

F.I.RE. FIGHTERS: FITNESS INTERVENTION IN RECRUIT FIREFIGHTERS

BY

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DISSERTATION

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ABSTRACT

As a population, firefighters are at high risk for many health-related issues (e.g., sudden cardiac events, obesity, hypertension, fatigue, depression, post-traumatic stress disorder, anxiety). Physical activity (i.e., exercise) is one the most effective strategies firefighters can use to prevent or attenuate multiple health risks as well as improve their health and physical fitness as well as job performance. Given the increased risk of many diseases and diminished health, firefighters' fitness levels are crucial for preventing these potentially morbid diseases or at least decreasing their risk.

The purpose of this project was to examine the relationships between: (1) physical fitness (cardiovascular endurance, muscular strength, muscular endurance, power, flexibility) and performance on the Illinois Fire Service Institute Academy Firefighter Challenge (AFC); (2) individual differences (exercise intensity preference and tolerance, extraversion) and physical fitness; and (3) individual differences and performance on the AFC. In addition to exploring these relationships, this study examined the effects of a 7-week functional fitness training program by assessing multiple components of fitness at baseline (Week 1), mid-Academy (Week 4), and post (Week 7). This project attempted to establish the role fitness plays on firefighting capabilities and the impact individual differences had on fitness and firefighting capabilities.

Participants were new/novice career firefighters [recruits enrolled in the Basic Firefighter (FF) Academy at the Illinois Fire Service Institute]. Measures of fitness (1.5-mile run time, number of repetitions on 60 s sit-ups and push-ups, vertical jump height, sit and reach) and simulated firefighting drills (Keiser Sled, SCBA maze, victim drag, hose charge, equipment carry, and ladder set-up) were assessed at Week 1 and Week 7 of the Academy. Descriptive measures (age, height, weight, BMI) were also recorded. In addition to these measures,

individual trait differences were assessed via questionnaires. Over the course the 7-week Academy, the participants took part in a functional fitness program, designed to improve not only fitness but also their skills as firefighters.

Firefighting is a challenging occupation that requires the men and women who choose to this profession to be in peak physical condition. However, this is not always the case and it is more common that there are unfit and unhealthy firefighters working as first responders. Targeting firefighters early in their careers and highlighting the importance of fitness is extremely vital to developing healthy, safe, and efficient firefighters.

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CHAPTER 1: GENERAL INTRODUCTION

As a population, firefighters (FFs) are at high risk for many health-related issues (e.g., sudden cardiac events, obesity, hypertension, fatigue, depression, post-traumatic stress disorder, anxiety; Norwood & Rascati, 2012). Physical activity, specifically regular exercise, is one the most effective preventative strategies FFs can use to combat multiple health risks as well as improve health and job performance. Firefighting is unique as it requires all aspects of health-related fitness (i.e., cardiovascular endurance, muscular endurance, speed, power, and flexibility). Improvements in physical fitness could potentially lead to reductions in both physical and mental ailments. In addition to health improvements, worksite productivity and efficiency could be improved with increased physical fitness.

Firefighting is a challenging occupation. The men and women who choose this profession should ideally be in peak physical shape to perform optimally. However, this is not always the case and it is more common that there are unfit and unhealthy FFs working as first responders (Mehrdad, Movasatian, & Momenzadeh, 2012; Poston, Haddock, Jahnke, Jintarin, & Day, 2013; Smith, 2011). Firefighters have specific requirements that need to be met in order to be hired by a department; however, there is a lack of required physical activity and fitness standards once hired and in the work force (Baur, Christophi, Cook, & Kales, 2012; Butler et al., 2013). Job-related injuries and health issues often shorten the career of FFs, but these can be prevented or attenuated with a regular, job-related exercise routine.

Statement of the Problem

The general lack of physical fitness impacts not only the individual firefighter, but also the public and the other men and women who choose firefighting as their profession (Baur et al., 2013; Leduc & Jahnke, 2015; Mehrdad et al., 2012; Smith, 2011). Nearly 75% of the men and

women who work as career FFs are overweight or obese (~50% overweight and ~25% obese) (Poston, Jitnarin, Haddock, Jahnke, & Tuley, 2011). They are also at risk for anxiety, depression, post-traumatic stress disorder, cardiovascular disease, hypertension, diabetes, and fatigue (Antolini, Weston, & Tidus, 2015; Baur et al., 2012; Jahnke et al., 2012; Leduc & Jahnke, 2015). Given the increased risk of many diseases and diminished health, firefighter fitness levels are crucial for preventing these potentially morbid diseases or at least decreasing their risk. Higher fitness levels are not only linked to decreased likelihood of health issues, but also to decreased risk of injury (Poston et al., 2011; Smith, 2011). The physical demands of firefighting are unique and can be very strenuous. Unlike other physically demanding jobs that may require one specific, unique skill set, firefighting requires a wide variety of skills and thus has much higher fitness demands. Due to these high fitness demands, it is clear that action must be taken to promote an activity regimen that can lead to better fitness in firefighters.

