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POST-INJURY TRAINING TO ESSENTIAL JOB DEMANDS FOR FIREFIGHTERS

INTRODUCTION

Tactical athletes are often exposed to injuries and may be exposed to serious, even life-threatening, injuries due to the nature of their professional tasks and demands. There has been a decrease in total firefighter injuries over a 10-year period from 2006 (83,400 injuries) to 2016 (62,085 injuries) with the majority of the 2016 injuries (24,325 injuries) occurring while "at fire ground" (5). The "fire ground" indicates an operations area where a fire is present and emergency personnel are on-site to combat the fire and treat individuals. Approximately 56.3% of the injuries in 2016 were categorized as a strain, sprain, or muscular pain, suggesting the importance of a robust strength and conditioning program to reduce severity or occurrence of injury (5).

McDonough et al. demonstrated improved health behaviors (e.g., increased maximal oxygen consumption, decreased resting blood pressure) and physical performance in firefighters during an eight-week occupational-specific health education program (8). The ability to improve overall health is one aspect that should be addressed initially, followed by progressing to fitness, and finally occupational performance (Figure 1). The fitness variables specific to the firefighter that should be assessed and increased are abdominal strength, lower-body power, upper-body muscular endurance, and resting heart rate (2,4,9). Once these fitness variables are improved to a "functional level," a progression to the development of the firefighter may proceed. Scofield and Kardouni provided a progression to follow for developing occupational performance of a tactical athlete that utilizes traditional concepts of periodization, starting with a general preparation phase emphasizing work capacity and fitness that progresses towards job task specific training (Table 1) (12). However, with the occurrence of injuries, progressive approaches to return a firefighter to full duty is needed, following release from medical care of a physician and physical therapist. There are a number of musculoskeletal injuries that a firefighter may experience, and this article will focus on an upper-extremity injury based on a case study about ruptured triceps brachii. The concepts and layout of the program for return to duty (RTD) from an upper-extremity injury can be applied to other injuries with modifications to the specific area and type of injury. Prior to a full unrestricted release to work, a firefighter will have to demonstrate the ability to successfully perform upper extremity tasks that will stress the previously injured area. Although specific to the job requirements of firefighters, other tactical atheltes may benefit from the program if an upper-extremity injury occurred. This program will provide information for a tactical facilitator to assist in returning an injured firefighter to duty.

FIGURE 1. OCCUPATIONAL PYRAMID

TABLE 1. TACTICAL DEVELOPMENT

DEVELOPING OCCUPATIONAL PERFORMANCE FOR THE FIREFIGHTER (12)
General physical preparedness with applied strength and conditioning
Endure rigorous selection and initial training
Develop and maintain technical and tactical expertise
Specific strength and conditioning prescription to optimize performance
Sustain general and occupational physical preparedness

JOB TASKS

As described by the United States Department of Labor, firefighters need to perform many tasks: *"When responding to an emergency, firefighters are responsible for connecting hoses to hydrants, operating the pumps that power the hoses, climbing ladders, and using other tools to break through debris. Firefighters also enter burning buildings to extinguish fires and rescue individuals. Many firefighters are responsible for providing medical attention,"* (15). A strength and conditioning plan and program for the firefighter occupation requires individuals to perform their job task with externally loaded gear (e.g., protective pants and jacket) and carrying equipment (e.g., hose). The mass of the objects and gear firefighters must carry or manipulate ranges from 22 – 68 kg, requiring muscular strength and endurance (9). Testing firefighters in their tactical gear provides an evaluation of their occupational-specific skills while incorporating strength and conditioning programs with gear may further prepare them for the required physical demands (10,11). Movements and occupational

skill executions while wearing protective pants, jacket, boots, and helmet can alter not only the kinematics, but also require greater physical exertion. There is a bifurcation between physical training for performance enhancement and occupational-specific skill training which would require wearing tactical gear (e.g., protective pants). This occupational specific skill necessity is not applicable to performing an exercise (e.g., power clean) while wearing gear, as this could increase the chance of injury along with altering technique. Additionally, the carrying of hoses or statically holding them in place while in use requires the strengthening of the upper-extremity musculature through dynamic and static exercises.

