that emphasize assessing proximal stability, such as the overhead deep squat, as it will be less time consuming and could potentially be more comprehensive in its assessment versus a series of movements as seen in the entire FMS. Practitioners may then determine from this single screen whether further assessments should be performed (9). Furthermore, although the scoring system for the assessment provides a quantitative assessment of movement, operators are limited to the subjectivity of the practitioner administering the test. It is important for the practitioner to understand why an operator attained a certain screening score, as opposed to just attaching importance to the score itself. Lastly, the FMS also requires specific equipment for testing, which can increase costs to the practitioner and agency to perform the screens. Therefore, it could be more advantageous if practitioners utilized a screen that is comprehensive with regards to movement limitation identification, time efficient, and uses minimal equipment.

This article presents the shoulder taps, which could serve as a more time-efficient screening tool for tactical operators. Shoulder taps are primarily utilized for assessing core stability. Although the term “core” can be used quite generally, McGill provided a more specific definition: the “core” is made up of the lumbar spine, abdominal wall muscles, back extensors, quadratus lumborum, along with other muscles that pass through the core linking to more distal segments (26). Any usage of the term “core” in this article will be within the context of this definition. The primary segments targeted during the shoulder taps will be the trunk (rectus abdominis, external oblique, internal oblique, and transversus abdominis) and lumbo-pelvic or hip (psoas and quadratus lumborum) regions. Therefore, shoulder taps will assess the stability of the trunk muscles, which involve the synergistic activation of muscles controlling position and motion of trunk and pelvis to allow for force generation and proper movement throughout the kinetic chain (18). This is crucial for movements that tactical operators will encounter in daily tasks (4,12). While the FMS, via the overhead deep squat, trunk-stability push-up, and rotary stability, directly screens for stability of the trunk and hips, the shoulder taps does so within the one screen (17).

SHOULDER TAPS – A NOVEL TIME-EFFICIENT SCREENING TOOL FOR TACTICAL OPERATORS

Additionally, the shoulder taps can also assess shoulder and hip stability. Although this article will present the shoulder taps as an assessment modality, it may be expanded upon and prescribed as an exercise for the purpose of improving trunk, hip, and shoulder stability.

THE SHOULDER TAPS SCREEN

Shoulder taps is a movement pattern designed to challenge the body in multiple planes of movement (sagittal, frontal, and transverse planes). To accomplish daily tasks, tactical operators rely on movement in all three planes, and thus, it is paramount for operators to be functional in all planes when on duty. The shoulder taps exercise challenges the trunk to resist flexion, extension, and rotation (i.e., anti-rotation) utilizing all trunk and hip musculature while maintaining a neutral spine. When analyzing the job tasks of tactical operators, the maintenance of proper spine alignment and appropriate gait mechanics in loaded situations can be negatively impacted by inadequate trunk and hip stability (5,18). This movement pattern has been successfully implemented as an exercise into training programs; however, it should be acknowledged that due to its novelty, there is a lack of research on its validity and reliability (i.e., test-retest, intra- and inter-rater reliability). Nonetheless, there still appears to be practical value for the shoulder taps, but practitioners that adopt this screen should do so knowing that further scientific analysis is required.

Many injuries occur in congruence to a lack of trunk and hip stability (i.e., low back pain) (20,32). While low back pain may not be prevented through core stability training, training the musculature with the intention of improving movement quality can reduce the occurrence of low back pain (16,28). When performing a job task (e.g., squatting to pick up a person or object, carrying and placing something overhead, or restraining a suspect) without maintaining proper trunk and hip stability, the spine may lose natural alignment. This creates inefficient transfer of force and can increase susceptibility to injuries (28). When moving a distal segment, such as the arms, force needs to transfer through the trunk and hips to that distal segment. For example, when carrying something heavy (i.e., a body drag), if the operator is unable to maintain appropriate posture (i.e., breaking at hips), weight gets redistributed and can place the back in a compromising position. Additionally, modification of the trunk or hip positions can create an increased risk of lower extremity injury when performing a task that involves decelerating or squatting (18), or altering walking or running gait patterns (22). One must also consider that these dynamic movements are often performed under load, increasing the risk of moving with a compensation (4). Therefore, it is important for the practitioner to understand the ability of an operator to control their trunk and hip regions. With regards to the shoulder taps screen, if any compensations are noted in an operator's movement (i.e., uneven hips) that may indicate that an operator cannot stabilize the appropriate musculature.