Coronary heart disease (CHD) is responsible for 40-50% of on-duty firefighter deaths in the United States (Kales, Soteriades, Christoudias, & Christiani, 2003; Soteriades, Smith, Tsismenakis, Baur, & Kales, 2011; Soteriades, Targino et al., 2011). This trend has been consistent and continues to be a pressing concern for the safety and well-being of volunteer and career FFs. Researchers have found that many of the stressors (e.g., physical exertion, smoke exposure, psychological strain) associated with firefighting may contribute to increased cardiovascular risk. Firefighting includes long periods of sedentary behavior often followed by acute bouts of vigorous exertion. These immediate stressors cause a significant increase in heart rate (Kales et al.). Following these immediate increases in heart rate, FFs often perform fire suppression tasks that require them to work at high or near maximal heart rates while wearing heavy protective equipment and often carrying implements of varying weights. Fire suppression

tasks have the highest incidence of cardiac incidents and death among on-duty FFs (Kales, Soteriades, Christophi, & Christiani, 2007). Between 1995 and 2004, 440 FFs died from sudden cardiac incidents in the US (Fahy, 2005, p. 5). This number accounts for nearly half of the on-duty deaths that occurred between the years 1995-2004. Obesity, age, diabetes, high cholesterol, high blood pressure, family history, and physical inactivity were all risk factors associated with an increased risk for sudden cardiac incidents. Many of these risk factors can be modified through regular participation in an exercise regimen.

Rates of overweight and obesity in FFs are alarming and detrimental to firefighter health. Poston et al. (2011) studied over 714 firefighters and found that 48.7% of the sample was overweight ($BMI \geq 25 \text{ kg/m}^2$ but $< 30 \text{ kg/m}^2$), 21.7% were class I obese ($BMI \geq 30 \text{ kg/m}^2$ but $< 35 \text{ kg/m}^2$), and 10.4% of the sample was labeled class II and III obese ($BMI \geq 35 \text{ kg/m}^2$). As firefighting can be a rigorous profession, physical strain and injury are nearly impossible to avoid. However, obesity increased the risk for injury in FFs. Firefighters who met the criterion of class II and III obesity had nearly five times the number of missed workdays due to injury compared to their normal weight peers (Poston et al.). Kuehl et al. (2012) found similar rates of obesity among a sample of 433 firefighters: 56% were classified as overweight ($BMI 25 \leq 29.9 \text{ kg/m}^2$) and 19% were considered obese ($BMI > 30 \text{ kg/m}^2$). Firefighters in the overweight and obese categories were more likely to experience bodily injury to all body parts excluding their foot/ankle, compared to their healthy weight counterparts. It is apparent that being overweight or obese puts additional strain on a firefighter's body, which increases their risk of injury. Annually, tens of thousands of FFs are injured in the line of duty.

Occupational injuries often lead to disability and/or early retirement among FFs in the US and globally (Kuehl et al., 2012). The majority of injuries among FFs are sprains and strains

(65.4%), with the most common cause of injury being overexertion (67.9%; Griffin et al., 2016). In 2012, among one million firefighters in the US, over 69,000 injuries were reported. Poplin, Roe, Peate, Harris and Burgess (2014) found that FFrs with lower levels of aerobic fitness ($VO_{2max} < 43 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) were over 2 times more likely to suffer from injury than their more fit ($VO_{2max} > 48 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) counterparts. These results further justify the need for at least satisfactory fitness levels in firefighters.

Background and Setting

Previous firefighter research has assessed risk factors contributing to sudden death (primarily cardiovascular events) among career and volunteer FFs. Little has been done to assess the effects of a functional (non-traditional) fitness program on FF fitness levels and ability to perform duty-specific tasks. Several studies have examined the impact a firefighter training academy had on recruits' fitness levels (Cornell, Gnacinski, Meyer, & Ebersole, 2017; Gnacinski et al., 2016; Gnacinski et al., 2015). While positive changes in health and fitness were observed during a 14-wk training academy, many of these gains were lost over a subsequent 6-month probationary period due to lack of adherence to a training program. Further research needs to explore possible ways to increase exercise adherence in active-duty FFs. As stated, optimal physical fitness is important for proper/efficient job performance among FFs. Establishing a clear and significant relationship between fitness (cardiovascular endurance, muscular strength, muscular endurance, flexibility, and power) and better performance on firefighting tasks is essential and extremely important to create a healthier and more capable firefighter.