Abel et al. addressed the needs of a firefighter by suggesting unilateral rowing and pressing exercises that would mimic the dynamic actions of ceiling breaching and hose pulling (1). Static upper-extremity drills, such as sled or mannequin drags and farmer's carry could improve isometric strength of the arm and grip musculature. Injuries to the upper extremities can compromise a firefighter's grip strength, secondary to immobilization or restrictions to loading during the recovery period. Prevention of upper extremity injuries would benefit from arm exercises that strengthen muscles from the shoulder to the hands during different training periods. During the return to duty period strength training sessions, Hofman suggests high training volume grip strength programming is necessary to perform occupational-specific tasks (e.g., opening fire hydrant) (6). Strength increases in grip and the isometric capabilities of the arm muscles are needed for carrying equipment, climbing, breaching, and the manipulation of hoses or other hand-held equipment (e.g., pike pole). Farmer's walks, sandbag lifts, and other drills that stress the upper-extremity muscles will need the isometric contraction qualities along with the isotonic movements. The swinging action of an axe, or ceiling breaching action with a pole axe, have dynamic actions in the elbow and shoulder joints with isometric contractions interspersed to hold the tool in a position for execution. The manipulation of firefighting implements requires isometric actions to perform fire-specific skills along with the dynamic strength and power movements involving the shoulder, elbow, and wrist or hand joints. In cooperation with the exercises that strengthen the muscles around the shoulders and arms, there is also a necessity in having a program that addresses the trunk muscles (1). Considering that the summation of forces goes from the legs through the trunk and finally to the upper extremities, there is a need to incorporate exercises that would be considered total-body exercises. Sled pulls, battle ropes, over the shoulder carry, and weight drags are suggested exercises to be included for performance and injury prevention (7). The increase of grip strength also transitions into total strength, as the firefighter will be developing this physical quality with other exercises (e.g., bent-over row).

Developing total strength provides a base for fitness that will benefit a firefighter's ability to perform activities under the external load of full occupational protective gear. External loading on a firefighter is amplified by the protective clothing, helmet, self-contained breathing apparatus (SCBA), mask, gloves, and tools. Upper-body strength programming, along with incorporating training sessions that utilize tactical equipment, can improve occupational performance in firefighters (10). The ability of a firefighter to perform sustained arm movements with the additional burden of an external load requires increasing strength and power, along with local muscular endurance. Returning the upper extremities to a level that allows for optimal occupational movements may be achieved by firefighters performing push-ups, pull-ups, inverted rows, and other exercises with a weighted vest in their program to develop this musculature.

INJURIES

During the needs analysis of firefighting, the type of injuries and their prevalence should be obtained from multiple sources, varying time frames, and personal accounts that can provide tactical facilitators with the best presentation of prioritizing injury prevention plans and programs. The needs analysis of firefighter injuries is specific to those that could be prevented through an effective training plan and program, as the job is inherently dangerous. For example, the majority of injuries that occur during fire ground activities has been reported at 38% from strains and sprains, while 59% of all non-fire ground injuries were from muscular pain, strains, and sprains (3). The causes of these fire ground injuries are most often from overexertion during job performance and muscular strains, while falls or slips can also be contributors, as the use of a self-contained oxygen tank can alter a firefighter's center of gravity. These injuries can occur anywhere on the body, along with severity that will influence loss of work time, length of rehabilitation, and amount of work conditioning to return to work. As strength and conditioning coaches plan to reduce the chance of athletes sustaining a non-contact injury during practices and competition, planning for firefighters should be focused on the job-specific skills as the work environments are chaotic and non-consistent. This work environment creates circumstances where injuries are inevitable; however, their occurrence and severity can be minimized from an effective training plan and program. Injury prevention for firefighting includes using appropriate tests to determine potential muscular imbalances and dysfunctions that will contribute to an effective strength and conditioning plan (13).

Occurrence of injuries in firefighters have an order of likeliness in the type of duty with "at fire ground," "at non-fire emergencies," "other on-duty activities," "training," and the lowest being "responding to or returning from incidents," (3). Tactical strength and conditioning plans should address the prevention of injury in all these environments, while there is a separate process of returning a firefighter to duty after a loss of work injury (14). The injury used in the article is adapted from a "real-life return to duty" as a method to display application. The various injuries that

may occur during fire ground operations prevent addressing each one in this article, but the process of the plan and programming presented in the article specific to a triceps brachii rupture can be adjusted to the uniqueness of any injury sustained.