HOW TO CONDUCT THE SHOULDER TAP SCREEN

The primary piece of equipment required for assessing the shoulder taps is a dowel (ideally 48 in. in length). This screen is addressed and scored bilaterally to address the trunk as a whole. To perform the screen, the operator begins in the plank position with their hands directly beneath their shoulders and with the feet shoulder-width apart (Figure 1). The plank positioning is adopted to create a stable base of support for performing the movement pattern. Placing the feet at a distance that is shoulder-width apart increases the hip abduction angle to allow for more stability while performing this as a movement screen. To ensure proper distance between feet (measured relative to the middle of calcaneus for each foot), the practitioner should measure a shoulder-width stance of the operator by using the dowel to measure the distance from shoulder to shoulder via the acromion processes (Figure 2). Once the operator is in the proper position, the practitioner will place the dowel along the individual's back (straight line from the head through the upper back and buttocks; Figure 3) or across the low back. The practitioner should then instruct the operator to tap the left shoulder with the right hand and return to the plank position (Figure 4). The operator is then instructed to tap the right shoulder with the left hand and return to the plank position. A minimum of one repetition is necessary for assessing the movement pattern. Time permitting, more can be performed for a more thorough assessment as this will stress motor control in conjunction with endurance capabilities, potentially enhancing the specificity relative to performing repetitive tactical tasks. The operator should perform these movements in a controlled manner. If they are unable to perform these movements in this position, the feet should be modified by spreading the feet to a shoulder-width and a half stance (Figure 5) and the movement should be repeated in this position (Figure 6).



FIGURE 1. SHOULDER TAPS START POSITION – BEFORE DOWEL PLACEMENT (A) SAGITTAL VIEW (B) FRONTAL VIEW



FIGURE 2. SETUP MEASUREMENTS (A) MEASURING SHOULDER WIDTH WITH LABELED DOWEL (B) MEASURING SHOULDER WIDTH AT FEET



FIGURE 3. SHOULDER TAPS START POSITION – SHOULDER WIDTH STANCE (A) SAGITTAL VIEW (B) FRONTAL VIEW



FIGURE 4. SHOULDER TAPS END POSITION – SHOULDER WIDTH STANCE (A) SAGITTAL VIEW (B) FRONTAL VIEW



FIGURE 5. SHOULDER TAPS START POSITION – SHOULDER WIDTH AND A HALF STANCE (A) SAGITTAL VIEW (B) FRONTAL VIEW (C) MEASURING SHOULDER WIDTH AND A HALF AT FEET



FIGURE 6. SHOULDER TAPS END POSITION – SHOULDER WIDTH AND A HALF STANCE (A) SAGITTAL VIEW (B) FRONTAL VIEW

Table 1 displays the movement requirements for the scoring criteria, in addition to the movement limitations that can be identified from the shoulder taps. If no deviations are present (as can be seen in Figures 3 and 4), and the movement is completed as instructed, score the individual at a “3.” If one or few compensations are noted in the screen, score the individual at a “2.” Common compensations observed when assessing the shoulder taps include: elevated hips, uneven hips, and an elevated foot. Elevated hips (Figure 7) will appear as the break in a line passing from the head to the ankles, as the head, upper back,

and hips will still be in line. Uneven hips (Figure 8) will appear as one hip dropping closer to the ground. An elevated foot (Figure 9) will appear as the contralateral foot of the moving arm lifting off the ground. Any of these observed compensations may be accompanied by tapping the shoulder swiftly (i.e., failure to decelerate) instead of tapping in a slow and controlled manner. Practitioners should also exercise caution when administering this assessment to operators with a history of cardiothoracic conditions or high blood pressure, as these movements can position the hips above the heart and thoracic impedance due to the fixed arm positions. If the movement cannot be completed (i.e., the operator cannot get into the position properly) or there is loss of balance, score the individual a “1.” If the operator notes pain during movement, they will be scored a “0.”