Previous research has examined FF performance related to strength and fitness measures (Henderson, Berry, & Matic, 2007). Participants were fire recruits in Milwaukee from 1992-1998. A variety of fitness measures were taken (upper body strength, maximal aerobic power

(VO_{2max}), and muscular endurance), as well as a battery of simulated firefighting tasks (ladder placement, fire axe chopping, and training rank assessment). Henderson et al. found significant relationships between fitness (muscular strength, relative VO_{2max}, muscular endurance) and performance (better fitness associated with better performance) on simulation tasks (timed ladder raise, rating of axe chopping, combat test speed). Such research provides insight and highlights the importance of physical fitness among FFs. New and emerging literature has shown that High-Intensity Functional Training (HIFT) increases aerobic and anaerobic capacity in military personnel, while still proving to be a safe and effective form of physical training (Poston et al., 2016). However, very few studies have examined the effects of a multiple week HIFT intervention within a firefighter sample.

The PHLAME (Promoting Healthy, Lifestyles: Alternative Models' Effects) study sought to improve healthy eating and exercise behaviors among firefighters (Ranby, Mackinnon, Fairchild, Elliot, & Goldberg, 2011). The study involved of 397 career FFs who were either assigned to a control or one of two intervention groups: a team-centered peer taught curriculum or one-on-one motivational interviewing. The participants took part in 11, 45-minute sessions over the course of a year with their assigned shift. There were four variables of interest: fruit consumption, vegetable consumption, self-reported exercise, and VO_{2max}. Ranby et al. hypothesized there would be five mediating variables: knowledge of fruit and vegetable benefits, knowledge of exercise benefits, personally monitoring diet, dietary coworker norms, and exercise support. Fruit and vegetable consumption were assessed via self-reported servings in the past month, exercise was computed as mean score of weekly exercise over the last month, and VO_{2max} was assessed via a treadmill test administered by a trained professional (Ranby et al.). It is important to note this was not a physical activity intervention, but rather an intervention to

promote healthy lifestyles among FFs. Ranby et al. found that the team-centered intervention group increased fruit and vegetable consumption positive changes in BMI when compared to the control group. Changes in knowledge of exercise and exercise support were related to changes in self-reported exercise. Despite these positive associations, exercise habits did not change significantly over the course of the intervention. Ranby et al. also found that a change in knowledge of exercise benefits was related to a change in VO_{2max} , but the intervention did not yield significant improvements in VO_{2max} . These findings suggest that a peer-taught curriculum may be an effective strategy to improve the health and wellness of firefighters.

In addition to the relative lack of intervention studies, very few, if any, studies have explored the relationship of psychological factors (e.g., personality) and aspects of fitness within a FF sample. Prescribing exercise and achieving adherence to an exercise program is challenging regardless of the population. Many individuals who begin an exercise program drop out within the first few months (Ekkekakis, Hall, & Petruzzello, 2005). Previous research has examined exercise intensity preference and tolerance as two individual difference factors that may impact exercise adherence. Knowing and understanding what type and intensity of exercise an individual prefers and perceives a tolerance for has proven beneficial in increasing positive affective responses following exercise (Ekkekakis et al.; Ekkekakis, Lind, Hall, & Petruzzello, 2007). The increase in positive affective response may lead to increased adherence rates. In addition to exercise intensity preference and tolerance, other aspects of an individual's personality may provide insight into their exercise or physical activity habits. Extraversion has been shown to be a predictor of physical activity habits (De Moor, Beem, Stubbe, Boomsma, & De Geus, 2006; Ingledew, Markland, & Sheppard, 2004; Salters-Pedneault, Ruef, & Orr, 2010), with individuals who score higher on extraversion being more likely to engage in exercise and

physical activity when compared to those who score lower on extraversion. By examining the relationship of individual differences and fitness, the present study has the potential to highlight specific individual differences that could help to better understand which individuals are more or less likely to engage in physical activity. This knowledge could help in fostering more fit, efficient, and healthier firefighters.