PLANNING AND PROGRAMMING

Upon release from physical therapy, the firefighter should have established close to normal range of motion (ROM) along with strength to move the elbow joint. A challenge that tactical facilitators may experience is that ROM will need to be maximized, and there may be permanent changes in ROM along with strength after some injuries, such as muscle or tendon ruptures. The initial session should begin with an interview asking the firefighter what activity created the injury, what is their opinion on the effectiveness of post-surgery recovery or therapy they received, do they have any pre-existing conditions, and what are their personal goals for the training. The last interview question is used to gain some insight into the person's commitment to the training and return-to-work that will contribute to planning, programming, and session coaching. Following the interview, test selection will revolve around the ability of the injured area, along with the occupational requirements. Table 2 has a list of tests for the person's injury while the occupational tests are general and need to be adjusted based on a department's specific job description. Table 2 provides a list of tests (e.g., inclinometer app) that will address the athlete's injured area along with firefighter-specific tests that could be selected for establishing a baseline while avoiding tests that will not provide useful information or cannot be performed safely. Additional testing of resting heart rate, resting blood pressure, and body fat percentage could also be added to complete a health assessment that can also contribute to tactical strength and conditioning planning. The difference with this type of planning in comparison to other occupations is the firefighter needs to be able to successfully complete all these tests for unrestricted return to duty.

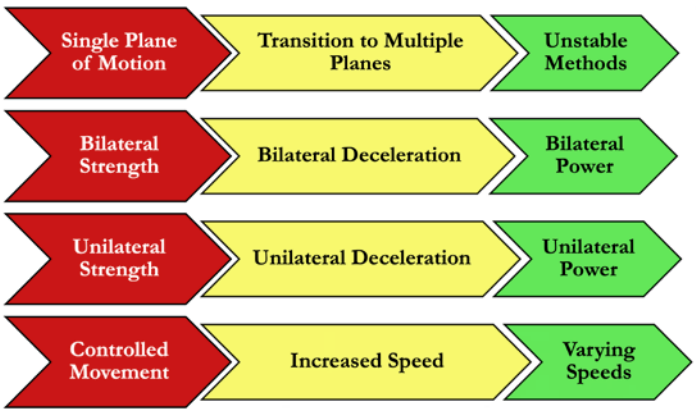

FIGURE 2. PLANNING PROGRESSION

A planning progression as a guide to select the most appropriate exercises to achieve the training goals based on basic movement characteristics is provided in Figure 2. The progression goes from the red phase that requires restraint/control, followed by the yellow phase with gradual increases to training complexity, and finally the green phase where training is at or near occupational performance requirements (e.g., weight drag). The single plane of motion applies to exercises that occur predominately in one plane, like the front squat and supine bench press, which are also in the bilateral strength category. Unilateral strength would be a step-up or dumbbell neutral grip bench press, while the first three red phase categories should be performed at a low velocity. As muscular strength is increased, the addition of multi-planar movements, such as cross-body chops can be added, along with emphasizing the eccentric phase of all movements by having a person hold a landing or have a 3 – 5 s eccentric phase. The speed of a movement is increased with exercise and incorporation of weightlifting exercises that develop muscular power. Despite firefighters having to stand, climb, or ambulate on unstable surfaces, exercises performed on unstable apparatuses limit force production. It is recommended to use both stable and unstable surfaces in the exercise programming of firefighters. Progressing the endurance requirements of an exercise and shifting towards more occupational specific drills should be applied as the firefighter adapts to the training stimulus. Planning involves the firefighter developing proficiency in bilateral and unilateral strength exercises, ending with bilateral-unilateral power exercises in the eight-week plan during specific training blocks. These training blocks (Figure 3) provide appropriate development and application of planning principles and programming methods. The progression within a program will begin with a general warm-up exercise (e.g., elliptical with arms) for five minutes to increase blood flow to the active skeletal muscles, neural stimulation, and prepare the cardiovascular system for greater stress that

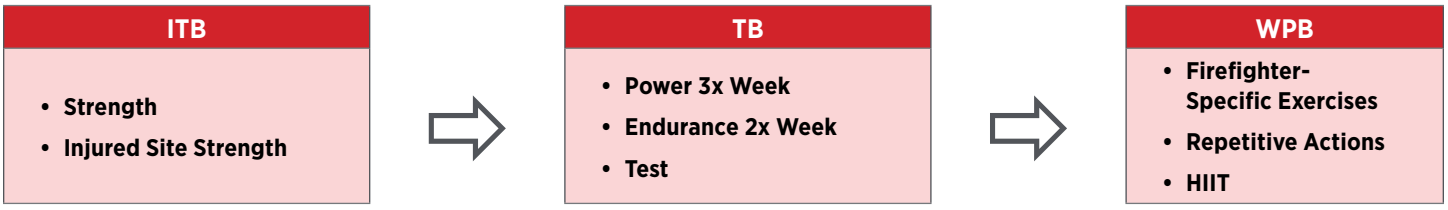

FIGURE 3. THE PROGRESSION OF THE TRAINING BLOCK GOALS FOR THE INITIAL TRAINING BLOCK (ITB), TRANSITION BLOCK (TB), AND WORK PREPARATION BLOCK (WPB)