POTENTIAL IMPLICATIONS

It is important to understand the implications of the compensations observed during the shoulder taps movement screen. Practitioners can use this information to program certain exercises, some examples of which are shown in Figures 10 – 22. Elevating the hips will decrease the angle of hip extension;



FIGURE 7. SHOULDER TAPS – HIP ELEVATION (A) STARTING POSITION (B) END POSITION



FIGURE 8. SHOULDER TAPS – UNEVEN HIPs (A) SAGITTAL VIEW (B) FRONTAL VIEW



FIGURE 9. SHOULDER TAPS – ELEVATED FOOT (A) SAGITTAL VIEW (B) FRONTAL VIEW

SHOULDER TAPS – A NOVEL TIME-EFFICIENT SCREENING TOOL FOR TACTICAL OPERATORS

TABLE 1. SHOULDER TAPS SCORING CRITERIA

3	2	1	0
Dowel remains in contact with spine (i.e., does not roll off)	Dowel remains in contact with spine (i.e., does not roll off)	Dowel does not maintain contact	
Able to control motion of shoulder	Able to control motion of shoulder	Hips rotate	Individual denotes pain with movement
Hips do not rotate significantly	Hips rotate more	Unable to control shoulder motion	
Able to complete with feet shoulder-width apart	Able to complete with feet shoulder-width and a half apart	Unable to complete with feet shoulder-width and a half apart	

anecdotally, this can be seen to place more of the stress of stabilizing the body to the shoulders. If the upper body is involved more in stabilizing the body than the feet, this could lead to lower activation of the trunk and hip muscles. Although this involved a different movement pattern and base of support, in an analysis of the plank performed with suspension trainers, Byrne et al. found significant reductions in rectus abdominis and external oblique activation when the arms were more stable in comparison to the legs (8). If the practitioner provides feedback to correct this position and the operator continues to return to hips elevated position, it may be more of an awareness aspect that needs to be trained to create a new habitual movement pattern, or the trunk and hip muscles need to be strengthened to ensure greater control of the hips (e.g., via an increase in psoas strength). To properly strengthen the trunk and hip musculature training, staff could consider programming a dead bug or body saw exercise, which are explained in detail by Mendrin et al. (28). These exercises train muscles to work isometrically as stabilizers, allowing for proper transfer of force and movement throughout the kinetic chain. Tactical operators could be required to perform crawling, dragging, or other potentially obscure tasks that require isometric contractions of the trunk and hips while moving to maintain safe and appropriate posture throughout the task performance (37). Thus, it is essential that the muscles are strong enough to support the operator's posture during these actions. The shoulder taps can help the practitioner identify these limitations and prescribe appropriate exercises.

Uneven hips often occur due to an inability to activate the psoas and oblique muscles to resist the rotation of the pelvis. The obliques, transverse abdominis, and psoas need to activate to resist gravity pulling the hips toward the ground. Training staff could program exercises such as the side plank, suitcase carry, or landmines, as these exercises train the muscles to resist pelvic rotation (28). For example, the landmine exercise involves moving an object overhead and side to side, while maintaining a rigid trunk and minimizing rotation of the shoulders and hips. This exercise can translate to job tasks of an operator as they can involve twisting and turning of the upper body (1).

Elevating the foot serves as a counterbalance maneuver during the shoulder taps. When tapping the left shoulder with the right

arm, weight gets shifted to the left side; thus, the right leg will elevate to counter the shift. If this compensation is performed, operators are attempting to shift all of their center of gravity to the left shoulder instead of maintaining their center of gravity over their naval and between both feet. Again, this is due to an inability to activate the trunk and hips to stabilize. Tactical operators could benefit from programs consisting of exercises, such as bird dogs or a cable presses, to train the trunk and hip muscles to work isometrically in order to improve pelvic stability (28). It is necessary for operators to have adequate control of these muscles and postural alignment to move and maintain a natural spinal and torso positioning in unloaded or loaded situations while performing tasks as simple as walking (36). With sufficient trunk and hip strength, operators can ensure proper weight distribution throughout the repetitious behavior and potentially reduce the risk of incurring injury.

LIMITATIONS

The shoulder taps could be of great use for the tactical practitioner. However, limitations for this screen should be noted. Currently, the shoulder taps movement pattern has been suggested for trunk and hip stability training (28). It is a preliminary idea new to the screening process and to the authors' knowledge has not been previously researched. Future research should address the validity and reliability of the movement as a screening tool, considering test-retest, and inter- and intra-observer reliability. Operators regularly perform movements with similar positioning (e.g., push-ups, planks) as observed in this particular assessment. However, quality of the movement is often not considered during their performances. Thus, the novelty of this movement screen gives a practitioner the ability to observe this movement, and other similar movements, with an enhanced perspective on the movement characteristics of their operators.

