

TSAC REPORT

ISSUE 70



THANK YOU TO BRIAN SCHILLING, PHD, CSCS, FNSCA

The National Strength and Conditioning Association (NSCA) would like to thank Brian Schilling, PhD, CSCS, FNSCA, for his service as Editor-in-Chief of the *TSAC Report*. During his tenure, the journal experienced substantial growth with a vastly growing readership. Under Dr. Schilling's guidance, the *TSAC Report* has aided countless tactical facilitators as well as other professionals who work with tactical populations to optimize the training and performance of military personnel, firefighters, emergency medical technicians, and law enforcement officers.

Dr. Schilling became the Editor-in-Chief of the *TSAC Report* in April of 2020. Since then, he has overseen the publication of 14 issues, consisting of 89 articles and 511 pages of content. Throughout this time, he worked with 104 different authors and co-authors, over 20 different members of the editorial review panel, and numerous staff members at the NSCA to deliver the highest quality information possible for NSCA Members.

The NSCA would like to recognize and thank him for the time and effort he has put forth over the years to drive the growth, quality, and exposure of the journal to new heights. His dedication to working with authors, reviewers, and NSCA staff to produce accurate and practical content has helped elevate the *TSAC Report* to one of the most valuable tactical resources in the field.

As Dr. Schilling steps down from his position, Katie Sell, PhD, CSCS, NSCA-CPT, RSCC, has been selected to be the next Editor-in-Chief of the *TSAC Report*. Thanks to Brian Schilling's hard work, the journal is currently in a great position to continue to grow and positively impact the training and performance of tactical populations.

The NSCA thanks Brian Schilling for his excellent work and dedication to the field of strength and conditioning.



Brent Alvar, PhD, CSCS,*D, TSAC-F,*D, FNSCA
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PERFORMANCE UNDER PRESSURE – COPING SKILLS AND MITIGATION STRATEGIES FOR TACTICAL PERSONNEL

INTRODUCTION

Performance under stress in tactical personnel and factors that influence performance were discussed in a previous *TSAC Report* article (54). Tactical professionals are exposed to acute and chronic stressors that negatively impact performance on the job (4,29,67). Energy restriction, minimal sleep or altered sleep schedules, intense physical and cognitive demands, environmental extremes, and psychological strain are just a few of the stressors tactical personnel are exposed to on the job (29,57,67). Performance decrements are a result of the body's physiological stress response, involving a cascade of hormonal responses and activation of the adrenal system (1,15,55). Performance decrements resulting from stress include declines in high-level cognitive processing and the ability to perform physical and skill-based tasks important for the job (19,24,42,64). The long-term health and resilience of personnel may be dependent on their ability to respond to, and tolerate, these demands over time. Therefore, understanding how to measure stress and the impact it has on personnel is critical to developing strategies to manage stress and attenuate associated negative responses that may be experienced. In this edition, specific measures of stress that can be monitored, as well as coping skills to mitigate the negative effects of stress, will be discussed.

OBJECTIVE MEASURES

Heart rate (HR), heart rate variability (HRV), body temperature, blood lactate, salivary cortisol (sCorti), salivary alpha amylase (sAA), and testosterone are some of the most commonly observed measures used by researchers in relation to physiological stress in tactical personnel (14,24,43,62,63). As a part of the body's "fight or flight" response, HR increases during acute, stressful events (29). When HR remains elevated, both during and following an event, it is not only a concern for performance, but also for the individual's health. The repeated and prolonged cardiovascular strain experienced by tactical personnel may lead to greater risks of developing cardiovascular disease (CVD) (16,59). Additionally, negative changes in HRV—an expression of neurocardiac function—are observed in environments and tasks where high levels of stress are experienced and sympathetic activity is increased. In line with these changes, body temperature typically increases, leading to a greater risk of experiencing a heat-related illness (25,69). This combination of cardiovascular and thermoregulatory strain may increase perception of exertion and decreases attention, vigilance, and short-term memory—critical components of the tactical personnel's role (36,66).

Elevated levels of blood lactate are a normal physiological response to intense physical exertion in an attempt to further supply energy to the system when glucose is depleted, similar to increases in HR as a means to supply more oxygen (20). However, the accumulation of lactate in the blood beyond a certain threshold, relative to each individual, ultimately leads to fatigue and the inability to continue physical activity at a high level (50). Much like blood lactate, increases in cortisol are a typical response to prolonged, high-intensity aerobic exercise and physical activity. Cortisol is a catabolic hormone that initially increases in response to a stressor as a result of activation of the adrenal system (56). When cortisol levels are elevated, typically levels of testosterone are suppressed (58). Testosterone is anabolic in nature, in that it supports the building of muscle proteins and muscle growth (30). When applied appropriately, this change in cortisol and testosterone can be beneficial for adaptations. Under conditions in which tactical personnel often find themselves in for prolonged periods of time, this response can lead to fatigue and poor performance in tasks necessary for the job, especially if prior fitness levels are not optimal (21,29,37,46). Furthermore, these stress-related changes have a negative impact on functions that are critical for coping with threatening, high-stress circumstances (12).

SUBJECTIVE MEASURES

In addition to objective measures, subjective measures that are based on an individual's feelings and perceptions may be used to examine stress. Vartanian et al. suggests one's psychological make up, based on their previous exposures to stress and trauma, may influence an individual's physiological response (63). Ratings of perceived exertion (RPE) is one of the most commonly used subjective measures during training and stressful events (34,44,68). RPE is typically examined on a 10- or 15-point scale, with low values representing less perceived effort and higher values representing greater perceived effort (10). In 14 different studies assessing RPE during combat simulations, parachute jumps, live-fire training events, and military assessment courses, all but two observed significant increases in RPE (13,14,19,24,34,35,44,47,50,51,60,61,64,68). This suggests that personnel's perceptions of physical effort had gone up drastically from start to finish in grueling tasks and environments. Another tool that assesses an individual's response to stressful scenarios is the state-trait anxiety inventory (STAI). The STAI is a self-report scale measuring anxiety in the moment (state anxiety) and one's predisposition to anxiety (trait anxiety) (53). Often, the state anxiety portion of the survey is used in isolation when assessing feelings of distress both before and after. Both significant decreases and increases

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have been observed in firefighting interventions, selection courses, and simulated operations (24,50,46). This discrepancy could be a result of hyperreactivity of the autonomic nervous system due to high-stress demands. The stress experienced by personnel may be perceived, such as stress or anxiety around performing a task, or actually from the physical demands of the task. It is not uncommon for incongruences to be seen in subjective reporting due to the effect of intense physical demands on superior cognitive processing (23). Therefore, it may be more beneficial to assess subjective measures in combination with objective measures to get a better picture of the stress experienced in tactical personnel.

COPING SKILLS/MITIGATION STRATEGIES

Performing skill-based tasks under pressure is a highly emotional experience (7). The implementation of coping strategies to mitigate the impact that acute physiological stress can have on tactical performance is vital to avoid degradation of gross and fine motor control, cognition, or perception (8,11,40,41). Failure to manage the stress response appropriately can have severe consequences on performance, potentially leading to catastrophic outcomes (65). Two potential coping skills/mitigation strategies include biofeedback breath work and stress exposure.

Biofeedback training in the form of breath work has been used extensively to mitigate the effects of anxiety and increase coping resources, as well as to attenuate the impact that stress has on an individual's physiology (11,22). The use of breathing techniques while in a rested state have been linked to the synchronization of breathing, baroreceptors, HRV, and cortical activity in the brain (22). "Tactical breathing," also known as "box breathing," has been used as a breath work technique to assist soldiers to control their physiological response in stressful situations, enabling them to remain in a zone of optimal performance (28). Tactical breathing consists of inhaling through the nose, holding the breath, exhaling through the mouth, and holding the breath (e.g., inhale X seconds, hold X seconds, exhale X seconds, hold X seconds) for 4 – 5 cycles of equal time (49). Some studies show that the use of prolonged exhalation may be more effective during physical activity than slow-paced breathing, whereas slow-paced breathing may be more beneficial in a resting state, such as post-activity (49).

The use of diaphragmatic breathing during activity may also provide some benefit when applied appropriately. Officers who used diaphragmatic breathing during virtual reality training were able to apply the technique as they proceeded through the scenario, decreasing the impacts of visual occlusion (narrowing of the field of vision) (38). This may be due to the influence that diaphragmatic breathing has on increasing attention and vigilance during performance (33). There are no significant differences in effectiveness between the varying types of deep, slow breathing techniques on respiratory sinus arrhythmia as mediated by baroreflex sensitivity (blood pressure variability) (17). Most of

these studies only examined the effectiveness in resting states, when the goal was parasympathetic activation (relaxation), not for regulating emotional control during performance (17,27,49).

Although effective, it is unclear if breath work would have a carryover effect during a critical incident or during a scheduled shift. However, a few studies would indicate that breath work during activity may mitigate the effects of acute stress during police performance (11,38,49). Although further studies are needed, breath work appears to be a viable modulation strategy for tactical personnel who are involved in high stress situations. The practice and training of diaphragmatic breathing may provide preventive measure to the repeat exposure to bouts of acute stress in future encounters (33). Both breath work and exposure to stress during training can be helpful in mitigating the negative effects of acute stress on tactical performance.

Exposure to stress in training is used by many military and law enforcement agencies as a technique to better prepare their personnel for stressors in high-pressure situations (5,9,26). The technique gradually exposes the personnel to increasingly challenging situations during training with the aim of mitigating the psychophysiological effects in real world situations (31). There are several studies that focus on the effectiveness of stress inoculation during training that mitigate the impact of undesired outcomes (6,31,45). Exposure to high-pressured scenarios during training can, over time, mitigate the negative effects of the stress response, leading to improved police performance (e.g., tactical decision making) in addition to increasing the capacity for effective stress management (2,32).

Reality-based training has been shown to significantly correlate to stress levels experienced in real-world scenarios, especially when live role players are incorporated into the training scenarios (3,31,58). The monitoring of physiological biomarkers (e.g., HR, HRV, sAA, sCorti) during training promotes training situations that incorporate the level of pressure that provides the desired activation of the stress response for effective training effect (3,18). Regularly including stress as part of the training improves performance (e.g., speed, accuracy, decision making), while potentially decreasing error rates (48).

Incorporating stressful conditions into training programs is an effective stress mitigation strategy, better preparing tactical personnel for real-world critical incidents (3,18,31,39,41). When developing an effective training program for tactical personnel, it is necessary to include some form of scenario-based training (e.g., live role playing, virtual reality) that also exposes the tactical personnel to high-stress situations that they must work through. This type of exposure during regular training is critical to induce real-world psychophysiological responses for tactical personnel to be able to learn and apply their skills under threatening conditions.

SUMMARY

Observation of both subjective and objective measures of physiological stress may be instrumental in determining the amount of strain personnel experience in tasks and environments they may be exposed to inherently in their occupation. When examined in conjunction, tactical facilitators may be able to get a deeper understanding of the detrimental effects of stress on task performance. In turn, strategies to mitigate these stressors can be implemented. Breath work, diaphragmatic breathing, and repeated exposure to stressful conditions are a few strategies that have been seen to help downregulate HR, cortical activity in the brain, and specific physiological biomarkers during simulated training events. It is important to educate personnel on the use of stress mitigation strategies and teach them how to implement them appropriately in training so that they may be able to apply them in real-life scenarios.

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TSAC RESEARCH COLUMN—APRIL 2023

Long-term fitness changes, experience-based physiology, and normative test data are the highlights of this issue's research column. In the first article, researchers tracked changes in fitness variables over five years in male and female law enforcement officers. The second article analyzed the relationship between occupational tasks and experience in military personnel. The researchers analyzed the data to establish how years of service, deployment time, and job experience may impact physiological variables during physically demanding tasks, such as a road march. The final article aimed to establish normative values for firefighters in eight different fitness assessments. The study also examined how physical attributes can vary between male and female trainees and between academy classes.

LONGITUDINAL CHANGES IN HEALTH AND FITNESS MEASURES AMONG STATE PATROL OFFICERS BY SEX. *JOURNAL OF STRENGTH AND CONDITIONING RESEARCH* 37(4): 881-886, 2023.

DAWES, JJ, DOS SANTOS, ML, KORNHAUSER, C, HOLMES, RJ, ALVAR, BA, LOCKIE, RG, AND ORR, RM

Health and fitness declines are an expected part of the aging process. However, these declines may decrease occupational safety in physically demanding jobs like law enforcement. In a recent longitudinal study, researchers analyzed changes in various fitness metrics over five years. Whether it is the stresses of the job or simply getting older, the researchers wanted to see which, if any, fitness metrics changed over time.

The data from 523 state patrol officers (494 men and 29 women) from a single agency were analyzed and encompassed the data from 2014 and 2018. The average age of the male and female officers in the first year was 39 ± 7 and 37 ± 8 years old, respectively. Height and weight data were self-reported by the officers and used to calculate body mass index changes over five years. The authors noted previous literature has shown no significant difference in self-reporting anthropometric data among law enforcement officers. Vertical jump height was used as a lower body power measurement and was collected using a Just Jump contact mat. Maximal push-ups and sit-ups in 60 s were used as muscular endurance tests. Finally, a 20-m multistage fitness test was used to estimate the officer's VO_2max . The test included running 20-m using an audio cue the officers needed to keep pace with. The audio cues started at a running speed of 8.5 km/h and increased by 0.5 km/h at each stage. The final speed the officer could complete on time was used to estimate VO_2max using an equation developed by Flouris et al.

Test scores among the male officers showed a small yet significant decline in fitness over the five years. Vertical jump (-3.4% , $d = 0.2$), push-ups (-11% , $d = 0.3$), and VO_2max (-3.5% , $d = 0.1$) significantly declined over the five-year period. However, female officers significantly improved their sit-ups score (10.4% , $d = 0.4$). All other measurements did not have significant changes. Based on the results the researchers found after five years, male officers appear to show small, yet significant, declines in lower body power, upper body muscular endurance, and aerobic capacity. However, female officers were shown to be more resistant to fitness declines and improved abdominal muscular strength. The tactical facilitator should assist officers in maintaining or improving various fitness scores to ensure officers' physical capacities do not significantly decline over the course of their career. Although female officers may be more resilient to fitness declines and thus may also show greater improvements in their 30s and 40s, the tactical facilitator should emphasize fitness capacity throughout the career regardless.

The authors noted that these results were observed in an agency that held annual fitness testing for their officers, a practice that is not universal. Fitness changes may be more pronounced in agencies that do not require yearly fitness assessments among their officers. Tactical facilitators working with law enforcement or other tactical athletes should emphasize fitness and performance goals during their training programs. Ensuring their athletes are maintaining or improving in their baseline fitness areas, such as lower body power and muscular endurance, can facilitate officers' success on the job as well as overall health.

OCCUPATIONAL EXPERIENCE EFFECTS ON PHYSIOLOGICAL AND PERCEPTUAL RESPONSES OF COMMON SOLDIERING TASKS. *JOURNAL OF STRENGTH AND CONDITIONING RESEARCH* 37(4): 894-901, 2023.

COHEN, BS, REDMOND, JE, HAVEN, CC, FOULIS, SA, CANINO, MC, FRYKMAN, PN, AND SHARP, MA

The United States Army recently researched how soldiers' occupational experience may collectively impact their physiology and perception of physically-demanding tasks. The researchers examined how soldiers' occupational experience may impact heart rate (HR), oxygen consumption (VO_2), and rating of perceived exertion (RPE) while performing five physically demanding tasks. Data was collected from 152 male and 85 female soldiers from various military occupational specialties with high physical demands.