TABLE 2. TEST SELECTION

TRICEPS BRACHII INJURY SITE	FIREFIGHTER OCCUPATIONAL TESTS (1,9,14)
1. Elbow joint flexion ROM 2. Elbow joint extension ROM 3. Isometric grip strength 4. Unilateral biceps brachii strength 5 – 12 repetition maximum (RM) (e.g., cable curl) 5. Unilateral triceps brachii strength 5 – 12 RM (e.g., cable press down)	1. 180-lb sled drag 80 ft for victim drag 2. 110-lb sandbag/dumbbell on shoulder step-up 8 – 12 repetitions for stair climb with hose 3. 110-lb barbell shoulder press (strength) 3 – 12 RM for equipment manipulation 4. Seated row (strength) 5 – 12 RM for hose pull 5. 2-min push-up for upper body muscular endurance 6. 2-min back extension hold for back health 7. 1.5-mile walk/run for cardiovascular endurance/health *Note: Firefighter may wear a 50-lb weight vest or their full gear when performing the tests.*

TABLE 3. FIREFIGHTER PROGRAM LAYOUT

MB – medicine ball; DB – dumbbell; KB – kettlebell; OH – over head; Ht. – height; SA – single-arm; Ext. – extension

MONDAY AND THURSDAY (POWER)	TUESDAY AND FRIDAY (STRENGTH)	WEDNESDAY (ENDURANCE)
General warm-up 5-min	General warm-up 5-min	General warm-up 5-min
Dynamic warm-up	Dynamic warm-up	Dynamic warm-up
Hang mid-thigh muscle clean = bar x 4 x 5	Push press = bar x 4 x 5	Rowing machine intervals = 5 min
Countermovement jump vertical = 5 x 4	**Vertical Strength**	(Work:rest = 1:4 – 6)
Box jump 4 x 3	DB or KB shoulder press = 3 x 5 – 8RM	• 2 – 4 min rest between intervals
(Box Ht. set 2” below CMJv mean jump Ht.)	Lat pulldown = 3 x 5– 8RM	Assault bike intervals = 5 min
Horizontal Strength	DB (Tuesday) deadlift 65 – 95 lb x 4 x 5 – 8	(Work:rest = 1:4 – 6)
Standing cable bar chest press = 3 x 5 – 8RM	Hex bar (Thursday) deadlift 65 – 95 lb x 5 – 8	OH squat = stick or barbell x 3 x 10 – 15
Bent over row = 3 x 5 – 8RM	Step-up with vest (10 – 40 lb) 2 x 5 – 8 each leg	MB sit-ups = 4 – 8 lb x 4 x 6 – 10
“Isometric” Arm Exercises	**Dynamic Arm Exercises**	MB trunk twists = 4 – 8 lb x 2 x 20 – 30
Sled drags = 45 – 90 lb x 4 – 6 x 80 ft	DB hammer curls = 3 x 5 – 8RM	Horizontal back ext. 3 x 10 – 15
Farmer’s walks = 30 – 60 lb x 2 – 4 x 80 ft	DB triceps kickbacks = 3 x 5 – 8RM	DB or KB side flexion = 4 x 10 – 20
Shoulder carry = 15 – 30 lb x 2 – 4 x 80 ft	Supinated DB biceps curls = 4 x 10 – 15RM	**Ancillary Preventive Exercises**
MB “bear hug” carry = 8 – 20 lb x 2 – 4 x 80 ft	SA pronated pressdowns = 4 x 10 – 15RM	Internal and external shoulder rotation = tube x 2 x 15
Push-up hold = 2 x 10 – 30 s	DB lateral raises = 2 x 12 – 15RM	Heel raises = 4 x 15 – 20RM
Dip hold off ½ foam roll = 2 x 5 – 20 s	DB reverse fly off bench = 2 x 12 – 15RM	Mobility work for 10 – 15 min
Mobility work for 10 – 15 min	Mobility work for 10 – 15 min	

Dynamic warm-up: bodyweight squats x 10, push-ups x 10, lunge with OH reach x 6 eacj leg, side-to-side leg swings x 15 each leg, front-to-back leg swings x 15 each leg, horizontal arm swings x 15, sagittal arm swings x 15, chest level band pull-apart x 15, 4-lb OH MB wall bounces x 15 – 20, 6-lb MB circles right and left x 10 each direction, 6-lb MB chops x 10

will be followed by a specific dynamic warm-up that emphasizes the upper body. Lastly, a single or two sets of the exercise to be performed may be completed at a lighter load for 2 – 5 repetitions. Due to the nature of the job that will stress the whole body every day, the program is set up to address that specific type of stress (Table 3). The program session is a 1.5 – 2 hr in length.