The shoulder taps screen presented here serves as an opportunity for practitioners to target the screening of proximal stability of the trunk via a singular screen. It should be noted that the FMS assesses stability and mobility throughout the kinetic chain, which indicates why several movements are included. If the tactical practitioner adopts the shoulder taps, they should note this assessment emphasizes the ability to provide stabilization via the trunk and hips. If a compensation is observed in the shoulder

taps leading to a break in the kinetic chain, practitioners may then opt to assess additional movements to investigate stability and mobility of the more distal segments.

CONCLUSION

While not an all-encompassing diagnostic tool, the shoulder taps is an effective means to identify movement deficiencies that may lead to poor, inefficient movements, or injury (19,26,27). Training staff should consider evaluating the movement restrictions associated with the score given to tactical operators performing the shoulder taps. With the understanding of the movement deficiencies observed, training staff can implement appropriate trunk and hip stability exercises to improve movement and potentially decrease the operator's risk of injury. Performing isometric trunk and hip exercises that train these areas in all three planes of movement could progress an operator to improve performance of the shoulder taps and thus, translate to healthier movement in a workplace environment. Additionally, the shoulder taps may also be used as an exercise to train operators in improving trunk and pelvic stability and endurance, and this may positively impact job-related task performance.

EXERCISES TO CORRECT ELEVATED HIP (OBSERVED DURING EXECUTION OF SHOULDER TAPS)



FIGURE 10. DEAD BUG - START POSITION



FIGURE 11. DEAD BUG - END POSITION



FIGURE 12. BODY SAW - START POSITION



FIGURE 13. BODY SAW - END POSITION

EXERCISES TO CORRECT UNEVEN HIPS (OBSERVED DURING EXECUTION OF SHOULDER TAPS)



FIGURE 14. SIDE PLANK

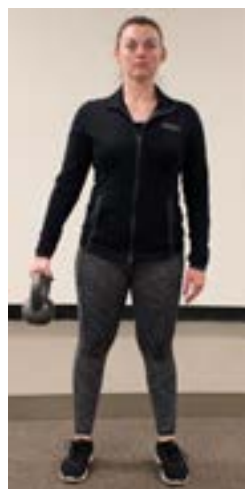


FIGURE 15. SUITCASE CARRY - FRONTAL VIEW



FIGURE 16. SUITCASE CARRY - SAGITTAL VIEW

SHOULDER TAPS - A NOVEL TIME-EFFICIENT SCREENING TOOL FOR TACTICAL OPERATORS



FIGURE 17. LANDMINE ROTATION - START POSITION



FIGURE 18. LANDMINE ROTATION - END POSITION

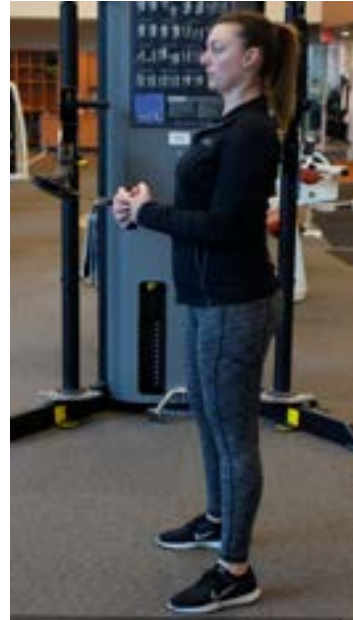


FIGURE 21. CABLE PRESS - START POSITION



FIGURE 22. CABLE PRESS - END POSITION

EXERCISES TO CORRECT ELEVATED FOOT (OBSERVED DURING EXECUTION OF SHOULDER TAPS)