Significance

Safety (of the public and the FF) is the top priority when entering and combatting structural fires. Due to the bodily demands of firefighting and the dangerous nature of this profession, injuries are common. Firefighting can place extreme burdens on the cardiovascular and musculoskeletal systems and such exposures increase the risk of injury. The leading cause of injury among emergency responders comes from the physical demands of these occupations (Reichard & Jackson, 2010). In 2016, there was a total of 62,085 injuries that occurred while FFs were on-duty. Nearly 40% of all injuries occurred during fire-ground operations (See Figure 1.1 below). Over half (58%) the reported injuries were attributed to strains, sprains, and muscular pain. Overexertion and strain accounted for 27.1% of all injuries among US firefighters (National Fire Protection Association (NFPA)). Increasing fitness has the potential to reduce overexertion in this population. Recent studies have revealed significant reductions in injuries among FFs during fitness interventions (Griffin et al., 2016; Peate, Bates, Lunda, Franics, & Bellamy, 2007). Additionally, a 5-year cross-sectional study revealed that higher BMI was linked to an increased chance of experiencing an injury and filing a worker's compensation claim (Kuehl et al., 2012). These findings suggest that more active and fit FFs are less likely to experience injury compared to their heavier and sedentary peers.

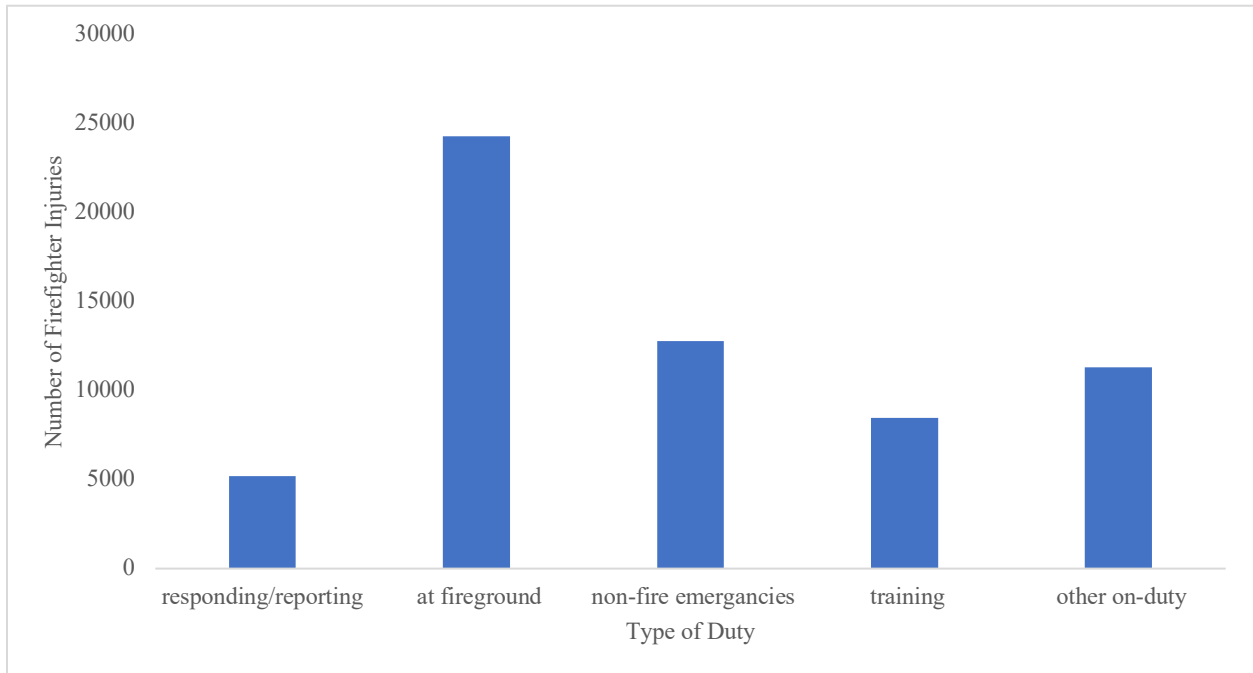


Figure 1.1. *Number of firefighter injuries by nature of injury and type of duty* (Note. Adapted from Haynes & Molis, 2017, p. 11).