The program should incorporate exercises that best suit the firefighter's physical and occupational needs while balancing the stressors from one day to the next. An approach to assist with this balance is dividing the core exercises in vertical and horizontal, pulling and pressing exercises. Within the session, there is also the division into bilateral and unilateral exercises that should be used in a program. The first exercise in the main part of the program are total-body power exercises, such as a push press, hang (e.g., mid-thigh, above knee, etc.), clean or snatch variations, backward medicine ball throws, and combination lifts (e.g., hang mid-thigh muscle clean plus shoulder press) followed by other power-based exercises. After the power exercises, multi-joint exercises that require bilateral pulling (e.g., standing cable row, bent-over row, kneeling wide and close grip pulldown, pull-ups) and pressing (e.g., shoulder press, standing chest press, incline bench press) would be the most effective. These bilateral exercises are complemented with unilateral pulling (e.g., standing single-arm cable low and high row, single-arm dumbbell row) and pressing exercises (e.g., dumbbell or kettlebell shoulder press, standing single-arm cable chest press) in the exercise order. The initial training block (ITB) should progress the exercises to upper-extremity power exercises (e.g., medicine ball chest throws, slams, and side throws) in the work preparation block (WPB). The length of the ITB and WPB may be 2 – 5 weeks long, depending on how the firefighter responds to the training. Priority of the exercises in the WPB should increase to more occupational-specific exercises, such as hand-over-hand rope sled pulling, 180-lb "dummy drag," breaching simulation, and movements with a loaded vest to simulate the weight of protective gear.

Injuries sustained by the firefighter dictate the objective of the program by having a part in the session that focuses on strengthening the injured area. The upper-extremity injury for the current example will be stressed by single-joint exercises that will strengthen the surrounding muscles (e.g., dumbbell hammer curls, triceps kickbacks). Along with the dynamic exercises, there should be a selection of isometric exercises focused on the specific joint (e.g., dip hold off ½ foam roll) and occupational exercises that will also challenge the joint (e.g., farmer's walk, dumbbell shoulder carry). The Wednesday session is for stressing the firefighter's energy system and acts as a recovery day while providing the necessary work environment stimulus of everyday physical exertion. These sessions should be adjusted based on the equipment and logistics available to the tactical facilitator to apply to the firefighter. Prior to the start of the plan will be the tests for the firefighter's occupational tasks, as well as tests to assess the injured area(s). The ITB is used for establishing a strength base while the TB is one or two weeks that will increase power focused exercises and endurance training. The WPB will have a greater amount of firefighter-specific exercises, repetitive actions that may improve work performance, and each session will have endurance training with 2 – 3 sessions using high-intensity interval training (HIIT). During the WPB would be the time that sessions may include the firefighter wearing a weighted vest to simulate the external load of their work gear or, if practical, wear boots, pants, and overcoat. The one line to avoid crossing is performing job skills that are more appropriate at the department or state's firefighter training facilities. The role of the tactical facilitator is to apply exercises that simulate and train the physical qualities needed to be successful in their occupation. After a firefighter has completed their physical therapy and is cleared for increased physical activity, a progression for a full RTD is necessary to achieve muscular balance while decreasing chance of re-injury.

CONCLUSION

On-duty injuries cannot be eliminated, but the severity of an injury and RTD timeline may be reduced through effective tactical strength and conditioning planning and programming (14). The challenge is taking a firefighter from physical therapy sessions that are limited on contact hours, due to regulations, to physical training for four hours. Tactical athletes are unique in planning and programming as there is no "off-season" and schedules are unpredictable. The RTD suggestions provided can be adjusted to address other injuries while the one provided is for context of how this has been applied to a specific injury. The most effective RTD plan would be best served through cooperation and communication between the injured person, service branch/department, command personnel, rehabilitation team, and the tactical facilitator.

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