Soldiers performed all tasks with a heart rate monitor and a metabolic unit and specified their ratings of perceived exertion (RPE) after each task. Task one was a simulated road march on a treadmill while wearing a full 46.3 kg load. Soldiers walked on the treadmill for 40 min at a 3 km/h pace. To simulate variations in terrain, two versions of the test were run. One version used no change in treadmill incline, and the second used an incline that changed throughout the test. Task two simulated a sandbag fill and carry and was performed wearing a 37.6 kg fighting load. Soldiers filled 26 sandbags 55 – 60% full (13 – 18 kg) of sand and carried them 10 m to build a fighting position. Task three was a simulated body drag using a 123-kg dummy. Soldiers dragged the dummy 15 m as fast as possible while wearing a fighting load (32.6 kg). The drag was performed on both concrete and asphalt. Task four simulated a casualty evacuation from a vehicle. While wearing a fighting load (35 kg), two soldiers pulled a 93-kg simulated casualty from the commander's seat of an armored vehicle. The task was performed with and without carrying a weapon. The final task was simulating movement under fire. Wearing a full fighting load (37.6 kg) and a training weapon in the ready position, soldiers moved 100 m while transitioning between sprinting, prone, and kneeling positions.

A linear regression model examined the soldiers' task performance and how they related to their occupational experience. There was a significant and large effect between deployment time and HR observed during road march ($p < 0.001$), sandbag fills ($p = 0.005$), and sandbag carry ($p = 0.007$). Based on the linear regression model, one year of deployment was associated with a decrease in HR post-road march by 10 beats per minute (bpm), three bpm during the sandbag fill, and one bpm during the sandbag carry. Years on the job and military service were also associated with a two- and one-bpm decrease for road march performance, respectively. Based on the study's results, the researchers suggested that simulating deployment conditions may enhance task performance, particularly with the road march task. Being more adapted to load carriage may improve physiological demand from similar tasks while on a mission. Using a loaded march in training under various environments (e.g., temperature, altitude, terrain) and tempos may improve overall adaptations both for training and while deployed. However, the tactical facilitator should monitor overall work volume to avoid overtraining. Additionally, using non-traditional training loads such as sandbags may assist soldiers in adapting and learning the most efficient way to handle non-ridged loads while on a mission.

DIFFERENCES IN FITNESS BETWEEN FIREFIGHTER TRAINEE ACADEMY CLASSES AND NORMATIVE PERCENTILE RANKINGS. *SUSTAINABILITY* 14(11): 6548, 2022.

LOCKIE, RG, ORR, RM, MONTES, F, RUVALCABA, TJ, AND DAWES, JJ

Testing and comparing an athlete's fitness against normative values can highlight possible weaknesses or areas needing improvement. Whether for training goals, or occupational assessment, normative values are great for strength and conditioning coaches to compare their athletes to a larger population. Recently, data were examined from six firefighter academy classes (274 males and 31 females) to establish normative value ranges. Additionally, the researchers aimed to determine differences between the classes to better understand which fitness areas may have wide ranges between and within classes.

Data collected from fitness tests conducted at the academy at the start of a 16-week academy training period was examined. Tests included: Illinois agility test (IAT), push-ups, pull-ups, leg tucks, multistage fitness test, backward overhead 4.54-kg medicine ball throw (BOMBT), 10-repetition maximum deadlift, and 18-kg kettlebell farmer's carry. All tests were conducted by the academy staff and completed in a single session. The IAT tested change-of-direction and used the fastest of 1 – 2 trials. Push-ups were performed using a metronome set to 80 bpm, where the trainees would lower themselves on one beat and up on the next. The test was concluded when the trainee could no longer keep up with the beats or if they performed 100 repetitions. Pull-ups were performed from a dead hang position using a pronated grip. Repetitions only counted if the trainee could get their chin above the bar and return to the original dead hang position. Using the legs in a "kipping" action was not allowed. The leg tuck was performed in a free-hanging position from a bar using an alternating grip. The trainees raised their legs touching knees to elbows, then returned to the original start position with no excess swinging. The multistage fitness test was used to estimate VO_2max . The BOMBT task used a 4.54-kg medicine ball to assess total body power. Trainees stood with their backs to the throwing area and threw the ball overhead and backward. The furthest distance from the start position was scored. Finally, the farmer's carry had trainees hold an 18-kg kettlebell in each hand and walk as fast as possible for 100 yards.

TABLE 1. NORMATIVE DATA FOR FIREFIGHTERS

PERCENTILE RANK	IAT (S)	PUSH-UPS (REPS)	PULL-UPS (REPS)	BOMBT (M)	VO_2MAX (ML/KG/MIN)	LEG-TUCK (REPS)	10-REP DEADLIFT (KG)	FARMER'S CARRY (S)
50 – 100th	16 – 18.5	60 – 100	13 – 28	9.6 – 13.8	46.2 – 61.2	13 – 30	145.2 – 185.9	21 – 27.5
0 – 49th	18.6 – 32	0 – 59	0 – 12	4 – 9.5	20.2 – 46.1	0 – 12	90.7 – 145.1	27.6 – 49

The full percentile rankings of the normative data can be found in the original paper, but a summarized version can be found in Table 1. There were significant differences in the IAT ($p < 0.001$), BOMBT ($p < 0.001$), leg tuck ($p = 0.022$), deadlift ($p < 0.001$), and farmer's carry ($p < 0.001$) between the upper and lower 50th percentile performing groups. These results indicate that even though each trainee qualified to enter the training academy, some trainees may still need improvements in specific fitness attributes. A tactical facilitator working with firefighters may benefit from using the normative data in this study to identify any possible weaknesses in their tactical athletes. Additionally, the data revealed that most female trainees fell below the 30th percentile for each test's normative values. For tests such as the farmer's carry and BOMBT, this may indicate that female trainees' strength levels are weaker when using an absolute load. However, tests that used the trainee's body weight as a resistance showed a much more normal distribution. In either case, female firefighters should aim to increase overall strength to ensure moving heavy equipment and potentially other humans can be accomplished safely on duty.

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DEVELOPMENTAL MODEL FOR PROSPECTIVE MALE AND FEMALE US AIR FORCE SPECIAL WARFARE CANDIDATES—PART II: TRAINING PROGRAM MANAGEMENT

The views expressed are those of the authors and do not necessarily reflect the policy or the position of the Department of the Air Force, the Department of Defense, or the United States Government.

INTRODUCTION

In the initial installment of this article series, the authors provided a brief exploration of previous literature relevant to the preparatory training of both men and women hopeful to enter the United States Air Force Special Warfare (AFSPECWAR) pipeline, which included comparisons of historical aerobic and strength/power sport performances, training outcomes during other military programs of initial entry, and physiological basis for the recommendations contained within this article (13). Part II will focus on management of that training process, including providing suggested training volumes, frequencies, and intensities intended to meet the demands to be encountered within the first phases of a Special Warfare Operator's development as well as a method to identify the length of introductory program duration based on absolute and relative performance in relation to entry requirements and known sources of injury risk.

Pre-enlistment physical training for those hopeful to be accepted into the formal AFSPECWAR training program should include a substantial amount of physical preparation directed toward the mastery of load carriage in the form of high frequency ground impacts including extensive and intensive plyometrics as well as traditional loaded marches. The manipulation of heavy objects as a skill should be included supplementary to training intended to increase the probability of passing the Physical Skills and Stamina Test Physical Abilities Stamina Test (PAST) (now referred to as Initial Fitness Test [IFT]), which includes "traditional" preparatory methods such as high-volume running, bodyweight calisthenics, resistance training, and swimming. In keeping with many of the "Ten Pillars for Successful Long-Term Athletic Development" highlighted in the National Strength and Conditioning Association (NSCA) position statement, developmental programs should aim to reduce or mitigate the risk of injury to ensure ongoing participation and continued physical development, as well as provide multiple modes of exercise to training to enhance health and specific skill-related fitness with systematic progression principles (11).

PART I: REVIEW

It should be acknowledged that the stress incurred during preparatory training geared toward passing the IFT, previously referred to as the PAST, the objective measure of preparedness for entry into basic military training (BMT) and the Special Warfare Candidate Course (SWCC), may increase the chance of injury in relation to most recreational physical training programs. An example of a common occupational task, or end-state goal that would also present injury risk in AFSPECWAR Operators and highlighted in Part I of this series, was the ability to move more than 15 mi while wearing 45 lb of personal protective equipment (PPE) and a 60-lb rucksack (12). Another common task within the occupational training pipeline that has been observed to be associated with upper-extremity injury in this population is the manipulation and utilization of ropes in the form of mountaineering, rescue operations, fast roping, and the ascent or descent of rope ladders. These "end-state performance goals" would be realized near completion of the approximately two-years of specialized training; however it has been documented that competency in general physical tasks can be highly influenced by the length of specific training history (5). In the first installment of this series, it was further noted that the greatest proportion of musculoskeletal injuries (MSKI) reported in this specific population were diagnosed as general or non-specific and affecting the lower extremities, with many injuries happening 30 – 180 days after entering apprentice training (3).

PROGRAM GOALS

The principle aim of this article is to provide each person, male or female, with awareness of the entry criteria, the necessity to surpass those criteria, the physiological adaptations necessary to arrive and immediately integrate into the established training program within the AFSPECWAR pipeline, and to provide an opportunity to familiarize themselves with the foundational work that may be necessary for completion of other highly competitive military selection processes. During each phase of this training program, the demands will build upon the last phase to provide greater individual resistance to high volume metabolic and cardiovascular challenge, ground impact demand, external load manipulation, and an overall physical robustness necessary to endure each stage of initial training. Once complete, those who fulfill the demands of this program should be able to clearly exceed IFT standards of performance, have increased physical work tolerance relevant to grueling load carriage over distance,

DEVELOPMENTAL MODEL FOR PROSPECTIVE MALE AND FEMALE US AIR FORCE SPECIAL WARFARE CANDIDATES— PART II: TRAINING PROGRAM MANAGEMENT

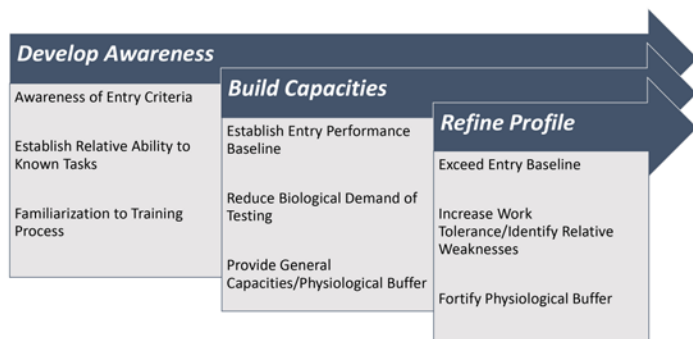


FIGURE 1. PROGRAM GOALS

and fortified their physiological buffering capacities to complete these tasks for successive days or weeks. Figure 1 provides visual representation of these overarching intentions.

An emphasis on frequency of important physical qualities will be the foundation of this intervention to supplement the sex-differences in translation of key metabolic factors observed between men and women in response to similar training programs. Additionally, the structure and duration of the program will initially hinge on general physical ability in relation to the known entry criteria and transition toward a more specific and absolute non-negotiable performance standard that indicates readiness to begin more formal AFSPECWAR training programs. See Figure 2 for a visual representation of the process for determination of the suggested length of the preparatory period as determined by relative aerobic performance and specific training, or exposure, history. This graphic is theoretical but may provide clarity when establishing timelines and identifying key training interventions. Run and swim performance were selected as primary screening tools due to the vast amount of evidence that aerobic performance clearly contributes to injury risk within entry-level military, sport, and general fitness populations (3,7,14).

Load carriage and impact sport history has also been established to be associated with bone mineral density (BMD), as individuals who exhibit low BMD have previously been identified to have an increased risk of injury during sports or military training (13,19,20). Overall training phase and program lengths are suggested due to the observed rates of skeletal muscle, connective tissue, and bone adaptation reported in similar groups of active young-adults of both biological sexes (2,8,9). Lastly, prior MSKI has a historically established influence to future injury in AFSPECWAR cohorts (3). The authors would suggest an extended preparatory period of at least 16-weeks and encompassing, at least phases 1 – 3, as a protective measure when a potential candidate has had prior MSKI that has resulted in periods where physical training or competition was halted or limited due to that injury within the prior 12-months

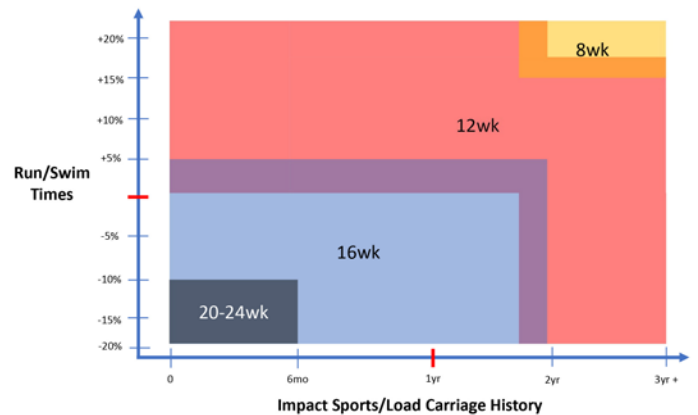


FIGURE 2. PROGRAM LENGTH DECISION MATRIX

(15). This suggestion is extended regardless of entrance test performance or training history duration.

The ability to surpass each expectation of the IFT should be desired prior to attendance to the AFSPECWAR training pipeline, but this test is not entirely representative of the rigors to be faced later within this training environment. It may be helpful to view the IFT, or similar military entry testing, as an assessment that could indicate whether a person is prepared to commence training within the pipeline, but not necessarily to complete the pipeline. Those who test higher during initial fitness evaluations may then be better prepared to begin the specific developmental process, which can impart much greater physical demand in the form of external load carriage, time demands, and a greater array of mental and physical difficulties over vast periods of time and distances when compared to the IFT (2,6,11,23).

RELATIVE ASSESSMENT OF ABSOLUTE PERFORMANCE CRITERIA

Establishing the initial parameters for training interventions directed toward attendance of a military training and selection program can often lead to an outcome-biased approach, as “success” hinges on performance of absolute tasks. Enlisting candidates must successfully complete all portions of the IFT to minimum standards prior to arrival at BMT and once more prior to acceptance into SWCC at the completion of BMT. There should be primary emphasis that these standards are minimums, and it is in the opinion of the authors that each potential candidate would be well served to surpass these expectations by as much as possible before arrival. Minimum IFT performance criteria and the suggested order of events when completing pre-testing is indicated in Table 1.

It would be valuable to ensure each potential candidate is aware of these criteria as non-negotiable for entry into the desired AFSPECWAR career fields, as stated above. Ensuring this relationship is explicitly represented prior to arrival will lessen

TABLE 1. SWCC ENTRY STANDARD ASSESSMENT GUIDE

	Event	-20%	-15%	-10%	-5%	Minimum Standard	5%	10%	15%	20%
1	1.5mi Run (mm:ss)	12:24	11:53	11:22	10:51	10:20	9:50	9:29	8:58	8:37
2	Pull Up in 2:00 (mm:ss)	5	6	7	7	8	9	9	10	12
3	Push Up in 2:00 (mm:ss)	32	34	36	38	40	42	44	46	48
4	Sit Up in 2:00 (mm:ss)	38	41	44	47	50	53	55	58	60
5	500m Surface Swim (mm:ss)	18:00	17:15	16:30	15:45	15:00	14:15	13:30	12:45	12:00

much of the anxiety and difficulty in an already stressful situation and confidently mitigate the chances of non-acceptance into training. An excellent method to integrate the elements vital to being prepared for a challenging physical training or selection course would be to emphasize training that is most relevant to the exact qualities that are tested during that course while constantly exposing each potential candidate to the training intended to provide robustness against known sources of injury (e.g., lower-extremity injuries in the presence of extended load carriage and running training).