Between the years 1977-2010, 7.8% of all on-duty FF deaths in the US occurred during training (Fahy, 2012). Training is an essential and vital part of a firefighter’s career. However, far too many unnecessary deaths and injuries still occur. From 2000-2010, 39 deaths occurred during training with apparatus and equipment drills (Fahy). These drills include ladder climbing, pump and drafting operations, self-contained breathing apparatus (SCBA) and smoke drills, driver and pilot training, and training in extrication. Of these 39 deaths, 25 (64%) were attributed to overexertion, stress, or underlying medical issues, which resulted in 22 sudden cardiac arrests (Fahy). Live-fire training resulted in 13 deaths, and of those 13, four were attributed to sudden cardiac death (Fahy). While training is an essential part of a FF’s career, it is important to highlight the dangers of overexertion, which is often linked to poor physical fitness.

Sudden cardiac death is clearly a major contributor to deaths among FFs in the US, both in training and on the fire-ground. Kales et al. (2003) found that physically active FFs were at a lower risk for coronary heart disease (CHD). The FFs who had CHD were also more likely to have cardiovascular risk factors, hypertension, and to smoke. Yang et al. (2013) found that 63% of sudden cardiac deaths occurred in obese individuals. Cardiovascular fitness is essential in reducing the risk of cardiac incidents (Scanlon & Ablah, 2008). Additionally, cardiovascular health is influenced by both modifiable and non-modifiable risk factors. Some of the modifiable risk factors include cigarette smoking, high blood pressure, high cholesterol levels, obesity, physical inactivity, and diabetes. Physical activity and, more specifically exercise, is a cost-effective, safe, and efficient way to modify these risk factors. Despite exercise being an effective strategy to prevent cardiac risk factors, only 30% of US fire departments have preventative programs in place to promote and maintain FF cardiovascular health and levels of physical fitness (Gnacinski et al., 2016). Previous research has highlighted the importance of cardiovascular fitness among FFs, however there is limited research that examines all aspects of fitness (i.e., cardiovascular fitness, muscular strength, muscular endurance, power, and flexibility).

Rationale

Firefighters are required to perform physical tasks while wearing heavy (~50 pounds) personal protective equipment (PPE) and other gear in extreme environments. This equipment is cumbersome to move with and often limits the FF's range of motion. Thus, there is a mismatch between the strenuous physical demands of firefighting and the levels of fitness in FFs (Storer et al., 2014). These below average levels of fitness put FFs at an increased risk for chronic diseases, injury, and even sudden death. Seyedmedhdi et al. (2016) found that FFs with higher levels of

aerobic fitness were at a significantly lower risk of having cardiovascular disease risk factors compared to their less fit counterparts. The leading cause of injuries among FFs comes from the physical nature and demands of firefighting (Reichard & Jackson, 2010). While the physical nature of firefighting cannot be changed, numerous lifestyle factors can be adopted to reduce the risk for disease, injury, and sudden death. Additional research has suggested that higher levels of obesity and lower levels of physical fitness are associated with poor movement scores (Functional Movement Screen™; Cornell et al., 2017). With their range of motion already limited due to the cumbersome PPE they wear and the equipment they often carry, further limitations in the FF's movement pattern can lead to injury. Overweight and obese FFs are of increasing concern and proper steps should be taken to prevent further injury or death in these individuals.

As noted, firefighting requires FFs to perform tasks (climbing ladders, drag hoses, forcible entry, victim rescue, etc.) under extreme conditions. These challenging tasks often require a relatively high energetic peak load (Plat, Frings-Dresen, & Sluiter, 2010). Research suggests that ideal aerobic capacity (i.e., VO_{2max}) in FFs is $42 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, but studies have shown the average VO_{2max} among FFs to be $34 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ (Storer et al., 2014). Personality factors may play an important role in exercise behavior and FF performance. Previous research has examined the relationship between exercise intensity preference and tolerance and performance during fitness testing. Hall, Petruzzello, Ekkekakis, Miller and Bixby (2014) found that both exercise intensity preference and tolerance scores exhibited significant relationships with several aspects of fitness, body composition (% body fat), and reported physical activity levels in a sample of 516 individuals, including 42 male FF recruits. Results for the FF sample revealed that exercise intensity preference predicted performance on the 60 s sit-up and 1.5-mile

run tests at Week 1, and exercise intensity tolerance was related to the 60 s push-ups test at Week 1 of a basic FF academy. Tolerance was also related to performance on sit-ups, 1.5-mile run, body fat, and perceived fitness at Week 1 and Week 6 of the firefighter academy. Such research highlights the important and understudied relationships between individual differences and exercise patterns and performance (Hall et al.).