FIGURE 19. BIRD DOG - START POSITION



FIGURE 20. BIRD DOG - END POSITION

REFERENCES

1. Anderson, GS, D Plecas, and T Segger. Police officer physical ability testing-Re-validating a selection criterion. *Policing: An International Journal of Police Strategies and Management* 24(1): 8-31, 2001.
2. Blacker, SD, Carter, JM, Wilkinson, DM, Richmond, VL, Rayson, MP, and Peattie, M. Physiological responses of police officers during job simulations wearing chemical, biological, radiological and nuclear personal protective equipment. *Ergonomics* 56(1): 137-147, 2013.
3. Bock, C, and Orr, RM. Use of the functional movement screen in a tactical population: A review. *Journal of Military and Veterans Health*. 23(2): 33, 2015.
4. Bock, C, Stierli, M, Hinton, B, and Orr, R. The Functional Movement Screen as a predictor of police recruit occupational task performance. *Journal of Bodywork and Movement Therapies* 20(2): 310-315, 2016.
5. Bonneau, J, and Brown, J. Physical ability, fitness and police work. *Journal of Clinical Forensic Medicine* 2(3): 157-164, 1995.
6. Butler, RJ, Plisky, PJ, Southers, C, Scoma, C, and Kiesel, KB. Biomechanical analysis of the different classifications of the functional movement screen deep squat test. *Sports Biomechanics* 9(4): 270-279, 2010.
7. Butler, RJ, Contreras, M, Burton, LC, Plisky, PJ, Goode, A, and Kiesel, K. Modifiable risk factors predict injuries in firefighters during training academies. *Work* 46(1): 11-17, 2013.