SPECIFIC TRAINING HISTORY

Achievement of physical abilities can be thought of as the sum of training frequency, duration of specific training sessions, length of that training program, and the intensity of that training in relation to the demand of the task (6). In lieu of an extended training period, 5-years of load carriage training which has been shown to be beneficial in performance of that task independent of body weight or biological sex for example, it is necessary to exploit the factors of frequency, intensity, and duration explicitly directed toward those goals most pertinent to the AFSPECWAR candidate (5). Identification of those factors at the initiation of training requires specific testing. Once proficiency and ability have been identified and compared to known entry or completion standards, the length of the program can be estimated within the personal context of available training time the individual has available.

For example, an individual who did not participate in contact sports or load carriage who is attending school and working a moderate to highly physical job 4 – 5 days per week may not be able to train more than three days per week. This situation may indicate that their specific training program may need to be longer in comparison to someone who is not attending school or working multiple days per week with a better training history. In contrast, a potential candidate who performs well above the established

standards and has a history of load carriage experience may require a shorter training program or possibly make due training with less frequency in order to simply meet or exceed initial-entry performance standards, due to the fact they have already displayed the physical aptitude and have possibly incurred the adaptations that would facilitate the training to increase tolerance of the biological tissue to the known physical tasks within the program. Though, it is advised to take heed of the general training recommendations in this article as best as possible. Limiting frequency (less than three training days per week) may not detrimentally affect IFT performance but may also not aid in mitigation of overuse-type injuries common to AFSPECWAR, as physical training occurs multiple times a day over the five-day training week.

PRE-TESTING

Initial testing can be conducted in one day in the following order with at least five minutes of rest between test events (Table 1) or over multiple days, again with five minutes of rest between events on each day. Only conduct water-event testing and training when a qualified lifeguard or swim instructor is present. For best results, seek to maintain the prescribed order of events; completing all events within a week, regardless of order, is also acceptable if that is the only option. Once testing is complete, compare individual results to the entry standards to establish length of the program, initial workload parameters, and program structure. It is not necessary to conduct testing each week, but a frequency of once every 4 – 6 weeks can provide a snapshot of progress as well as provide a time to rehearse the IFT.

TRAINING PROGRAM DAILY STRUCTURE

Each day, training will be prioritized by the importance of each task. This means the most important activities for that day and phase of training will be placed first with respect to the magnitude of residual fatigue and necessary volume of exposure necessary

DEVELOPMENTAL MODEL FOR PROSPECTIVE MALE AND FEMALE US AIR FORCE SPECIAL WARFARE CANDIDATES— PART II: TRAINING PROGRAM MANAGEMENT

TABLE 2. DEVELOPMENTAL PROGRAM MANAGEMENT

Pre-SWCC Program Element Suggestions				
Phase	0: Training Familiarization	1: Establish Work Capacities	2: Increase Workload Tolerance	3: Exceed Entry Baseline
Duration	4-6 Weeks	4-6 Weeks	4-6 Weeks	4-6 Weeks
Plyometrics	Frequency: 2-3 days/week Weekly Volume: 100-150 reps Structure: 40-50 reps/session Double to Single Leg Low Amplitude Surface: Grass/Rubber Track Load/RPE: 3-5 RPE, band assist Intent: Quality Movement Rest: 180s	Frequency: 2-3 days/week Weekly Volume: 200-250 reps Structure: 50-75 reps/session Single Leg (75%) Low/Mod Amplitude Surface: Grass/Rubber Track Load/RPE: 4-6 RPE, bodyweight Intent: Quality Movement Rest: 120s	Frequency: 3-4 days/week Weekly Volume: 300-500 reps Structure: 100 reps/session Double to Single Leg Mod Amplitude Surface: Rubber Track/Hard Load/RPE: 4-6 RPE, +10-20lbs Intent: Rhythm/Balance Rest: 60s	Frequency: 4 days/week Weekly Volume: 400-600 reps Structure: 125-175 reps/session Single Leg (75%) Mod/High Amplitude Surface: Rubber Track/Hard Load/RPE: 4-6 RPE, +15-30lbs Intent: Rhythm/Transitions Rest: 30-60s
	Frequency: 1 day/week Weekly Volume: 3500-7000m Structure: 1:3 Work/Rest Long Day: 100m-300m Long Pace: 2.68 m/s (10:00/mile) Short Day: 10-100m Runs Short Pace: Variable (5-8 RPE)	Frequency: 1-2 days/week Weekly Volume: 4300-8000m Structure: High/Low Long Day: 12-24min LSD Long Pace: 2.68 m/s (10:00/mile) Short Day: 30-150m Runs Short Pace: Variable (5-8 RPE)	Frequency: 2-3 days/week Weekly Volume: 5400-9000m Structure: High/Low Long Day: 18-28min LSD Long Pace: 2.68 m/s (10:00/mile) Short Day: 200m Runs Short Pace: 4.76-5.56m/s (36-42s)	Frequency: 3 days/week Weekly Volume: 6700-10000m Structure: High/Low Long Day: 20-30min LSD Long Pace: 2.68 m/s (10:00/mile) Short Day: 400m Runs Short Pace: 4.44 m/s (90s)
	Frequency: 2-3 days/week Weekly Volume: 280-240 reps Structure: 2-10 rounds/circuit 3-4 exercises/circuit 1-20 reps/exercise Load/RPE: 10lb vest/RPE 3-6 Intent: Quality movement Rest: As Needed	Frequency: 2-3 days/week Weekly Volume: 500-600 reps Structure: 3-8 rounds/circuit 3-9 exercises/circuit 3-20 reps/exercise Load/RPE: 10lb vest/RPE 6-8 Intent: Quality movement Rest: 60-90s per round	Frequency: 2-3 days/week Weekly Volume: 500-800 reps Structure: 2-3 rounds/circuit 5-12 exercises/circuit 4-15 reps/exercise Load/RPE: 15-20lb vest/RPE 5-7 Intent: Finish all reps in time Rest: 60s per round	Frequency: 3-4 days/week Weekly Volume: 600-825 reps Structure: 2-4 rounds/circuit 4-6 exercises/circuit 3-20 reps/exercise Load/RPE: 20-25lb vest/RPE 6-8 Intent: Finish all reps in time Rest: 30-45s per round
	Frequency: 2-3 days/week Weekly Volume: 1500-2225m Structure: 250-1675m/session 2-4 drills/session 25-50m/drill 2-7 reps/drill Fin Day: 5-7 x 125-225m Treading Day: 8x15-20s Rest: 180s	Frequency: 2-3 days/week Weekly Volume: 2700-3900m Structure: 250-1525m/session 4 drills/session 25-100m/drill 2-10 reps/drill Fin Day: 3-5 x 275-575m Treading Day: 4-5 x 30-75s Rest: 180s	Frequency: 2-3 days/week Weekly Volume: 3150-4400m Structure: 800-3000m/session 4 drills/session 25-300m/drill 2-8 reps/drill Fin Day: 2-4 x 650-1000m Treading Day: 4-5 x 90-120s Rest: 60-120s	Frequency: 3 days/week Weekly Volume: 3400-5400m Structure: 800-2400m/session 4-7 drills/session 25-500m/drill 1-4 reps/drill Fin Day: 1-2 x 875-1500m Treading Day: 1-2 x 150-180s Rest: 30-150s
	Frequency: 1 day/week Weekly Volume: 1500-3200m Ruck Pace: 16:00/mile Weight: 0-20lbs	Frequency: 1 day/week Weekly Volume: 4000-4800 Ruck Pace: 15:00-16:00/mile Weight: 20lbs	Frequency: 1-2 days/week Weekly Volume: 4800-6400m Ruck Pace: 15:00-16:00/mile Weight: 25-30lbs	Frequency: 1-2 days/week Weekly Volume: 2400-4800m Ruck Pace: 15:00/mile Weight: 30-40lbs

to provide adequate adaptation while still allowing quality training to be conducted from session to session. Prioritizing an element of training on a certain day does not mean all others are not important, simply that the sessions are structured so that everyone is exposed to the appropriate stimulus regardless of time available while providing high-frequency exposures to most modalities of training on most days to assist in adaptive response. In many cases, schedules change, training facilities close, or life presents situations that are more important than training. By accomplishing what is most important first and most often, the preparatory process can be more effective over time and is more robust against the unexpected. See Table 2 for a breakdown of suggesting loading progressions within each training modality by phase.

WARM-UP AND PLYOMETRICS

The first task of each day will be preparing the body to train through a simple, yet comprehensive warm-up intended to stimulate the tissues to be trained that day to be resistant to impact and high-volume work demand of the stretch-shortening cycle (SSC). The concept of balancing the trainee's center of

mass over their center of balance during the low-effort hops, skips, and jumps will be emphasized on most days. These plyometric movements will be progressed to more maximal versions, including external loading in the form of vests or hand-held dumbbell or kettlebells, while increasing speed and effort of movement to better mimic the types of loaded movements seen throughout AFPSECWAR training. Much of the warm-up will also consist of lateral and rearward movement to counteract the straight ahead, or linear, running volume necessary in this program. This general warm-up will be conducted 3 – 6 times per week, increasing in frequency and intensity as the trainee progresses through the program and slightly varied to provide novelty and necessary variety to each body part and movement pattern. Beginning at three low-intensity plyometric sessions per week and progressing to 5 – 6 per week has previously been established as an acceptable workload progression, while minimizing excessive joint and muscle soreness, even in rehabilitation settings (4). The total volume counts listed in Table 2 are inclusive of prescribed general warm-ups and the suggested hop, skip, or jump circuits contained within the main workout themselves.

These higher-frequency, low- to moderate-intensity plyometric sessions have been shown to elicit increases in bone density and connective tissue adaptation in both sexes (2,8,9,12). However, the research shows a generally impaired acute genetic translational response in women when compared to men (1,10). It would also appear that running alone, which is a common preparatory method for military selection courses, is insufficient to increase tendon and bone quality in women and the inclusion of multi-directional plyometric training would serve both sexes best, especially when training in a mixed-sex group where training cannot always be acutely adjusted to the individual (22). This preparatory training is also structured to enhance intramuscular and intermuscular elastic qualities, or the ability of the connective tissues and the constituent proteins within skeletal muscle to synergistically interact to provide passive and active tolerance to the impact stress incurs during running, load carriage, and any other task that may incorporate the SSC (17,21). Passive tolerance to load would be observed when the foot strikes the ground and the inherent stiffness of the muscle and connective tissues resist, store, and return energy through the lower extremity without the aid of muscular contraction.

Active resistance to the loading of ground impact is best observed when body positioning, timing, and coordination of the active muscular recruitment pattern is conducted in such a way that a majority of the muscular effort devoted to the activity is directly returned into the act of moving the body, usually best trained through frequency of exposure to tasks known to contribute to specific patterns of interest (4,16,17,21,23). When these elastic and

coordinative qualities simultaneously contribute to the passive and active completion of work during running and load carriage, the training effect may serve to reduce chronic energy expenditure benefitting a trainee taking part in high-volume and long-duration training characteristic of AFSPECWAR occupational demands.

STRENGTH AND WORK CAPACITY

After the comprehensive warm-up, the next objective will be to prepare the individual to tolerate the total volume of work expected within this training pipeline. This will be accomplished by gradually increasing work volume throughout all aspects of the program to include strength training, swimming, running, and rucking. The strength training is designed to compliment those qualities to prevent injuries and build general strength needed to perform in the AFSPECWAR pipeline. Training loads are primarily increased in correlation with training frequency beginning with 2 – 3 days per week and progressing to four days per week, inclusive of body and loaded calisthenics alongside dumbbell or kettlebell loaded resistance training. Specific events or exercises are progressed accordingly to mirror future activities within the pipeline to aid in reduction of injury as well as increase performance and tactical readiness. As previously stated, there has been a trend identified of lower arm and elbow injury once training with ropes and rope ladders begins within the pipeline. To mitigate this risk, it is recommended to utilize a rope or towel attachment multiple times a week during pulling exercises to prepare the trainee for this demand. An example is provided within the example training week depicted in Table 3.

TABLE 3. EXAMPLE TRAINING WEEK

Week 19 of 20											
Day 1			Day 2			Day 3			Day 4		
Swim Warm Up			Extensive Run Warm Up			Swim Warm Up			Strength Warm Up		
5-10 min Individual Drills			800m Hop/Skip/Jog Continuous			5-10 min Individual Drills			In Place Calisthenics Warm up		
Freestyle Swim			LSD Run			Freestyle Swim			Strength		
Meters	Reps	Rest Time	Time	Pace	Meters	Meters	Reps	Rest Time	Exercise	Sets	Reps
50	4	1:15	20min	~10-11 min/mi	~2900	200	5	2:30	DB Goblet Squat	4	6
100	3	2:00	Instructions			Fin Swim			DB Military Press	4	6
150	2	3:15	Maintain conversational pace; increase speed if 10min pace is too slow.			Meters	Reps	Rest Time	Accessory Circuit		
300	2	0:40				1350	1	n/a	Exercise	Sets	Reps/Time
50	3	1:15				Active Recovery			Curtis Lunge	4	6 Each
100	2	2:40				Option #1			1-Leg RDL	4	6 Each
200	1	n/a				Exercise	Min	Distance	Plank	4	30s
Extensive Run Warm Up			Strength Warm Up			Walk	20-30	Variable	Y-Raise	4	20
800m Hop/Skip/Jog Continuous			Strength			Instructions			T-Raise	4	20
Intensive Plyometrics*			Strength Endurance Circuit 1*			Take a leisurely walk, outside if possible. Keep heart rate <60% Max. Complete Hip and Shoulder Mobility.			Extensive Run Warm Up		
Exercise	Sets	Reps	Exercise	Sets	Clusters	Active Recovery			800m Hop/Skip/Jog Continuous		
12" Depth	4	3 to 5	Deadlift	4	6	Option #2			Intensive Plyometrics		
Broad Jump			Exercise	Sets		Exercise	Min	Distance	Exercise	Sets	Reps
Run			Pull Up	2	4x4	Upright Bike	20-30	Variable	Skater Bounds	4	4 Each Leg
Meters	Reps	Time	Push Up	2	4x15	Instructions			Run + Calisthenics Circuit		
200m	6	36-42s	Inverted Row**	2	4x15	Maintain Zone 1 Pace. Keep heart rate <60% Max. Complete Hip and Thoracic Mobility.			Meters	Sets	Time/Reps
Rest	Reps	Time	Side Bear Crawl	2	2x20m (L/R)	Active Recovery			400	4	90s
200m Walk	6	90s	Strength Endurance Circuit 2*			Option #3			Push Up	4	25
Instructions			Exercise	Sets	Reps	Exercise	Min	Distance	Pull Up***	4	6
Run 200m in 36-42s. Walk back to start within 90s.			18" Lateral Step Up	4	7 Each Leg	Instructions			Inverted Row	4	25
			Good Morning	4	14	Maintain Zone 1 Pace. Keep heart rate <60% Max. Free stretch/foam rolling.			Face Pull**	4	8
			Supine Bwt Row*	4	14				Bear Crawl	4	30s
			Burpee	4	20s				Instructions		
			Accessory Circuit 3*						Rest 30s rest between exercises, 2min between sets. No vest.		
			Exercise	Sets	Reps						
			Hamstring Curl**	2	7 each leg						
			Copenhagen	2	20s						
			Bicep Curl**	2	14						
			Burpee	2	20s						

* = Wear 20-25lb Vest

** = Use Suspension Trainer

*** = Use Towel Draped Over Pull Up Bar

DEVELOPMENTAL MODEL FOR PROSPECTIVE MALE AND FEMALE US AIR FORCE SPECIAL WARFARE CANDIDATES— PART II: TRAINING PROGRAM MANAGEMENT

Resistance training volume will be increased almost exclusively within the loaded and unloaded calisthenics sessions. This program feature is to provide adequate exposure to known stressors as well as limit global stress incurred through using greater absolute weights during axial-loaded barbell strength training. The inclusion of external load during the load carriage (rucking) and plyometrics program will constitute the bulk of axial loading present in the current program. Early in the program, the focus will be to complete all repetitions within the prescribed workout to standard, resting as necessary to complete the training session. As the trainee approaches the end of the preparatory program, the goal will be to meet the training volume of each set and session, only resting for the duration defined in the program. By increasing volume and decreasing rest, total work density will be increased to prepare the individual for the multiple bouts of strenuous exercise per day encountered in the formal training pipeline. An example training week has been included in Table 3, which outlines a possible structure for program delivery.