Understanding the personality of rescue responders could prove beneficial for several reasons (Wagner, Martin, & McFee, 2009). Rescue professions expose individuals to a variety of stressful and physically demanding events that may impact the physical and mental well-being of the first responder. Personality has been used to predict post-traumatic symptoms as well as effective job performance. Significantly higher levels of extraversion have been shown in FFs compared to their counterparts who were not rescue workers (Meadows, Shreffler, Mullins-Sweat, 2011; Wagner et al.). It has been found that FFs reported fewer Type A behaviors and personality traits than their non-rescue counterparts. Extraversion has been linked to higher levels of physical activity and a greater likelihood to engage in physical activity or exercise (Courneya & Hellesten, 1998). Extraversion was positively related to exercise behavior (i.e., greater extraversion associated with more activity). In addition to its role in dealing with trauma and mentally taxing events, personality may be a useful tool when prescribing exercise to FFs. We know that individuals who engage in higher levels of physical activity and exercise have lower mortality risk compared to their inactive peers (Ekkekakis et al., 2007). Despite this, the majority of individuals who begin an exercise program drop out within the first few months. Understanding why an individual is more or less inclined to engage in and continue exercise is equally as important as the activity itself. Less than 30% of fire departments require physical activity and exercise or provide an exercise program for their FFs (Rhea, Alvar, & Gray, 2004).

By understanding the personality profile of FFs, exercise professionals and researchers may be able to better prescribe and implement exercise/physical activity programs.

Purpose

The purpose of this project was to attempt to establish the role fitness plays on firefighting capabilities and what impact individual differences have on fitness and firefighting capabilities. Specifically, the study examined the relationships between: (1) physical fitness (cardiovascular endurance, muscular strength, muscular endurance, power, flexibility) and performance (i.e., time to complete) on the Illinois Fire Service Institute Academy Firefighter Challenge (AFC); (2) individual differences (exercise intensity preference and tolerance, extraversion) and physical fitness; and (3) individual differences and performance on the AFC. In addition to exploring these relationships, this study examined the effects of a 7-week functional fitness program by assessing fitness at baseline (Week 1), mid-Academy (Week 4), and post (Week 7).

Specific Aims & Hypotheses

Aim 1. Examine the effect a 7-week high intensity functional fitness (HIFT) program had on levels of fitness and performance (i.e., time to complete) on the AFC.

H₂: It was hypothesized that a 7-week HIFT program may improve all aspects of fitness (cardiovascular endurance, muscular strength, muscular endurance, flexibility, and power).

H₃: It was hypothesized that a 7-week HIFT program may improve performance on the AFC.

Aim 2. Examine measures of fitness (cardiovascular endurance, muscular strength, muscular endurance, flexibility, and power) and their relationship with firefighting capabilities (AFC performance) at baseline and at Week 7.

H₁: It was hypothesized that greater levels of physical fitness may be associated with better performance on the AFC at baseline and Week 7 of the Basic Firefighter Academy.

Aim 3. Examine the relationship between personality traits (i.e., extraversion & exercise intensity preference and tolerance) and performance on both fitness-related tasks and the AFC.

H₄: It was hypothesized that higher levels of extraversion may result in better performance on both fitness tests and the AFC.

H₅: It was hypothesized that greater levels of exercise intensity preference and tolerance may result in better performance on both fitness tests and the AFC.

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CHAPTER 2: LITERATURE REVIEW

Introduction

Given the strenuous burden that firefighting places on the body, it could be assumed that those who choose this profession would be able/willing to tolerate such demands. Firefighting requires individuals to have high levels of aerobic fitness, anaerobic capacity, flexibility and muscular strength and endurance (Smith, 2011). Firefighting is unique as it encompasses all aspects of fitness and requires the individual firefighter (FF) to be able to perform optimally under high stress and high-risk situations. The physiological strain of firefighting mandates FFs be able to perform at near maximal heart rates for extended periods of time while engaged in necessary duties (e.g., attack/suppression, climbing stairs, search/rescue, etc.). The Personal Protective Equipment (PPE) that FFs are required to wear is heavy (22 kg/48.8 lbs) and can place additional strain on the already fatigued FFs (Smith). It has been reported that working heart rates (HRs) during fire suppression activities can range from 84-100% of estimated maximum HR (Sothmann, Saupe, Jasenof, & Blaney, 1992). During actual fire emergencies, estimated oxygen uptake can range from 63-97% of maxima aerobic capacity (i.e., VO_{2max}). Perroni et al. (2010) found that simulated firefighting tasks required $86 \pm 5\%$ of estimated VO_{2max} , making these tasks vigorous and considered high intensity. After a 30-minute recovery period, HRs remained significantly higher than resting values. Additional research has highlighted the importance of muscle strength, power, endurance, aerobic power, and maintenance of cardiovascular endurance (Del Sal et al., 2009). Firefighting tasks are associated with high energy expenditure and are very physically demanding. Firefighting challenges the individual FF and, as such, they should maintain adequate fitness levels to ensure safe and efficient

firefighting. In order to ensure that adequate fitness is maintained, proper exercise prescription is essential.

