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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 (L×min-1) or relative (mL×kg-1×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 mL×kg-1×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 mL×kg-1×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

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 **1 – 3 min rest between each set; finish all working sets of HAK PCL prior to progressing to the squat* **HIIT Portion** *2x initially and progress to 3x through* • 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 **After completing each time through full circuit, follow the W:R ratios referenced above*	**Main HIIT Session** *2x initially and progress to 5x through* *Sled load progress to 185 lb* • 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 **After completing each time through full circuit, follow the W:R ratios referenced above*
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 **Complete all working sets, one exercise at a time, prior to progressing to the next exercise* **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 **Complete one set of each exercise prior to rest period* **Trunk** • Superset format • MB sit-up: 2 x 15 – 30 • Horizontal back extensions: 2 x 10 – 15 **Complete one set of each exercise prior to rest period.*	**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 **Complete all working sets of each resistance training exercise prior to transitioning to next exercise* **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 **Complete one set of each exercise prior to rest period*
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% VO_2max 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

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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