RUNNING AND RUCKING

Maintaining a balance between accumulating adequate training volume on the feet and conserving necessary bone, tissue, and metabolic adaptive capacity for the other training modalities can be facilitated by keeping exposure frequency relatively high (3 – 5 times per week) but keeping total session duration specific to running and rucking relatively lower, regardless of biological sex (12). As previously stated, straight-line running may not facilitate the protective adaptations necessary to reduce the risk of injury during training, so it is again recommended to incorporate movement in all directions during the dynamic warm-up before running or ruck training. These types of movements, such as lateral shuffles, backward pogo hops, 45-degree bounds, and split-lunge jumps, are key to ensuring robustness with the added benefit of exposure to diverse movement demands, which may also increase overall coordination and rhythm (16,23).

Specific run training is recommended at three days per week and ruck training is recommended at once per week early in the developmental period. The extensive and intensive plyometrics previously described and depicted in Table 2, which may occur at times independent of running or rucking, serve as additional load carriage preparation at magnitudes above and below those incurred during load carriage, while keeping total session volume down to reduce the risk of overuse-type injuries in those unaccustomed to these specific physical demands. The biological basis for this recommendation is identified in Part I of this series (13). Prescribed running paces are given in meters per second (m/s) and are recommended in relation to the demands of the courses early within AFSPECWAR physical training. Though maximal sprinting may be necessary within these career fields and the tactical train ups, it is difficult to gauge the exact velocities each unique individual will attain during short, fast running bouts and these types of activities should be scaled up under the

supervision of an experienced professional. These conservative recommendations are geared toward the trainee who has not trained for speed or power-based sports performance and carries the intent to develop general capacities which are not present. Refer to Table 3 for example running interventions within a training week.

SWIMMING

Ensuring a potential candidate has pool access is vitally important for successful preparation. Each training course has a swimming component and those who are unable to meet and exceed minimum competency expectations will struggle to find success. The authors recommend beginning swim training is at two sessions per week, progressing to three total sessions each week with increased work density, which will ensure suitable exposure to begin more intensive swim training inherent to AFSPECWAR training. These training sessions will be characterized by shorter “sprint” type intervals, longer bouts to build work capacity, and a focus on either treading or fin swimming once a week per modality to ensure foundational ability when a prospective candidate begins their formal training. The authors stress that all swim training sessions should be conducted in the presence of a qualified lifeguard or certified swimming instructor familiar with the tasks that have been recommended within this program. Table 2 outlines recommended distances per repetition, workout structure, and overall volumes per day and per week.

FINAL THOUGHTS

If a trainee is unable to comfortably meet the weekly volume suggestions of each phase, it is not recommended to progress forward and instead to repeat that phase in all modalities with all prescribed program elements (e.g., rest intervals, difficulty, frequencies, and volumes). The time of each phase, 4 – 6 weeks, is provided as a soft guideline and more time may be necessary to meet these training demands and results should be guided by relative performance, not simply the length of each block of training. Understanding the link between injury and fitness in initial military courses of entry, it would be advantageous to prepare everyone to perform well above minimum standards at the onset of formal training, regardless of biological sex or background.

Enhancing the individual ability to recover and adapt may provide a smoother transition when the work volume and intensity increase within these training guidelines. A comprehensive guide to employing stress mitigation, sleep, nutrition, and recovery modalities (e.g., foam rolling, compression garments, cold-water immersion) can be found elsewhere (18). Promoting adequate energy availability, avoiding fad dieting, and managing the individual responses to stress while adhering to the program guidelines provided in this article may enhance the efficacy of training.

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DEVELOPMENTAL MODEL FOR PROSPECTIVE MALE AND FEMALE US AIR FORCE SPECIAL WARFARE CANDIDATES— PART II: TRAINING PROGRAM MANAGEMENT

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FITNESS ABOARD A CANADIAN PATROL FRIGATE

The purpose of the Royal Canadian Navy (RCN) is to generate combat-capable, multipurpose maritime forces that support Canada's participation in security operations anywhere in the world, as part of an integrated Canadian Armed Forces (CAF). RCN ships routinely perform their duties either in "sea-trial" (i.e., workups), conditions (i.e., short periods of training exercises performed at sea), or in an actual deployment (i.e., months-long oversea trips). Working in the RCN is associated with a very distinctive lifestyle and unique reality. Such work has its own set of internal and external environmental influencing factors that affect the confines, limits, directives, and restrictions of a command's workplace, combat zones, and physical training (PT) domains. Taken together, all those elements lead to a challenge unlike any other military branches.

This article will focus primarily on the physical fitness considerations of sailors aboard Canadian Patrol Frigates while out at sea. The ideas presented are supported by a four-month sea deployment (fall 2021) experienced by one of the authors. The author acted as the civilian fitness, sports, and recreation coordinator aboard during the deployment. The fitness, sports, and recreation coordinator is a fitness expert deploying on the vessel who is responsible for providing activities to the sailors aboard. As the only civilian aboard, the coordinator must be able to work around and within the daily schedule of the operational vessel. The coordinator will be called "fitness expert" throughout this article. The ship left for a total journey of 122 days with 97 at sea and the rest ashore across several locations. This deployment was completed during the COVID-19 pandemic, which might have limited the number of port stops, thereby likely extending the length at sea.

BACKGROUND

It is well recognized that physical activity has many benefits: physically, physiologically, and psychologically. Nevertheless, CAF personnel spend an average of 30.5 hr per week engaged in sedentary leisure-time activities, in addition to an average of 27.5 hr per week seated at work (1). Therefore, it is important to reduce sedentary time and increase opportunities for physical activity both at work and beyond. The military life can present challenges to the adoption and maintenance of an active lifestyle, particularly considering elements such as operational tempo, distance to facilities, resources, shift work, and family life. These factors added to an operational sea deployment make this challenge even greater. It is therefore important to provide opportunities for physical activity by allocating time, equipment, and staff while on sea deployment for the crew to maintain a healthy lifestyle.

RCN VERSUS CAF: FORCE ANNUAL EVALUATION

The FORCE evaluation is the CAF Physical Employment Standard (equivalent of the Army Combat Fitness Test [ACFT] in the United States Army) and must be completed by all CAF members on an annual basis (2). It reflects physical fitness attributes related to common defense and security duties known as the "Universality of Service Principle." It consists of four tasks separated by five minutes rest:

- 20-m Rushes: Starting from the prone position, complete two shuttle sprints (one shuttle = 20 m there, 20 m back) dropping to the prone position every 10 m for a total of 80 m. To be completed in 51 s or less.
- Sandbag Lift: 30 consecutive lifts of a 20-kg sandbag from the floor above a height of one meter. The tactical athlete alternates between left and right sandbags separated by 1.25 m. To be completed in 3:30 min or less.
- Intermittent Loaded Shuttles: 10 consecutive shuttles (one shuttle = 20 m there, 20 m back), alternating between loaded shuttles with a 20-kg sandbag and unloaded shuttles, totaling 400 m. To be completed in 5:21 min or less.
- Sandbag Drag: Carry one 20-kg sandbag and pull a minimum of four on the floor over 20 m without stopping. Number of sandbags being dragged depends on the type of floor.

The FORCE evaluation performances of all CAF members are compiled in an electronic database which can provide some insight into the health and fitness of all CAF members including RCN sailors. This data indicates an annual average compliance for the RCN of approximately 70% of total strength evaluated. This is consistent with the CAF average but slightly lower than compliance for the Canadian Army (CA) or Royal Canadian Air Force (RCAF). Results from the FORCE evaluation shows that performances of RCN sailors are lower when compared with the CA, RCAF, Military Personnel Command (MILPERSCOM), and the CAF average. Results from the health component of the FORCE evaluation also shows the RCN performing lower than the CAF population. These trends are concerning and it is currently impossible to fully understand their cause.

CONSIDERATIONS WHEN DELIVERING PT SESSIONS

Deployment on a frigate comes with some barriers to physical activity, such as work schedule, fatigue, lack of equipment, lack of motivation, and lack of space. The sailors can use the flight deck as their space to exercise (with limited equipment) but have to adapt with the operations schedule, weather, and sea state (3). Even with a low sea state, it can be challenging for some to stabilize, especially for those who never experienced sea state previously.

Canadian Patrol Frigates typically measure about 135 m in length, 17 m beam, and 5 m draught. As an example, HMCS Winnipeg contained one room (Figure 1) dedicated to traditional strength equipment (machines and free weights) allowing 4 – 6 sailors to exercise at a time. The cardiovascular machines (two treadmills, one rower, one elliptical, and four spin bikes) were spread in different areas across the vessel to allow eight sailors to exercise at a time (Figure 2). When procuring equipment for a Navy Frigate, one must consider equipment with high functionality and movement, allowing safe traffic flow, and not causing overcrowding of the strength room. Square footage of the strength room being very limited, each piece of equipment must be selected and placed to work around certain limitations of the vessel (e.g., ceiling pipes, ceiling height, floor traps, hatches, square footage needed).

Furthermore, the storage space dedicated to fitness equipment is very limited. The fitness expert must be careful and mindful as to what equipment is needed for PT. Larger pieces of equipment are kept in their designated spaces. However, smaller items such as kettlebells, Olympic barbells, medicine balls, jump ropes, sandbags, elastic bands, and suspension trainers can be stored at various locations throughout the ship. Most of the smaller items were stored by the flight deck where PT sessions were held for ease of access for setting up and taking down every time a session took place. The flight deck surface has a unique “non-skid” surface that can be very abrasive to skin; thus, the use of a fitness mattress is recommended to perform ground-based exercises.

When developing a PT plan for on land or at sea performances, it is important to assess the fitness level and experience of the members; typically this is done via FORCE evaluation prior to deployment. It is also important to take into consideration experience at sea as some sailors might be on their first deployment, which is a completely new and unique training environment for them. Even with strong PT experience on land, sailors must adjust to the environment at sea. The moving vessel itself can make PT very different, and weather and sea state may further contribute to the instability and unsteadiness of surfaces. Another factor to take into consideration is the direction of the waves, either side-to-side or front-to-back, which can affect how one must stabilize and brace trunk muscles during any given exercise. Indeed, constantly having to take into consideration sea state and the direction of the waves was one of the biggest challenges and adjustments for the fitness expert when leading PT sessions.

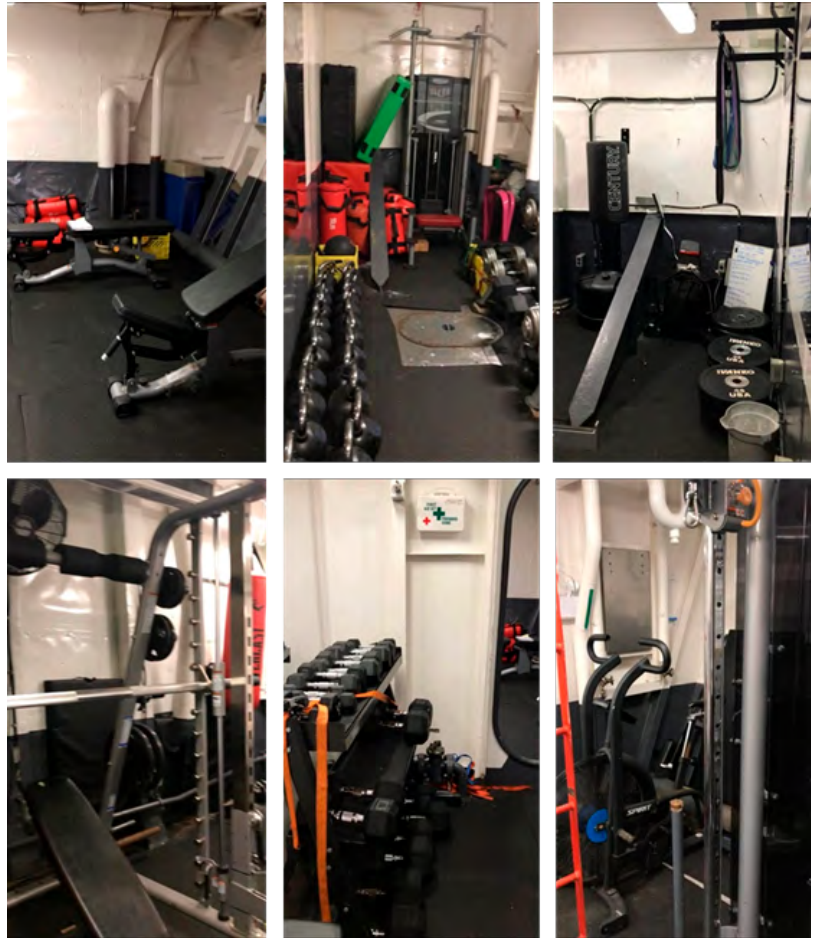


FIGURE 1. EQUIPMENT AND SPACE AVAILABLE IN THE STRENGTH ROOM ON HMCS WINNIPEG FOR THE 2021 FALL DEPLOYMENT



FIGURE 2. AEROBIC CONDITIONING EQUIPMENT AVAILABLE ON HMCS WINNIPEG FOR THE 2021 FALL DEPLOYMENT

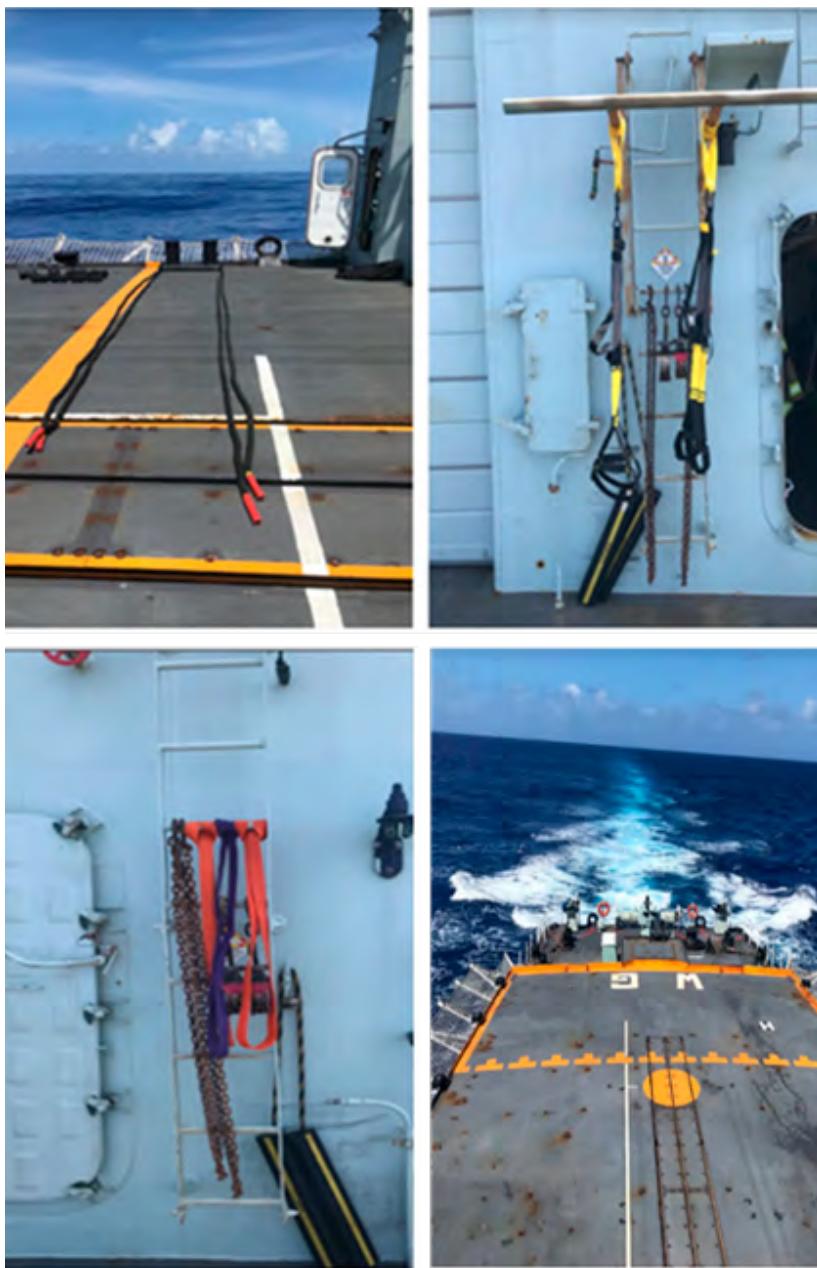


FIGURE 3. SETUP FOR ONE THE FITNESS EXPERT LED PT SESSION ON THE FLIGHT DECK

TABLE 1. SAMPLE OF A TYPICAL WEEK OF PT ABOARD HMCS WINNIPEG DURING THE FALL 2021 DEPLOYMENT

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
Off day	Strength and conditioning	Strength and conditioning	Team training	Strength and conditioning	Strength and conditioning	Mobility/active recovery

All of these factors need to be taken into consideration when creating a PT plan while at sea. Variability in terms of the number of sailors showing up, where the session can be held, and what kind of exercises and intensities can be planned for that session require a high level of flexibility on the fitness expert's end. As an example, PT sessions were cancelled on 15 days due to either bad weather (waves up to 2.5 meters [8 ft]) or operational reasons throughout the deployment.