Despite the rigorous nature of firefighting, many FFs fail to meet minimum physical activity guidelines. This failure often leads to musculoskeletal injuries, overexertion, early retirement, death, and even risking the lives of others (Dennison, Mullineaux, Yates, & Abel, 2012; Kales et al., 1999). The risks of firefighting include, but are not limited to, toxic fumes, dangers of combustion, heat load, and a constantly changing and often unpredictable work environment (Smith, 2011). Even with these potentially deadly dangers, the leading cause of death among on-duty FFs is sudden cardiac events, which accounts for ~45% of deaths. Many FFs do not possess the levels of fitness needed to safely and efficiently fight fires. Given that most FFs are overweight or obese (Poston et al., 2011), there needs to be better designed exercise programs that take into account type of exercise, duration, intensity, and how these all relate to firefighting, that is, there is a need for functional fitness programming. There is a clear mismatch in the demands of firefighting and the current fitness profile of many FFs.

Additionally, understanding the personality profile of FFs may prove beneficial in predicting how s/he may respond in the face of high stress and high risk. By examining the personality profile of the FF, researchers could obtain a better understanding of why certain FFs handle stress differently, engage in high risk activities, engage in and adhere to an exercise regimen, and why some lead unhealthy and inactive lives (Gnancinski et al., 2015; Wagner & Fraess-Phillips, 2016). However, while there has been preliminary research that has assessed psychological and physical characteristics of FFs, very few studies have examined the relationship between them. There has been extensive literature to assess the relationship between psychological characteristics (e.g., personality) and physical activity/fitness in non-rescue

personnel. By examining the relationship between personality in FFs and their fitness profiles and exercise habits, researchers may be able to understand and better prescribe exercise in this population.

Obesity

Firefighters in the US have only average levels of physical fitness in a career that places extreme physical demands on the body (Storer et al., 2014). Firefighters often have excess weight and high rates of obesity. Rates of overweight/obese FFs have been reported to be as high as 75% (50% overweight, 25% obese; Firefighter Life Safety Research Center, 2008). Obesity is a precursor to a variety of diseases/injuries: hypertension, diabetes, musculoskeletal injuries, and injuries due to over exertion. Firefighters who are overweight/obese are more likely to miss work due to disease and/or injury compared to their more normal weight counterparts (Kuehl et al., 2012). Suboptimal fitness levels and high rates of overweight/obesity in FFs trigger a mismatch with the high-energy demands of firefighting. This combination between inadequate health and high-energy demands can trigger sudden cardiac events, which are often due to over-exertion (Storer et al.). It is evident that FFs who are overweight or obese are at higher risk for occupational injury and are often unable to perform optimally when on duty.

Poor physical health can have adverse effects on the ability to perform adequately as a career FF. Firefighting tasks are associated with high energy expenditure. Del Sal et al. (2009) examined physiologic responses to firefighting activities. Five tasks were performed: (1) carrying a hose for 20 m; (2) pushing a water pump trailer for 10 m; (3) pulling the hose toward the fire; (4) extinguishing the fire; and (5) return to the initial conditions (Del Sal et al.). The FFs went through an acclimation phase where they simply stood in turn-out gear. During this phase, there was a ~45% increase in heart rate (HR). During the simulated firefighting tasks, the peak

HR reached $179.4 \pm 12.4 \text{ b} \cdot \text{min}^{-1}$ ($96.9 \pm 7.4\%$ of age-predicted HR_{max}). Body mass index and mean/minimal HR during both the acclimation and the work phase were strongly correlated, meaning heavier individuals reported higher HRs than their lighter peers (Del Sal et al.). Weight and maximal METs were positively correlated during the work performance. Energy expenditure was higher in overweight FFs compared to their healthy weight counterparts. Additionally, the overweight FFs reported higher METs than their lighter-weight colleagues, indicating that the heavier FFs had to expend a greater effort (Del Sal et al.). These findings highlight the impact that physical fitness and anthropometric characteristics of FFs can have on job performance.