8. Byrne, JM, Bishop, NS, Caines, AM, Crane, KA, Feaver, AM, and Pearcey, GE. Effect of using a suspension training system on muscle activation during the performance of a front plank exercise. *The Journal of Strength and Conditioning Research* 28(11): 3049-3055, 2014.
9. Clifton, D, Grooms, D, and Onate, J. Overhead deep squat performance predicts functional movement screen score. *International Journal of Sports Physical Therapy* 10(5): 622-627, 2015.
10. Cook, G, Burton, L, and Hoogenboom, B. Pre-participation screening: The use of fundamental movements as an assessment of function—Part 2. *North American Journal of Sports Physical Therapy* 1(3): 132, 2006.
11. Cook, G, Burton, L, and Hoogenboom, B. Pre-participation screening: The use of fundamental movements as an assessment of function—part 1. *North American Journal of Sports Physical Therapy* 1(2): 62, 2006.
12. Frost, DM, Beach, TA, Callaghan, JP, and McGill, SM. Using the Functional Movement Screen™ to evaluate the effectiveness of training. *Journal of Strength and Conditioning Research* 26(6): 1620-1630, 2012.
13. Frost, DM, Beach, TA, Callaghan, JP, and McGill, SM. Exercise-based performance enhancement and injury prevention for firefighters: Contrasting the fitness- and movement-related adaptations to two training methodologies. *Journal of Strength and Conditioning Research* 29(9): 2441-2459, 2015.
14. Goss, D, Christopher, G, Faulk, R, and Moore, J. Functional training program bridges rehabilitation and return to duty. *Journal of Special Operations Medicine: A Peer Reviewed Journal for SOF Medical Professionals* 9(2): 29-48, 2009.
15. Gray, SE, and Collie, A. The nature and burden of occupational injury among first responder occupations: a retrospective cohort study in Australian workers. *Injury* 48(11): 2470-2477, 2017.
16. Ikeda, DM, and McGill, SM. Can altering motions, postures, and loads provide immediate low back pain relief: A study of 4 cases investigating spine load, posture, and stability. *Spine* 37(23): E1469-E1475, 2012.
17. Johnson, DC, Whitehead, NP, Pletcher, RE, Faherty, SM, Lovalekar, TM, Eagle, RS, and Keenan, AK. The relationship of core strength and activation and performance on three functional movement screens. *Journal of Strength and Conditioning Research* 32(4): 1166-1173, 2018.
18. Kibler, W, Press, J, and Sciascia, A. The role of core stability in athletic function. *Sports Medicine* 36(3): 189-198, 2006.
19. Lee, BC, and McGill, SM. Effect of long-term isometric training on core/torso stiffness. *The Journal of Strength and Conditioning Research* 29(6): 1515-1526, 2015.
20. Leetun, DT, Ireland, ML, Willson, JD, Ballantyne, BT, and Davis, IM. Core stability measures as risk factors for lower extremity injury in athletes. *Medicine and Science in Sports and Exercise* 36(6): 926-934, 2004.
21. Letafatkar, A, Hadadnezhad, M, Shojaedin, S, and Mohamadi, E. Relationship between functional movement screening score and history of injury. *International Journal of Sports Physical Therapy* 9(1): 212014.
22. Liew, BX, S Morris, and K Netto. Joint power and kinematics coordination in load carriage running: implications for performance and injury. *Gait & Posture*. 47:74-79. 2016.
23. Lisman, P, O'Connor, FG, Deuster, PA, and Knapik, JJ. Functional movement screen and aerobic fitness predict injuries in military training. *Medicine and Science in Sports and Exercise* 45(4): 636-643, 2013.
24. Lockie, RG, Schultz, AB, Jordan, CA, Callaghan, SJ, Jeffriess, MD, Luczo, TM. Can selected functional movement screen assessments be used to identify movement deficiencies that could affect multidirectional speed and jump performance. *Journal of Strength and Conditioning Research* 29(1): 195-205, 2015.
25. Mauntel, TC, Post, EG, Padua, DA, and Bell, DR. Sex differences during an overhead squat assessment. *Journal of Applied Biomechanics* 31: 244-249, 2015.
26. McGill, S. Core training: Evidence translating to better performance and injury prevention. *Strength and Conditioning Journal* 32(3): 33-46, 2010.
27. McGill, SM. The biomechanics of low back injury: Implications on current practice in industry and the clinic. *Journal of Biomechanics* 30(5): 465-475, 1997.
28. Mendrin, N, Lynn, SK, Griffith-Merritt, HK, and Noffal, GJ. Progressions of isometric core training. *Strength and Conditioning Journal* 38(4): 50-65, 2016.
29. Mokha, M, Sprague, PA, and Gatens, DR. Predicting musculoskeletal injury in National Collegiate Athletic Association Division II athletes from asymmetries and individual-test versus composite functional movement screen scores. *Journal of Athletic Training* 51(4): 276-282, 2016.
30. Nindl, BC, Williams, TJ, Deuster, PA, Butler, NL, and Jones, BH. Strategies for optimizing military physical readiness and preventing musculoskeletal injuries in the 21st century. *US Army Medical Department Journal*: 5-24, 2013.
31. O'Connor, FG, Deuster, PA, Davis, J, Pappas, CG, and Knapik, JJ. Functional movement screening: Predicting injuries in officer candidates. *Medicine and Science in Sports and Exercise* 43(12): 2224-2230, 2011.
32. Oliver, GD, and Adams-Blair, HR. Improving core strength to prevent injury. *Journal of Physical Education, Recreation and Dance*. 81(7): 15-19, 2010.
33. Orr, R. The history of the soldier's load. *Australian Army Journal* 7(2): 67, 2010.
34. Orr, RM, Pope, R, Stierli, M, and Hinton, B. A functional movement screen profile of an Australian state police force: A retrospective cohort study. *BMC Musculoskeletal Disorders* 17(1): 296, 2016.

35. Padua, DA, DiStefano, LJ, Beutler, AI, De La Motte, SJ, DiStefano, MJ, and Marshall, SW. The landing error scoring system as a screening tool for an anterior cruciate ligament injury-prevention program in elite-youth soccer athletes. *Journal of Athletic Training* 50(6): 589-595, 2015.
36. Park, H, Branson, D, Kim, S, Warren, A, Jacobson, B, Petrova, A, Peksoz, S, and Kamenidis, P. Effect of armor and carrying load on body balance and leg muscle function. *Gait and Posture* 39(1): 430-435, 2014.
37. Peate, W, Bates, G, Lunda, K, Francis, S, and Bellamy, K. Core strength: A new model for injury prediction and prevention. *Journal of Occupational Medicine and Toxicology* 2(1): 3, 2007.
38. Post, EG, Olson, M, Trigsted, S, Hetzel, S, and Bell, DR. The reliability and discriminative ability of the overhead squat test for observational screening of medial knee displacement. *Journal of Sport Rehabilitation*: 1-4, 2017.
39. Sell, TC, Pederson, JJ, Abt, JP, Nagai, T, Deluzio, J, Wirt, MD, McCord, LJ, and Lephart, SM. The addition of body armor diminishes dynamic postural stability in military soldiers. *Military Medicine* 178(1): 76-81, 2013.