16-WEEK PT PROGRAM

The fitness expert aboard the Frigate was available for services such as one-on-one training sessions, group PT sessions (twice per day), and also provided the ship's crew with daily PT workouts as well as routines to perform on the cardiovascular machines. On top of these activities, the fitness expert created monthly challenges for the ship's company to partake and compete with each other.

The deployment experienced by the author lasted 18 weeks, but deployments can last as long as 8 – 9 months. For this particular deployment, it was ideal to create a PT program for 16 weeks, as the first and last week of the deployment are usually transition weeks to settle on the ship's routine. Table 1 provides an example of a typical PT week for this deployment.

The strength and conditioning sessions consisted of a full body PT typically held on the flight deck (Figure 3). The exercises, sets, repetitions, and sequencing could significantly be affected by factors such as sea state, weather, wave direction, equipment/room availability, and number of sailors participating. Every strength and conditioning session was conducted as three circuits of a tri-set each. Each circuit lasted nine minutes: 50 s per exercise and 10 s of extra rest/transition time for three rounds. An extra rest time in between circuits was also given to the participants. The fitness expert opted for such a format in order to have access to the required equipment and

considering the changing number of participants at each session. The fitness expert ensured a progression from week-to-week inside the same phase of training by challenging the participants to adjust their weight used from the previous week, adding repetitions (within the range prescribed), or modifying the tempo of the movement (e.g., concentric, isometric, eccentric portion of the movement). The fitness expert ensured that every participant was feeling challenged to their capability and offered regressions and progressions to exercises when necessary. Most sessions were considered within the moderate intensity range.

The team training session consisted of mostly bodyweight exercises, or exercises that required minimal pieces of equipment, and was performed either for time or for rounds. The workouts varied from week to week. This session was a way to build a sense of community between members aboard and provided an opportunity for friendly competition.

Lastly, on Saturdays, a mobility/active recovery session was held. It included a mix of static stretching and mobility drills. However, it was difficult to perform mobility drills that required equipment as availability was limited. Some sessions were completed as a circuit type to ensure all sailors could have access to the specific equipment when required.

Every session ended with some breathing exercise to allow sailors to return to a state of calmness as some of them needed to go back to sleep. All of these sessions were inclusive to all sailors no matter the experience level, rank, trade, age, gender, etc. The sessions mainly took place at 0800 and 1300 as these times were voted the most appropriate hours by the ship's company.

CONCLUSION

While at sea, sailors face unique challenges for PT. To help with all the environmental limitations and factors, it is suggested to have fitness experts deploy aboard Navy ships to offer multiple supervised PT sessions per day, in collaboration with the ship's department, promote maximal participation, and promote a sense of community aboard. It is suggested that fitness experts develop and print PT sessions ahead of time to offer variety and appropriate progression to sailors that cannot attend the supervised sessions. The fitness experts not only can facilitate progressive, creative, and adaptable PT, but can also play a role in the promotion of healthy lifestyle behaviors. Physical activity and training are an important aspect of a healthy lifestyle but must be combined with proper sleep and healthy nutrition (4). These three behaviors being often correlated, proper interventions and holistic approach are best suited to have positive impact on health and operational performance (4). Navy ships are a very limiting environment to work in, especially when deploying, but with proper support in place (e.g., chain of command, experts available), sailors can develop healthy lifestyle and even improve operational and functional performance during deployments.

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TABLE 2. SAMPLE TRAINING PROGRAM FOR WEEKS 1 – 4

MONDAY				TUESDAY			THURSDAY			FRIDAY		
S&C				S&C			S&C			S&C		
	Exercise	Sets	Reps	Exercise	Sets	Reps	Exercise	Sets	Reps	Exercise	Sets	Reps
1A	Snap down into athletic position	3	5	Banded horizontal push	3	12 – 15	180 degrees jump	3	3 ES	DB/banded chest fly	3	8 – 12
1B	Front plank	3	*For time	Quadruped reach through	3	6 – 10 ES	¼ Turkish get-up	3	3 – 5 ES	Cat/cow	3	10 each
1C	BW/DB/KB standing calf raise	3	15 – 20	Glute bridge	3	12 – 15	DB hammer curl	3	15 – 20	Banded pull apart	3	15 – 20
2A	Supported reaching single-leg deadlift	3	4 – 6 ES	Half-kneeling single-arm DB/KB press	3	6 – 8 ES	DB/KB forward lunge	3	6 – 10 ES	DB/KB/banded/plate floor press	3	8 – 12
2B	Banded lateral pulldown	3	15 – 20	Prone superman	3	8 – 12	Banded face pull	3	15 – 20	Banded/plate cook hip lift	3	8 – 12 ES
2C	Conditioning of choice	3	"X" time	Conditioning of choice	3	"X" time	Conditioning of choice	3	"X" time	Conditioning of choice	3	"X" time
3A	DB/KB goblet squat	3	8 – 12	V-sit	3	*For time	Banded pull through	3	8 – 12	Wide stance banded horizontal chop	3	6 – 10 ES
3B	DB/KB tripod row	3	4 – 6 ES	Wide-stance banded Palloff press	3	6 – 10 ES	TRX row	3	8 – 12	Side plank	3	*For time
3C	Bird dog	3	6 – 10 ES	DB/KB/sandbag/plate farmer's carry	3	*For time	DB/KB/plate pullover	3	*For time	KB front rack carry	3	*For time

*For time: to a maximum of 50 (or 25 for unilateral exercises) s total or until good form can no longer be sustained

ES = each side; BW = bodyweight; DB = dumbbell; KB = kettlebell

FITNESS ABOARD A CANADIAN PATROL FRIGATE

TABLE 3. SAMPLE TRAINING PROGRAM FOR WEEKS 5 – 8

	MONDAY			TUESDAY			THURSDAY			FRIDAY		
	S&C			S&C			S&C			S&C		
	Exercise	Sets	Reps	Exercise	Sets	Reps	Exercise	Sets	Reps	Exercise	Sets	Reps
1A	Squat jump	3	5	Tall kneeling banded horizontal push	3	12 – 15	4-way hurdle jump	3	2 each way	Glute bridge DB/KB/ banded/ plate floor press	3	8 – 12
1B	TRX body saw	3	*For time	Floor slide	3	10 – 12	Half Turkish get-up	3	3 – 5 ES	90/90 sidelying chest opener	3	6 – 10 ES
1C	Glute bridge march	3	8 – 10 ES	Banded glute bridge	3	10 – 12	Banded triceps pushdown	3	15 – 20	Tall kneeling banded pull apart	3	15 – 20
2A	Reaching single-leg deadlift	3	4 – 6 ES	Tall kneeling alternating DB/KB press	3	6 – 8 ES	DB/KB backward lunge	3	6 – 10 ES	Push-up	3	8 – 12
2B	Seated banded lat pulldown	3	15 – 20	I, Y, T, W	3	8 – 12 each	Tall kneeling banded face pull	3	15 – 20	Sidelying banded adduction	3	10 – 12 ES
2C	Conditioning of choice	3	“X” time	Conditioning of choice	3	“X” time	Conditioning of choice	3	“X” time	Conditioning of choice	3	“X” time
3A	DB/KB front rack squat	3	8 – 12	TRX knee to chest	3	*For time	KB deadlift	3	8 – 12	Tall kneeling banded horizontal chop	3	6 – 10 ES
3B	DB renegade row	3	4 – 6 ES	Tall kneeling banded Palloff press	3	6 – 10 ES	TRX reverse fly	3	8 – 12	Side plank reach through	3	*For time
3C	Hollow hold	3	*For time	DB/KB/ sandbag/ plate suitcase carry	3	*For time	Alternating plank reach	3	*For time	KB single-arm front rack carry	3	*For time

TABLE 4. SAMPLE TRAINING PROGRAM FOR WEEKS 9 – 12

	MONDAY			TUESDAY			THURSDAY			FRIDAY		
	S&C			S&C			S&C			S&C		
	Exercise	Sets	Reps	Exercise	Sets	Reps	Exercise	Sets	Reps	Exercise	Sets	Reps
1A	Tuck jump	3	5	Half-kneeling banded single-arm horizontal push	3	6 – 8 ES	Broad jump (single)	3	3	Hollow position DB/KB/banded/plate chest press	3	6 – 10
1B	Bear crawl hold	3	*For time	DB/KB arm lock with twist	3	6 ES	Full Turkish get-up	3	1 – 2 ES	SB/plate sidelying shoulder IR/ER	3	6 – 10 ES
1C	Curtsey lunge	3	6 – 8 ES	Single-leg glute bridge	3	6 – 8 ES	DB skullcrusher	3	15 – 20	Half-kneeling banded pull apart	3	6 – 10 ES
2A	Supported DB/KB single-leg deadlift	3	4 – 6 ES	Half-kneeling single-arm bottom-up KB	3	1 – 6 ES	DB/KB Cossack squat	3	6 – 10 ES	Single-arm DB/KB floor press	3	6 – 10 ES
2B	“X” banded pulldown	3	10 – 12	Prone angels	3	8 – 12	Half-kneeling banded face pull	3	6 – 10 ES	4-way mini band walk	3	5 m each
2C	Conditioning of choice	3	“X” time	Conditioning of choice	3	“X” time	Conditioning of choice	3	“X” time	Conditioning of choice	3	“X” time
3A	Single-arm KB front rack squat	3	4 – 6 ES	Leg lowering	3	*For time	DB/KB/sandbag/plate top down RDL	3	8 – 12	Half-kneeling high-to-low banded chop	3	6 – 10 ES
3B	DB bird dog row	3	4 – 6 ES	Half-kneeling banded Palloff press	3	6 – 10 ES	Single-arm TRX row	3	4 – 6 ES	Copenhagen plank	3	*For time
3C	Deadbug	3	6 – 10 ES	DB/KB cross-body carry	3	*For time	Alternating clock plank	3	*For time	DB/KB goblet carry	3	*For time

FITNESS ABOARD A CANADIAN PATROL FRIGATE

TABLE 5. SAMPLE TRAINING PROGRAM FOR WEEKS 13 – 16

	MONDAY			TUESDAY			THURSDAY			FRIDAY		
	S&C			S&C			S&C			S&C		
	Exercise	Sets	Reps	Exercise	Sets	Reps	Exercise	Sets	Reps	Exercise	Sets	Reps
1A	Repeated vertical jump	3	3 – 5	Lunge banded single-arm horizontal push	3	6 – 8 ES	Repeated broad jump	3	3	DB/KB deadbug chest press	3	6 – 10
1B	3-point bear crawl hold	3	*For time	Wrist pulse/clock stretch	3	10 ES	Full Turkish get-up	3	1 – 2 ES	90/90 sidelying windmill	3	6 – 10 ES
1C	Nordic hamstring curl	3	4 – 6	Banded single-leg glute bridge	3	4 – 6 ES	DB/banded lateral/ frontal shoulder raise	3	15 – 20	Hollow position banded pull apart	3	8 – 12
2A	DB/KB single-leg deadlift	3	4 – 6 ES	DB/sandbag push press	3	6 – 8	DB/KB clock lunge	3	3 ES	Plyo push-up	3	6 – 8
2B	KB upright row	3	8 – 12	I, Y, T, W	3	8 – 12 each	Single-leg banded face pull	3	6 – 10 ES	Deep squat hold	3	*For time
2C	Conditioning of choice	3	"X" time	Conditioning of choice	3	"X" time	Conditioning of choice	3	"X" time	Conditioning of choice	3	"X" time
3A	1.5-rep goblet squat	3	8 – 10	DB/KB/ sandbag/ plate front rack side pull	3	*For time	DB/KB swing	3	8 – 12	Lunge high-to-low banded chop	3	6 – 10 ES
3B	Bear crawl row	3	4 – 6 ES	Lunge banded Palloff press	3	6 – 10 ES	Inverted TRX row	3	6 – 10	Side plank banded row	3	*For time
3C	Banded deadbug	3	6 – 10 ES	DB/KB overhead carry	3	*For time	Plank banded row	3	*For time	DB/KB waiter carry	3	*For time

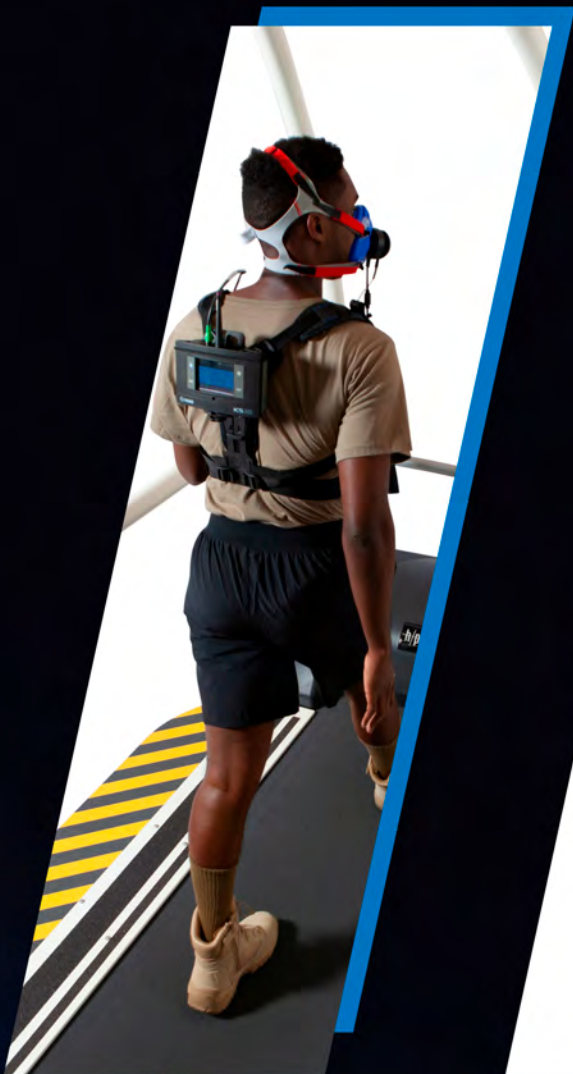


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POLAR

PREPARING FIREFIGHTER RECRUITS TO SUCCESSFULLY PASS AND TOLERATE THE DEMANDS OF THE CPAT

INTRODUCTION

As of 2023, the combined number of career and volunteer firefighters in the United States was estimated at 1.063 million (21). Career firefighters are defined as “full-time uniformed firefighters regardless of assignments,” and make up approximately 34% of active firefighters (3,21). Volunteer firefighters are defined as “any active part-time (call or volunteer) firefighters... involved in firefighting,” and comprise approximately 53% of active firefighters (3,21). The remaining approximate 12% of active firefighters were reported as “paid per call” firefighters (21). As firefighting is both physically and mentally demanding, an individual should prepare their body to adequately handle those stressors (1). Consequently, the physical training must be reflective of the requirements to both, graduate from an academy, and ideally sustain a long-term firefighting career. Due in part to firefighting being a hazardous occupation, applicants could be required to pass a series of physically demanding circuit-based tests intended to simulate firefighter job duties as part of the screening process for possible candidates. The current series of tests, known as the Candidate Physical Ability Test (CPAT), was adopted in 2000 as part of a joint venture between the International Association of Fire Chiefs and International Association of Firefighters to promote improvements in firefighter’s performance (8). Both career and volunteer fire departments could require their candidates to successfully pass the CPAT; however, not all departments currently have this requirement. At present, there are over 900 jurisdictions throughout the United States requiring their firefighters to successfully complete the CPAT prior to employment (9).

The CPAT is composed of eight firefighting specific tasks: stair climb, hose drag, equipment carry, ladder raise and extension, forcible entry, search, rescue, and ceiling breach and pull (9). Each component of the test is separated by a 22.9-m walk and all candidates are required to wear a 22.68-kg vest to simulate the weight of firefighter’s personal protective equipment (PPE) and the self-contained breathing apparatus (SCBA) (23). To successfully pass the CPAT, all recruits must finish the test in 10:20 min or less (23). Ultimately, due to the physical rigors associated with successful completion of the CPAT and various occupational duties upon entering service, firefighters may require specific training and guidance on how to improve and maintain physical fitness qualities related to firefighting. Thus, the purpose of this article is to provide Tactical Strength and Conditioning Facilitators® (TSAC-F®) and Certified Strength and Conditioning Specialists® (CSCS®) in a fire academy setting with pertinent information and examples that may be used to prepare firefighter recruits for the

rigorous demands of the CPAT. The focused information provided in this article could ultimately be implemented to assist firefighter recruits achieve a successful CPAT performance.

UNDERSTANDING FACTORS AFFECTING SUCCESSFUL COMPLETION OF THE CPAT

Two of the most important determinants in successfully completing the CPAT are aerobic and anaerobic fitness (19). Aerobic exercise and fitness rely on the presence of oxygen to sustain movement and performance (6). Specific to aerobic fitness is the measure of VO_2max , which can be defined as, “the maximum rate of oxygen an individual consumes to supply their muscles and organs with sufficient oxygen,” and may be measured in absolute ($\text{L}\times\text{min}^{-1}$) or relative ($\text{mL}\times\text{kg}^{-1}\times\text{min}^{-1}$) units (17). Findings from an investigation by Williams-Bell et al. on the physiological determinants of the CPAT suggested, of the 32 men and 4 women that completed the CPAT, VO_2 measurements during the CPAT were between 36.6 – 38.5 $\text{mL}\times\text{kg}^{-1}\times\text{min}^{-1}$ which equated to approximately 71 – 73% of VO_2max levels and 90 – 91% of maximal heart rate (HRmax) (23). For comparative purposes, current standards call for firefighters to maintain a minimal VO_2max value ranging from 41.5 – 42.0 $\text{mL}\times\text{kg}^{-1}\times\text{min}^{-1}$ to perform required occupational duties successfully and safely (2,5,7,14). Furthermore, in a study of 33 career and volunteer firefighters on the physiological determinants of the CPAT by Sheaff et al., nearly half of the subjects failed to successfully complete the test (19). Those candidates that successfully passed the CPAT possessed greater levels of aerobic fitness than those that failed. More specifically, test subjects that successfully completed the CPAT had 23% greater absolute VO_2max and 17% greater relative VO_2max (VO_2max measurement relative to individual bodyweight) compared with subjects that did not pass. Ultimately, findings from Williams-Bell et al. suggested the best predictors of successfully completing the CPAT were related to absolute and relative VO_2max , in addition to handgrip strength, accounting for greater than 67% of the total variance of whether a candidate is successfully able to pass the CPAT (23).

Whereas aerobic fitness relies on the use of oxygen to fuel activity anaerobic functions rely on contributions from the phosphagen and glycolytic energy systems (6). Measures of anaerobic power via the Wingate Anaerobic Cycling Test (WAnT) have shown to be a critical physiological determinant in passing the CPAT. Sheaff et al. observed greater values for mean power (45%), relative peak power (22%), and relative mean power (25%) during the WAnT in test subjects that successfully completed the CPAT (19). Furthermore, HRmax and percentage of HRmax responses

PREPARING FIREFIGHTER RECRUITS TO SUCCESSFULLY PASS AND TOLERATE THE DEMANDS OF THE CPAT

during the stair climb component of the CPAT were also related to successful completion ($p < 0.01$). Findings from Williams-Bell et al. reported respiratory exchange ratios of 1.02 and 0.97 for men and women, respectively (23). These respiratory exchange ratios indicate a heightened reliance on anaerobic metabolism to successfully perform the required task(s). Conclusions from Sheaff et al. suggested more than 80% of the variability for successful CPAT performance could be attributed to both aerobic capacity and resistance to anaerobic fatigue (19). Thus, aerobic and anaerobic fitness are suggested as likely predictors of successful CPAT performance.

As a secondary focus of preparation for the CPAT, upper body strength and endurance should be developed. Muscular strength is the ability of a given muscle or group of muscles to generate force, whereas muscular endurance is related to a muscle or group

of muscles' ability to sustain repeated muscular contractions (22). A systematic review by Fyock-Martin et al. noted that of the five studies and 265 total subjects included in their review of various firefighter ability tests similar in nature to the CPAT, both upper body strength and endurance showed the strongest correlation to successful performance (4). Upper body strength in the previous study was indicated to account for as much as 43.6% of the total variance in test performance, while upper body endurance could explain up to 37.2% of total variance in test performance. A study from Saari et al. explored the impact of age on firefighter combat challenge testing, which included many test components similar to the CPAT (16). Out of 63 subjects, upper body strength and endurance were the two highest rated physiological determinants (in addition to cardiovascular fitness) in terms of self-reported importance related to numerous firefighting tasks. Furthermore, an investigation by Michaelides et al. including 90 firefighters

TABLE 1. HIIT PROGRAM EXAMPLE FOR FIREFIGHTERS

MONDAY AND FRIDAY	WEDNESDAY
Warm-Up Barbell complex: HMT CL high pull + HMT muscle clean + push press + front squat 3 x 5 with barbell only (or < 30% CL 1RM)	Warm-Up MB chops - MB cross chops R and L - MB big circles R and L - MB lunges - MB slams: 2 x 10 - 15 each exercise/direction
Main Session - HAK PCL: 5 x 1 65 - 80% 1RM - Squat: 2 (progress to 4) x 5 - 8 75 - 85% 1RM <i>*1 - 3 min rest between each set; finish all working sets of HAK PCL prior to progressing to the squat</i>	Main HIIT Session <i>2x initially and progress to 5x through</i> <i>Sled load progress to 185 lb</i> - DB CL to press: x 3 - 6 RM - Backward sled drag 40 - 80' - DB HAK pulls x 3 - 6 RM - Over right shoulder sled drag 40 - 80' - DB floor chest press x 8 - 12 RM - Over left shoulder sled drag 40 - 80' - DB bentover row x 8 - 12 RM - Backward sled drag 40 - 80' - DB upright row x 8 - 12 RM <i>*After completing each time through full circuit, follow the W:R ratios referenced above</i>
HIIT Portion <i>2x initially and progress to 3x through</i> - CDL: x 5 - 8 RM - ALT arm conditioning ropes: 15 - 45 s - Shoulder press: x 5 - 8 RM - ALT arm conditioning ropes: 15 - 45 s - Bentover row: x 5 - 8 RM - ALT arm conditioning ropes: 15 - 45 s - Stiffed-leg deadlift: x 10 - 15 RM - ALT arm conditioning ropes: 15 - 45 s - Push-ups: x 20 - 60 s <i>*After completing each time through full circuit, follow the W:R ratios referenced above</i>	
Cool-Down Leg swings 2 x 15 each; side to side leg swings 2 x 15 each; cat/cow x 15; overhead squat x 15; static quadriceps stretch 10-30 s each; static hip flexor stretch 10 - 30 s each; stick shoulder dislocates x 15	

HMT = hang mid-thigh; HAK = hang above knee; PCL = power clean; CDL = conventional deadlift; ALT = Alternating; MB = medicine ball; DB = dumbbell; CL = clean

TABLE 2. UPPER BODY FOCUSED PROGRAM EXAMPLE FOR FIREFIGHTERS

TUESDAY AND THURSDAY	SATURDAY
Warm-Up Push-ups 2 x 10 – 20 + BW squats 2 x 10 – 15 + CMJ 2 x 4 + jump rope 30 – 60 s	Warm-Up Barbell complex: HMT muscle clean + push press + front squat 3 x 5, < 25% CL 1RM
Main Session - Squat: 2 x 5 – 8 75 – 85% 1RM - CDL: 2 x 3 – 5 70 – 90% 1RM - Shoulder Press: 4 x 5 – 8 75 – 85% 1RM - Pull-up: 4 x max repetitions - Incline BP: 2 x 8 – 12 RM 1-arm DB row: 2 x 8 – 12 RM <i>*Complete all working sets, one exercise at a time, prior to progressing to the next exercise</i>	Main Session - PCL: 2 – 3 x 3 – 5 70 – 90% 1RM - Push press: 2 – 3 x 3 – 5 70 – 90% 1 RM - T-bar/landmine row: 4 x 8 – 12 RM - Supine BP: 4 x 5 75 – 85% 1 RM - CG upright row: 2 x 8 – 12 RM <i>*Complete all working sets of each resistance training exercise prior to transitioning to next exercise</i>
Ancillary - Tri-set format - Rear DB fly: 2 – 3 x 12 – 15 RM - DB biceps curl: 2 – 3 x 12 – 15 RM - DB OH triceps extensions: 2 – 3 x 12 – 15 RM <i>*Complete one set of each exercise prior to rest period</i>	Ancillary - Tri-set format - Good morning: 2 x 12 – 15 RM - BB biceps curl: 2 x 12 – 15 RM - BB OH triceps extensions: 2 x 12 – 15 RM <i>*Complete one set of each exercise prior to rest period</i>
Trunk - Superset format - MB sit-up: 2 x 15 – 30 - Horizontal back extensions: 2 x 10 – 15 <i>*Complete one set of each exercise prior to rest period.</i>	

Leg swings 2 x 15 each; side to side leg swings 2 x 15 each; cat/cow x 15; overhead squat x 15; static quadriceps stretch 10 – 30 s each; static hip flexor stretch 10 – 30 s each; stick shoulder dislocates x 15

BW = bodyweight; CMJ = countermovement jump; CDL = conventional deadlift; BP = bench press; ALT = alternating; MB = medicine ball; DB = dumbbell; OH = overhead; PCL = power clean; CG = clean grip; BB = barbell

explored the relationship of numerous physiological determinants to a variety of firefighting tasks via a physical ability test utilizing several components used in the CPAT (13). Their observations suggested upper body strength as measured by a bench press one-repetition maximum (1RM) and upper body muscular endurance as measured by a maximum push-up test displayed low to moderate correlations in successful performance of the physical ability test utilized. Lastly, Sheaf et al. found those individuals with faster CPAT times and successful test performances to have greater upper body strength, accounting for approximately 23% of the variance and a medium to large effect on performance outcomes when compared with those that did not pass (19).

APPLICATIONS TO IMPROVE PHYSIOLOGICAL DETERMINANTS RELATED TO SUCCESSFUL CPAT PERFORMANCE

Due to successful performance on the CPAT relying on both aerobic and anaerobic energy systems, one of the most effective forms of preparation could be the utilization of high-intensity interval training (HIIT). HIIT workouts are completed at intermittent intensities, with work phases possibly greater than 90% VO₂max with the goal of taxing both the aerobic and anaerobic energy systems simultaneously (12). Aside from the requisite intensity needed to elicit physiological changes, HIIT workouts must adhere to a strict work to rest (W:R) ratio. The W:R

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ratios may range from 1:1 to 1:8 depending upon the individuals' current aerobic base and the desired training goal (12). As with W:R ratios, the length of the interval will be dependent on the focus of the training session or program. Furthermore, HIIT workouts may be completed with the use of virtually any mode of aerobic exercise, providing the tactical facilitator with numerous options to utilize in programming (12). Possible modes of aerobic exercise that could be prescribed include cycling, jogging, sprinting, and swimming. An extension of the HIIT training method could also include the use of multimodal HIIT training. This type of training incorporates both interval and resistance training to elicit positive adaptations towards aerobic capacity and muscular endurance (11). A recent study from Mang et al. evaluated the effects of multimodal HIIT training with 12 firefighter recruits over the course of 12 weeks (11). Results from the implementation of multimodal HIIT training yielded an increase of approximately 25 – 28% from baseline VO_2max measurements. Furthermore, upper body muscular endurance as measured by a maximum push-up test increased by 25 – 37% over the course of the 12-week study. Table 1 provides a HIIT program example with suggestions that should be used for planning purposes.

With upper body strength and endurance also serving as important physiological determinants in successful CPAT performance, use of a specific program to target those qualities is also warranted in preparation for a successful test. Current National Strength and Conditioning Association (NSCA) guidelines to improve muscular strength call for 2 – 6 sets per exercise utilizing 1 – 6 repetitions per set, and a 2 – 5 min rest period between sets (20). In regard to resistance training for muscular endurance, current NSCA guidelines recommend performing 2 – 3 sets of more than 12 repetitions and resting for no longer than 30 s between sets (20). Concerning exercise selection for both muscular strength and endurance training, movements should primarily be compound and multi-joint in nature as a means of engaging the largest amount of musculature possible per exercise (20). A study from Larose et al. observing the effects of concurrent resistance and aerobic training concluded that improvements in eight-repetition maximum upper body strength were observed after three and six months of training when programmed in combination with aerobic training (10). The preceding observation suggests upper body strength training could be performed on separate days from HIIT workouts while still potentially eliciting improvements in aerobic and anaerobic fitness. Moreover, the previously referenced study from Mang et al. indicated that the use of multimodal HIIT could be an effective form of preparation to improve upper body muscular endurance over the course of a training academy (11). Applying Table 2 to develop overall strength and conditioning can be preceded by focusing on upper body strength to target areas that may improve the success rate of the CPAT. This vital information may be used by tactical facilitators to design programming aimed at preparing recruits for the successful completion of the CPAT.

CONCLUSION

With aerobic fitness, anaerobic fitness, upper body strength, and endurance suggested to potentially lead to greater success rate during the CPAT, those physiological qualities should take precedent when designing programming for firefighters attempting this test (4,11,16,18,20). To facilitate continued development of firefighters preparing for the CPAT, the training program should follow the principles of specificity, progression, overload, and variation (18,20). The preceding guidelines, in addition to the NSCA recommendations on aerobic, anaerobic, and resistance training to improve upper body strength and endurance presented in Table 3, should assist tactical facilitators in developing the training programs targeted at improving those physical qualities related to successful CPAT performance (12,15,18,20). Due to firefighter recruits possibly having unique schedules, the associated programming and periodization need to be flexible in its delivery. A CSCS or TSAC-F certified individual within the department that is familiar with the unique departmental needs and schedules will provide the most effective delivery of the training program.