Robert Lockie is an Assistant Professor in Strength and Conditioning at California State University, Fullerton. He obtained his undergraduate and honors degrees in human movement from the University of Technology, Sydney. Lockie also completed his PhD at the University of Technology, Sydney, within research that analyzed the sprint technique and strength and power capacities of field sport athletes. He has previously worked at the University of Newcastle in Australia as a lecturer in biomechanics, and an Assistant Professor in biomechanics and strength and conditioning at California State University, Northridge. Lockie conducts research into linear speed, change-of-direction speed, and agility; strength and conditioning; post-activation potentiation; team sport analysis; and analysis of law enforcement, correctional, and tactical populations.

ABOUT THE AUTHORS

Katherine Balfany is currently pursuing a Master of Science degree in Kinesiology from California State University, Fullerton. She received her Bachelor of Science degree in Exercise and Sports Science from the University of Wisconsin-La Crosse. Balfany is a Certified Strength and Conditioning Specialist® (CSCS®) through the National Strength and Conditioning Association (NSCA) with 10 years of experience in strength and conditioning, personal training, and health and wellness promotion. She has worked with developmental and elite athletes, corporate populations, and has over four years of experience working in the sports performance wearable technology industry. In addition to her tactical research, Balfany conducts research in exercise physiology and biomechanics of sports performance with the use of wearable technology and sport and exercise psychology; she also coaches tennis.

Caitlyn Heredia is currently pursuing a Master of Science degree in Kinesiology at California State University, Fullerton with an emphasis in Biomechanics. She obtained her Bachelor's degree in Health Sciences from Whitworth University in Spokane, WA. Heredia has a background in sports medicine, which included providing emergency care, therapeutic treatment, and movement-based training to athletic populations. She has previously interned with the Gonzaga University men's soccer team, Gonzaga University women's rowing team, Spokane Chiefs Western Hockey League team, and Seattle Mariners Major League Baseball (MLB) team. She is currently teaching anatomy lab at California State University, Fullerton. Heredia's research interests include biomechanics of screening movements, and sports and tactical performance. She is currently working on an anterior cruciate ligament (ACL) research project and her own research on kinematics of the Functional Movement Screen (FMS).

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



SORINEX®
EXERCISE EQUIPMENT

KEEP SOLDIERS SAFE. **KEEP SOLDIERS READY.**

Protect soldiers while in training

Zephyr™ performance systems wearable monitors used in training can provide potential life-saving and performance-enhancing benefits.¹

USE PHYSIOLOGICAL DATA TO HELP SOLDIERS PERFORM — AND STAY SAFE.

Real-time physiological status monitors (RT-PSM) can track and manage²:

- Thermal strain and workload
- Alertness and neurocognitive status
- Early signs of physical fatigue and potential injury

MONITOR SOLDIERS FOR MENTAL AND PHYSICAL READINESS

Zephyr™ BioModule device features include:

- Estimated core body temperature algorithm
- Stress detection algorithm
- Physiological and mechanical loads

ZEPHYR™ PERFORMANCE SYSTEMS — ACCURATE AND RELIABLE

When compared to 11 RT-PSMs on the market, Zephyr™ systems heart rate monitor was the most accurate under all training conditions compared to the gold standard.¹ Wearable technologies like Zephyr™ systems can monitor physiological performance during soldier selection and training for specialized operations.

They can also help¹:

- Reduce injuries
- Decrease physical training costs
- Improve retention by improving Physical Fitness Scoring



For more information, contact betsy.v.sammons@medtronic.com

1. Murdoch RC, Hagen JA. Soldier safety and performance through wearable devices. *Proc SPIE Int Soc Opt Eng*. 2018; doi: 10.1117/12.2304899

2. Friedl KE, Buller MJ, Tharion WJ, Potter AW, Manglapus GL, Hoyt RW. Real Time Physiological Status Monitoring (RT-PSM): Accomplishments, Requirements, and Research Roadmap. Natick, MA: U.S. Army Research Institute of Environmental Medicine. 2016.



1885 BOB JOHNSON DRIVE | COLORADO SPRINGS, CO 80906
PH: 719 632-6722 | TF: 800 815-6826 | FX: 719 632-6367
NSCA.com