TABLE 3. NSCA TRAINING PRESCRIPTION RECOMMENDATIONS

Muscular Strength Development Guidelines:

- Intensity: > 85% 1 RM
- Repetitions: 1 – 6
- Sets: 2 – 6
- Rest Interval: 2 – 5 min

Muscular Endurance Development Guidelines:

- Intensity: < 67% 1 RM
- Repetitions: > 12
- Sets: 2 – 3
- Rest Interval: < 30 s

Aerobic Training Prescription Guidelines:

- Long, slow distance (LSD); 1 – 2x/week; 30 – 120 min/session; 70% VO_2max
- Pace/tempo; 1 – 2x/week; 20 – 30 min/session; near lactate threshold; performed intermittently in 3 – 5 min work bouts interspersed with 30 – 90 s rest intervals or at a steady pace
- Fartlek; 1x/week; 20 – 60 min; alternate intensity between LSD and pace/tempo training rates

Anaerobic Training Prescription Guidelines:

- Interval; 1 – 2x/week; 3 – 5 min intervals (1:1 W:R ratio); near VO_2max
- HIIT; 1 – 2x/week; 5 – 30 min total/session; 5 s to 8-min intervals (1:1 – 1:8 W:R ratio); > 90% VO_2max

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POPULATION-SPECIFIC TSAC RESEARCH COLUMN

The purpose of the following article is to discuss current interventions surrounding prevention of musculoskeletal injury and improved physical fitness across military, fire, and police populations. The goal is to provide tactical human performance professionals with up-to-date research results that may affect their practice.

MILITARY

IMPACT OF A 5-WEEK INDIVIDUALIZED TRAINING PROGRAM ON PHYSICAL PERFORMANCE AND MEASURES ASSOCIATED WITH MUSCULOSKELETAL INJURY RISK IN ARMY PERSONNEL: A PILOT STUDY

Chelsea Smith, Kenji Doma, Brian Heilbronn, and Anthony Leicht

Prevention of musculoskeletal injury (MSKI) is a primary goal among the military population. Lower levels of physical activity among this population result in poor muscular strength, balance, aerobic fitness, and increased likelihood of muscular asymmetries. While physical fitness is essential for optimal military performance, traditional generic fitness tests have been used to assess overall fitness. Recently, more occupationally-specific fitness tests have been introduced to evaluate military performance. However, these tests have limitations in assessing individual movement characteristics that could lead to increased injury risk. Incorporating pre-screening assessments like force plates and individualized training programs can help identify these imbalances and reduce the risk of MSKI among military personnel.

Seventeen Australian Defence Force military personnel across infantry, artillery, cavalry, communications, and military police units were divided into two groups: experimental (seven male, two female) and control (six male, two female). Following completion of a five-minute warm-up, all participants engaged in the following assessments: countermovement jump (CMJ), balance, plank, push-ups and multistage shuttle test, and muscular strength. The countermovement jump assessment consisted of a two-leg CMJ, a one-arm plank, a one-leg balance, and a barefoot one-leg CMJ assessment using a Bertec/Sparta piezoelectric force plate. A “Sparta profile” was created to visually evaluate participant imbalances that would drive the individualization of training. Occupational performance was assessed during a 24 kg weight-loaded five-kilometer march in which participants were instructed to march as fast as possible by either walking or shuffling. Occurrence of injury was documented via survey following the five-week training protocol. The training intervention had both groups perform one interval-based cardiorespiratory running session, two strength sessions and one occupational training session, all progressively altered to improve training response. However, strength training sessions differed between groups; the control group was prescribed the same resistance and circuit training program and the experimental group was

prescribed individual training that was unique to each participant’s Sparta profile derived from their individual CMJ results. Load, explode, and drive were derived from the average eccentric rate of contraction (AERC), average concentric force (ACF), and concentric vertical impulse (CVI) during the CMJ.

The results of the individualized training approach were similar to the physical performance outcomes of the control group, with a 21% improvement observed for muscular strength. This outcome reflects the low-explode profile exhibited by participants in the experimental group during the two-leg CMJ, implying poor initial trunk and torso stability. Observations in overall force plate profiles indicate that the individualized training program managed to create similar, balanced load, explode, and drive scores by week six, compared to the high-drive and low-explode profile measured prior to the start of the training intervention. In contrast, week six results for the control group exhibited a low-drive profile compared to the initial two-leg CMJ, which has been linked to increased risk of quadriceps and hamstring strain. Although the control group significantly decreased time to completion in the weight-loaded five-kilometer march, the low-drive profile observed in this group may exacerbate the stress accumulated from marching over uneven terrain and marching for longer distances under heavier loads. Overall, this pilot study offers insight into the use of an individualized training program among military personnel. Force plate technology may provide a feasible option for creating an individualized training program with the potential to reduce overall risk factors associated with musculoskeletal injury and improve occupational productivity. Given this is a pilot study, greater sample sizes and longer training durations are necessary to find group differences associated with validity of the use of this training intervention.

FIREFIGHTER

EFFECT OF A HIGH-INTENSITY CIRCUIT TRAINING PROGRAM ON THE PHYSICAL FITNESS OF WILDLAND FIREFIGHTERS

Jorge Gutiérrez-Arroyo, Fabio García-Heras, Belén Carballo-Leyenda, José G. Villa-Vicente, Juan Rodríguez-Medina, and Jose A. Rodríguez-Marroyo

Wildland firefighting is a highly physically and psychologically demanding occupation, with work energy consumption exceeding 2,628 kcal·day⁻¹. The workload of wildland firefighters (WFF) can vary depending on the orography and environmental conditions of the deployment sites in addition to the loads associated with their personal protective equipment. To maintain the physical demands of the job, WFFs must maintain an adequate level of fitness, which is tested annually using physical competency tests such as the Pack Test. The Pack Test is a high-intensity work capacity assessment evaluating muscular strength and aerobic endurance,

mimicking the physiological strain experienced by WFFs on the job. However, there has been growing interest in the inclusion of training that requires less training volume and time while still attaining the desired muscular and cardiovascular adaptations.

High-intensity circuit training involves repeated bouts of high-intensity effort (85 – 95% maximal heart rate) and recovery periods over the course of a ~40-min session. This type of training improves both aerobic and anaerobic capacity and muscular power while only being performed on a twice per week basis, reducing the volume or time required to achieve the desired adaptations. To test the effect of this training on wildland firefighters, nine WFFs (eight males, one female) performed an eight-week intervention period and nine WFF candidates (eight males, one female) were assigned to the control group. Initial $\dot{V}O_{2\max}$ testing was measured using a treadmill graded exercise test to obtain the WFF's ventilatory thresholds, and five physical fitness tests were chosen to assess the strength of different regions of the body. These tests included the push-up test, plank test, CMJ, handgrip strength assessment, and the Pack Test. The control group performed low-to-moderate intensity physical activity (rating of perceived exertion [RPE] <6 using CR 0 – 10 scale) for two h-wk-1 while the WFFs underwent training sessions at intensities more than 80% of maximal HR and an RPE of more than 7.5 for ~45 min, twice per week. Exercises were chosen to avoid muscular fatigue by alternating muscle groups associated with wildland firefighting. Rest periods were modified as the intervention period progressed, with load intensities increasing up to a 2:1 ratio.

The post-intervention assessment revealed a ~five-min (12%) reduction in testing time for the Pack Test in the training group versus the control group, noting an improvement in aerobic capacity that may translate to improved job performance. The intervention caused a ~31% increase in abdominal strength and a ~7% increase in vertical jump performance. Additionally, the intervention group performed a greater percentage of $\dot{V}O_{2\max}$ at which ventilatory threshold and respiratory compensation threshold were determined and the percentage of maximal heart rate at which respiratory compensation threshold occurred. Greater ventilatory thresholds have the potential to increase the work performance and efficiency of WFFs, which is particularly important given the long duration and high, sustained work rates of wildland firefighting deployments. Integration of a high-intensity circuit training program that includes wildland firefighting-specific tasks is a time-efficient alternative to help WFFs meet and exceed the physical demands of wildland firefighting.

POLICE

CAN TRAINING TRUNK MUSCULATURE INFLUENCE MUSCULOSKELETAL PAIN AND PHYSICAL PERFORMANCE IN MILITARY POLICE OFFICERS?

Gabriel Grani, Cintia de Lourdes Nahhas Rodacki, Henrique Lubas, Elisangela Franciele Resende, Rodrigo Hoinatski, Rafael Gomes Sentone, Robin Orr & Anderson Caetano Paulo

Musculoskeletal pain is frequently reported among military police officers, despite being considered very physically fit and being regularly tested for physical fitness. Military police officers regularly work shifts longer than eight hours while wearing and carrying heavy loads and commonly work in confined spaces creating sustained, inefficient postures (2). These loads consist of operational and protective equipment such as heavy ballistic protection vests and equipment belts that can exceed 20 kg (1). Given 50% of Special Weapons and Tactics (SWAT) operators have shown weak lower back endurance, it is speculated that a lack of trunk strength may place military police officers at an increased risk for MSKI, specifically at the low back. Trunk-specific training that improves activation of the trunk musculature may have a greater likelihood of reducing musculoskeletal pain and injury versus a general fitness plan.

Twenty participants from the Special Force Police Company, Battalion of Special Operations (Curitiba, Brazil) were recruited for an 11-week testing period, where the first and last weeks consisted of physical performance, trunk endurance, and anthropometric testing. The physical performance test mirrored the participants' biannual Special Force Police Company assessment and consisted of an agility (shuttle) test, a strength test (pull-ups), and an aerobic test, which required participants to walk or run as far as possible in 12 min. Trunk endurance was assessed using side plank, double-leg lift, and sit-up exercises. During the nine-week intervention period, the 20 participants were evenly and randomly placed into two groups: the trunk training (TT) intervention group and the control group. Both groups maintained their operational duties and reported the number of completed work missions throughout the 11-week study period. Both groups underwent 60 min of physical training three times a week, consisting of sessions alternating between aerobic and bodyweight exercise days without progression. However, the TT intervention group included an additional 25-min of trunk training, three times per week on alternate days, consisting of trunk exercises that increased in total sets every three weeks with cycling of new exercises every two weeks. The Corlett's Diagram was used to collect subjective responses of pain. Twenty-two body segments in the posterior aspect of the body were represented, with scoring ranging from "1" (no pain/no discomfort) to "5" (extreme pain/extreme discomfort).

Before the start of the participants' workday, collective scores of the Corlett's Diagram were recorded as ranging from 22 (all scores were a "1") to 110 (all scores were a "5"). On average, both the control group and TT group reported general pain and low back pain scores above 22 and 1, respectively. Post-intervention scores showed a significant effect for the TT intervention on scores of general pain and low back pain, while the control group did not. When isolating for low back pain, the TT group had a significant effect on low back pain compared to the control group, with the side plank and double-leg lift showing a moderate correlation ($r=-0.495$, -0.475 , respectively) with the side plank test having a moderate-to-large effect size (1.9). The post-training values in the TT group were 64%, 34%, and 24% higher in the side plank, double-leg lift, and pull-ups, respectively, compared to pre-training scores. The TT group had a significant effect on ratings of general pain and on low back pain, denoting a reduction in general pain and low back pain with a trunk training program. The utilization of the trunk musculature isometrically, as well as the postures used in each exercise, may improve activation and neuromuscular control of the trunk musculature, which may potentially improve overall stability for military occupational tasks that mandate the wear of loads on the trunk. Improved trunk muscular endurance and posture may lessen low back pain during prolonged periods of carrying torso-borne loads and improve the outcome of regularly assessed physical fitness tests.

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TRAINING FOR UPPER BODY POWER IN PROTECTIVE SECURITY PERSONNEL—A TACTICAL ATHLETE APPROACH

INTRODUCTION

Tactical athletes are personnel participating in military, law enforcement, and rescue professions that require a unique physical training approach to maximize occupational performance (3,31). Repeatedly faced with physically-demanding tasks, tactical athletes must possess physical qualities of muscular strength, power, endurance, flexibility, and speed (31). As with other tactical populations these physical qualities should be considered part of occupational duties within the profession of protective security personnel (PSP). Frequently referred to as “bodyguards,” PSP can be defined as a individual hired to personally watch, guard, or escort a person or specific group from physical harm or unwanted approaches in a public or private setting (23). Primary occupational tasks for PSP are to prevent or impede an attack targeting the physical wellbeing of the person/group of people employing the security member (23). Additionally, this role may also include crowd control during athletic or entertainment venues, adding a unique cognizant awareness to occupational demands. In past practice, PSP would be selected based on having a law enforcement background, muscularity, or possessing physical size. However, as training methodologies have improved, possessing physical size has not been as advantageous as previously thought (19,21). Since muscularity and size may not be indicative of higher occupational performance, other physical qualities are required to perform close contact occupational tasks.

Unfortunately, there is a gap in literature specifically investigating fitness attributes related to PSP. As such, the fitness attributes listed are based on personal and anecdotal experience. The literature referenced is similar in nature to the perceived tactical duties of PSP, focusing on asymmetrical combat and melee combat scenarios in active military and law enforcement populations (5,8). Asymmetrical combat encompasses combat situations, often times in urban areas in the presence of civilians, with the threat of a constantly changing environment, unexpected attacks and close quarter combat (5). Melee combat is characterized by close quarters and disorganized confrontations with poor control (8). Many interactions between PSP and challengers could occur within arm’s reach of an individual, making melee combat techniques and skills essential. Melee tactics can include hands-on techniques to rapidly strike/counterstrike to subdue, reduce, or eliminate a threat (4). Due to the unpredictable nature of close contact interactions, PSP may perform several upper body actions (e.g., striking, pushing, pulling) while experiencing a concurrent increased response from the body’s “fight or flight” response system (4,8,28,40,41). Consequently, increases in isometric hand grip strength have been reported

(4,8,40). As strength underscores the long-term development of power, a reasonable connection can be made on the importance of training for both physical qualities for PSP (4,7,8,40).

As a result of the close encounters and quick response needed for occupational tasks, upper-body power (UBP) may be of great importance (4). Defined as the amount of work per unit of time and equal to force times distance divided by time, power must be understood to train for optimal outcomes (42,44). For PSP, UB is crucial to the outcome of an altercation. Tornero-Aguilera et al. observed a positive correlation between lower-body strength and post combat simulation lactate levels indicating a heightened reliance on anaerobic metabolism (41). Although the preceding study did not directly study UB with their elite and non-elite soldier subject groups, the heightened lactate levels could signal reliance on type II muscle fibers, which are crucial in the production of powerful, “explosive” maneuvers and exercises (13). Given the proximity of an attacker during an altercation, quick, explosive strikes will have an immediate impact on the aggressor. The effectiveness of this type of strike could leverage outcomes in favor of the PSP. Specifically, PSP trained to maximize UB could obtain an advantage in hand-to-hand combat situations calling on the need to control, strike, and subdue an aggressor, thus improving the likelihood of a successful restraint and de-escalating of a situation (4). Understanding that these tactical athletes are hired to protect another individual or group, UB in the form of striking or counterattacking are vital to occupational success.

Currently there is no previous literature regarding PSP as a tactical athlete. Additionally, the authors were unable to find literature on the importance of developing UB within PSP. Prior literature of tactical athletes has focused on muscular endurance, strength, lower body power, and flexibility (10,12,18); however, the authors were unable to find specific studies regarding PSP. Furthermore, discussions of upper body strength and power have been done regarding military and law enforcement personnel, but there are no studies specifically dedicated to UB with PSP (12,39). Recognition of the occupational tasks, including close physical encounters, emphasizes the rapid upper body reactions needed to halt or quell an aggressor. These rapid upper body actions underscore the importance of developing UB for occupational duties. Specifically, UB could be the deciding factor between success or failure to contain or stop an attack. Therefore, UB training is of importance to this specific group as a potential occupational performance marker.

TRAINING FOR UPPER BODY POWER IN PROTECTIVE SECURITY PERSONNEL—A TACTICAL ATHLETE APPROACH

PROTECTIVE SECURITY UPPER BODY POWER

Power consists of both force (strength) and displacement over time (velocity) (44). Thus, both strength and movement velocity impact power development. With many tactical athletes, upper body muscular strength and endurance is often implemented in training (22,26). However, as mentioned previously, there is a gap in the literature regarding fitness attributes specific to PSP. This could be due to a minimal emphasis across all tactical occupations on power development and movement velocity, both as a physical assessment and focus of training (22,26). Unfortunately, there is also historically a lack of literature focused specifically on UBP training and testing. Original research on UBP testing assert that while lower body power tests are prominent in literature, tests for UBP have been neglected (2,27,33,37). A more recent critical review covering fitness testing for tactical personnel by Orr et al. did not report any relevant articles studying UBP physical fitness assessments, out of a total 1,377 that were originally entered into their search database (26). The paucity of evidence on UBP testing and training could be reflective of a lack of understanding on demonstrating the application of UBP principles in testing and training. Given the potential significance to strike/counterstrike rapidly, subdue an immediate threat, and operate in melee and asymmetrical combat settings, PSP may greatly benefit from UBP testing and training with an emphasis on movement velocity (4,5,8).

Training for power can involve a wide range of intensities, velocities, and movements. While UBP lessens the scope for training parameters, an emphasis on velocity further narrows UBP training intensities, underscoring the importance of movement speed. With occupational tasks potentially dictated by the ability to rapidly strike or counterstrike an individual, a concentration on maximal velocity within training for UBP could relate more closely to PSP performance (4). Force and velocity have a direct relationship, which can be seen in the equation below detailing the basic relationship between impulse and momentum (30):

$$F\Delta t = m\Delta v$$

In the equation above, F = force, Δt = change in time, m = mass, and Δv = change in velocity. As greater force is applied to a constant mass throughout a resistance training exercise, the resultant velocity will increase, allowing the individual to complete the movement in a shorter timeframe. Throughout resistance training exercises specifically, mass will remain constant, leading to a focus on acceleration. Acceleration can be calculated using the equation below:

$$a = \Delta v / \Delta t$$

In the equation above, a = acceleration, thus greater movement velocity over a shorter time period, leads to increased acceleration of a given object. Ultimately, Newton's Second Law ($F = ma$) will

dictate that as the force applied to an object of constant mass increases, the resultant velocity will also increase due to quicker time of exercise completion (30). Therefore, in order to improve UBP, external resistance (i.e., mass) used should remain low due to the concentration on high movement velocity in UBP training.

While there is a wide intensity range for UBP development (20 – 70% one-repetition maximum [1RM]), UBP focusing on velocity may best be suited between bodyweight and 30% 1RM (36). As stated by Soriano, Suchomel, and Marín, intensities of 0 – 30% 1RM displayed highest velocities while still achieving peak power production during a bench press throw (36). Due to the emphasis on velocity and extension of upper limbs, a bench press throw would appropriately fit the needed criteria for increasing UBP while still maintaining maximal or near maximal velocities. Additionally, Jandacka and Beremlijski underlined bench press intensities of 0 – 40% 1RM to deliver the highest velocities while still contributing to UBP output (15). Nevertheless, specific percentages may be prescribed based on the individual's previous training experience, fitness testing, and ability.

Furthermore, implementation of countermovement, plyometric, or ballistic type activities should be performed. Exercises incorporating such movements may more closely resemble those seen within occupational performance of PSP (e.g., countermovement prior to strike). Application of countermovement motions can contribute to increases in peak velocities during a movement by utilizing a mechanism called the stretch-shortening cycle (17,29). Most commonly observed in plyometric exercises, the stretch shortening cycle can be utilized in a variety of upper body movements including countermovement or ballistic (weighted/unweighted) actions (e.g., striking, throwing, counterattacking). While traditional resistance training exercises (e.g., barbell bench press) provide benefit for developing muscular strength and power, application to specific PSP upper body tasks requires a more unique approach. One major limitation to traditional resistance training is the limited acceleration through the concentric portion of the lift. For example, during a barbell bench press, as the barbell is pushed off the chest there is only limited acceleration through the lower and middle range of motion (7). As the individual reaches the end range gravity begins to decelerate the bar reducing velocity and restricting the power output (7). Though a bench press can improve UBP, ballistic methods incorporating non-traditional exercises (e.g., Smith machine throws, medicine ball puts) may provide greater benefit for striking applications. These ballistic exercises avoid the limited deceleration towards the end range of motion as the object will be projected, or released/thrown, achieving constant acceleration beyond the limitation of an end range, or stopping point (7).

Given the striking nature of PSP occupation, the continued acceleration into a projection more specifically fits the needs of a strike that is only slowed or stopped when PSP hit an object

at maximal velocity. Additionally, implementation of ballistic exercises has displayed increases in power of sports-specific movements greater than in traditional resistance training applications under a variety of loaded conditions (7). Thus, incorporation of ballistic exercises more specifically replicated the demands of occupational tasks but also creates the potential for higher levels of power output to be achieved. Enhancements of velocity from countermovement, plyometric, and ballistic exercises can exhibit increases in power output while maintaining greater velocities during movement. Given that PSP producing a quicker strike may disorient or distract the attacker for the needed duration of time to detain or subdue the threat, these should be of high importance for training.

The development of power at varying relative loads (30 – 70% 1RM) and muscular strength are also of significance for occupational duties. PSP, like other tactical athletes, require training for upper body strength as it will positively benefit occupational performance including grabbing, holding, carrying, and lifting, and serves as the foundation for power development (25,38). Thus, neglecting upper body strength in training may decrease occupational effectiveness, potentially increasing chances of failure. Moreover, due to the dangerous occupational situations, many PSP wear a tactical vest to reduce the chances of items penetrating their vital organs during potential altercations. This external loaded condition further dictates the importance of upper body strength and power to be developed and established, as physical altercations could have an added load of a tactical vest and weight associated with the attacker (35). However, a loaded condition also indicates the need for proximal stability of the torso and lower body musculature when developing UBP. A previous study on balance and stability with law enforcement officers indicated appropriate vestment fitting can affect stability of the individual (35). Thus, proximal stability may be a necessary quality to translate force from a loaded position to full extension from the ground into a strike. Additionally, the anterior trunk and lower body musculature will need to overcome the additional load for transference of lower body movement into the strike (i.e., rotation from the lower half and torso into a strike). An understanding that energy can be transferred from the lower body musculature to the upper extremities via kinetic chain solidifies the need for proximal stability of the trunk as well as lower body strength and power to aid in development of UBP. In summary, the required physical abilities and needs of PSP display the impact upper body strength, anterior trunk stability, and lower body strength/power have on the potential for improvements in UBP. Thus, all elements of upper body performance, as well as proximal stability, and lower body strength and power, including the ability to retract/extend the upper limbs powerfully and forcefully, are essential for the capability to develop UBP in this tactical population.

TACTICAL UBP ASSESSMENT

The use of appropriate assessment techniques for UBP is vital to evaluate training outcomes. The occupational duties of PSP involve rapid extension of the upper limbs to act upon a threat or individual; a related assessment may be appropriate to gauge increases in performance (23). Due to the nature of the occupation and potential for erratic and lengthy hours, a simple field assessment may be preferred for UBP measurement. Knowing that speed is distance traveled by an object/entity over time, these tactical athletes may benefit the most from a strike or rapid extension of an upper limb to determine UBP (1). Previous literature has indicated the use of portable force platforms as reliable and valid testing applications for explosive push-ups (43). However, given the cost and software application needed, this tool is unlikely to be available. A plausible field test of a bench press performed with the use of a linear displacement transducer (e.g., Tendo© unit, Gymaware©, Flex©, etc.) could be used as both a reliable and easy access system for UBP measurement (24). This type of assessment would provide instant feedback on UBP performance relating to specific occupational tasks. Given the lesser cost, variety of use, ease of access, and various applications, this assessment may prove to be the most effective field-testing method for PSP.

Additionally, the implementation of a seated (supported or absent support) upper-body medicine ball throw can be used to measure UBP. The seated medicine ball throw eliminated the ability of the lower half to aid in force production, thus demonstrating the maximal velocity capacity of the upper body muscles during extension (20). Due to an increase in velocity of the medicine ball, the distance traveled may increase correlating to an increase in UBP. This test may also reveal the need for additional upper body strength training to be performed. Tactical facilitators training protective security staff may find the use of these testing methods both easily accessible and reliable when assessing UBP.

PROGRAMMING CONSIDERATIONS

Considerations for developing UBP with an emphasis on maximal velocity will consist of traditional volume and rest period for muscular power; however, a more selective approach to intensity and exercise selection. Below are general outlines for programming UBP (Figure 1) and an example training program for UBP with PSP (Figure 2). Understanding the programming considerations listed in Figure 1 will provide tactical facilitators a more complete overview of basic principles to apply for programming. Recommendations for muscular power programming include intensities of 20 – 70% 1RM, dependent upon type of exercise (single- or multi-joint) and specificity of the adaptation (e.g., velocity, peak power, time to peak power, etc.) (13). In this instance however, an emphasis on velocity of UBP movement leads to the conclusion that intensities will be on the lower side (<30% 1RM) (36). Including other exercises with intensities ranging from bodyweight to 30% 1RM will ensure the

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focus on velocity. However, inclusion of other types of power including explosive power and repeat power has been added. Due to the nature of PSP occupational performance an array of sets and repetitions may be necessary to develop UBP. The specificity applied to UBP programming is derived from the National Strength and Conditioning Association (NSCA) recommendations on muscular power (32).

Generally, set and repetition protocols of 1 – 6 sets and repetitions are recommended when training for muscular power (13). Adherence to technical proficiency within the preceding set and repetition range will improve the overall adaptation seen from the program. Due to the high velocity of the exercises, suboptimal technique may lower the intended result of the program while increasing risk of injury (9). Additionally, an increase in volume

and/or intensity may change the desired adaptation and shift the application away from UBP.

Recommendations for rest intervals will remain as long or longer than that of muscular strength prescriptions at 2 – 5 min. Due to the intensity and velocity required during training, UBP primarily relies on neuromuscular function for adaptation (6). Therefore, recovery from exercises may require longer rest to ensure safety and effectiveness of UBP training (14). Although rest interval recommendations of 2 – 5 min are common, exact rest interval duration will vary between individuals given previous training exposure and experience. Likewise, more advanced trainees may benefit from intra-set rest periods commonly found in methods like cluster training. These brief intraset rest intervals allow for phosphocreatine stores to be replenished between repetitions, thus improving overall quality and output of the exercise (11). However, it should be noted that these methods and rest intervals will fluctuate based on the individual's previous training experience and overall physical ability. Tactical facilitators training PSP should be cognizant of potential variances to programming based on the needs of the individual.

- **Sets per Exercises: 1 – 6**
 - Explosive power: 3 – 5
 - Repeat power: 3 – 5
- **Repetitions per Exercise: 1 – 6**
 - Explosive power: 1 – 2
 - Repeat power: 3 – 5
- **Rest between Sets: 2 – 5 min**
- **Load/Intensity: <30% 1RM***

**Individuals performing force-velocity profiling may differ/require separate intensities*

TACTICAL APPLICATION

PSP are hired to defend and safeguard those employing them. In many scenarios, PSP will face close encounters with dangerous individuals, some of which are armed. Rapid decision making and reactions may be a key determinant in how quickly and safely a conflict may end. For PSP to successfully carry out operations, development of several upper body physical abilities, including UBP, are needed. Considering the sudden and prompt reaction necessary, decisive UBP actions such as striking and counterstriking are essential. Additionally, proper awareness of movement through crowds, venues, and arenas is a must for

FIGURE 1. PROGRAMMING CONSIDERATIONS FOR UPPER BODY POWER WITH AN EMPHASIS ON VELOCITY

TABLE 1. THREE-DAY UPPER BODY POWER DEVELOPMENT PROGRAM

DAY 1	DAY 2	DAY 3
Warm-up (2 x 10 each movement): • Bodyweight push-ups • Suspension trainer rows • Countermovement push-up: 3 x 6 • Standing medicine ball push (chest level): 4 – 6 x 3 • Barbell isometric bench press (push bar as hard as possible into pins located within first half of ROM): 4 x 10 s/repetition • Heavy bag – open palm strike (as fast as possible): 3 x 5 each palm	Warm-up (3 x 10 each movement): • Resistance band overhead shoulder distractions • Resistance band pull apart • Resistance band rows • Barbell bench press (dynamic effort): 6 x 3 at 20 – 30% 1RM • Smith machine bench press throw: 4 x 3 – 5 at 30% 1RM • Reactive supine medicine ball toss: 4 x 3 – 5 • Speed bag: 4 x 15 – 20 s	Warm-up (2 x 10 each movement): • Bodyweight push-ups • Suspension trainer rows • Banded dumbbell bench press: 3 x 5 – 6 • Seated medicine ball throw: 3 x 5 – 6 • Rotational single-arm cable press (light weight – quickly rotate to punch; cable and pulley are behind the trainee): 3 x 4 – 6 each arm • Heavy bag forearm strikes (progress to completing with weighted vest at 10% of body weight): 4 – 6 x 5 strikes/forearm

occupational duties. The ability to recognize potential threats early ensures PSP will have an advantage when confronting a threat. Since much of the occupation is performed in large settings with minimal physical separation (e.g., barriers, distance) the use of quick powerful bursts from the upper extremities is necessary in many altercations.

Tactical facilitators working with PSP should consider upper body occupational demands when developing a training protocol. Those principles and templates listed in Figures 1 and 2 provide an overview for UBP programming and exercise selection. Inclusion of UBP exercises provides the potential to develop rapid upper body responses to occupational threats. Additionally, practicing close combat scenarios, in both large and small venues that simulate confrontations, may aid in translation of UBP training to occupational performance. Furthermore, wearing padded or protective vests during simulations could more closely relate to upper body physical abilities seen while on duty. A previous study demonstrated the importance of proper fitting and design of protective vests which affects the relationship to stability scores on police officers (35). Even though lower body power production has demonstrated a strong relationship with stability scores, it would be logical to assume UBP also is positively assisted by lower body power production, especially in a stabilizer role (16,34). Based on these outcomes, the occupational duties for PSP demand that upper body physical abilities including UBP are developed. Thus, tactical facilitators training PSP should place an emphasis on UBP, with a velocity focus, during training as occupational performance may be improved for duty.

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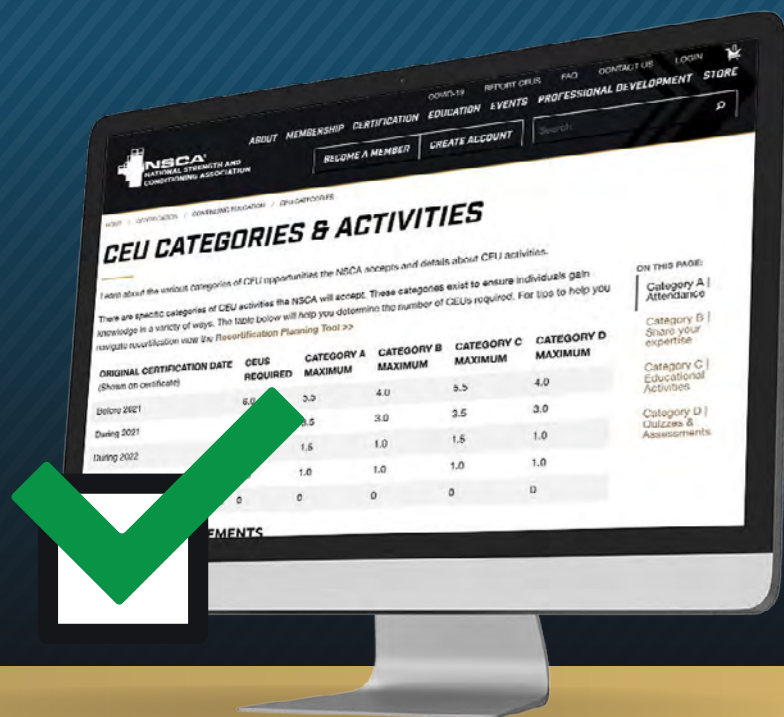
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