More recent research has added to existing literature that highlights the detrimental and adverse effects poor physical health can have on the ability to perform during job specific tasks. Firefighters are required, as part of their PPE, to wear a self-contained breathing apparatus (SCBA) in order to protect their respiratory systems while on the fire ground (Kesler et al., 2017). While this equipment is necessary to protect the FF's well-being, the SCBA is often cumbersome and adds additional weight and strain (~25 lbs) on the FF's bodies. Kesler et al. had 30 FFs (29 male, 1 female) performed one and two bouts (5 min rest versus no rest) of simulated firefighting tasks in a thermal chamber while wearing a large SCBA cylinder (Kesler et al.). Participants completed, in a counterbalanced design, one 19-min bout of tasks (stair climb, hose advance, search, overhaul), two bouts of tasks with a 5-min rest period outside of the heat chamber (38 minutes total), or two back to back bouts of the simulated firefighting tasks (35 minutes total). Kesler et al. found that 37% of the FFs were unable to complete the second bout in at least one of the two-bout conditions. Those who were unable to complete both bouts of firefighting tasks were heavier and less fit compared to the individuals who successfully

completed all tasks. Such research highlights the deleterious effects poor physical health can have on the FF's ability to successfully and safely perform job specific-tasks.

Obesity and low levels of physical fitness are becoming an increasing concern among FFs in the US. Consequently, obesity is considered a significant risk for disability among FFs (Poston et al., 2011). One of the first studies to evaluate the impact of obesity on the risk of absenteeism among firefighters showed that, of 478 male career FFs, 115 reported injuries. Of these, 21 were normal weight, 54 were overweight, 26 had class I obesity, and 12 had either class II or III obesity. Firefighters who met the criteria for class II and III obesity ($BMI \geq 35 \text{ kg/m}^2$) had nearly five times more missed work days (odds ratio= 4.89) due to injury compared to their normal weight counterparts (Poston et al.). Individuals with class II and III obesity also had higher odds of missing work due to an injury when compared to firefighters with class I obesity (odds ratio= 2.71) or those who were overweight (odds ratio= 2.55). Interestingly, there was no significant relationship between the number of injuries and BMI. However, there was a significant relationship between BMI and number of days missed due to work-related injury (Poston et al.). For every one-unit increase in BMI there was a corresponding 9% increase in work days missed due to injury.

Another study examined 433 FFs who participated in a worksite wellness program in fire departments across Oregon and Washington (Kuehl et al., 2012). Of the 433 participants, 56% fell into the overweight category ($BMI 25 \leq 29.9$) and 19% were obese ($BMI > 30$). Kuehl et al. found that FFs who fell into the overweight or obese category had a higher percentage of injuries for all body parts (excluding foot/ankle), and all injury types (excluding contusions). The low back was the most injured body part among the obese participants (17.6%), while only 11.5% of FFs who were normal weight experienced low back injuries. Obese FFs were three times more

likely to file a compensation claim compared to their healthy weight counterparts (Kuehl et al.). There was an inverse relationship between vigorous physical activity and odds of filing a compensation claim. These findings suggest that engaging in vigorous physical activity, which is important in maintaining a healthy body weight, is imperative to reduce injury and compensation claims among FFs.

Due to the extreme nature of firefighting, injuries are common and are often inevitable. These injuries range from strains, sprain, and muscular pain (55.2%). These injuries are often caused by unsafe or poorly performed movements (Cornell, Gnacinski, Zamzow, Mims, & Ebersole, 2016). Making sure FFs are moving properly and efficiently is essential in preventing injuries in this population, especially given the high rates of overweight and obesity (which further increases the likelihood of injury causing missed work). Cornell et al. examined the relationship between BMI (kg/m^2) and Total Functional Movement Screen (FMS) scores in a sample of FFs. The FMS test involves seven separate sub-tests: deep squat, hurdle step, inline lunge, shoulder mobility, active straight leg-raise, trunk stability push-up, and rotary stability test. Each test is scored from 1-3 (worst-to-best) and then a composite score is calculated for overall FMS score. Seventy-three male FF recruits were categorized, based on BMI, as normal ($n=19$), overweight ($n=38$), or obese ($n=16$). Cornell et al. found there was a significant negative relationship between BMI and Total FMS score (i.e., as BMI increased, FMS scores decreased). There was also a negative relationship between fat free mass (FFM) and Total FMS score. These results suggest that an increase in muscle mass may also negatively impact movement quality as indicated by FMS scores. As occupational injuries are the leading cause of disability and early retirement in FFs, body mass is something that clearly needs to be addressed.

Research has examined the influence body mass has on physical fitness test scores in male FF applicants. Phillips, Scarlett, and Petersen (2017) had a sample of 414 male FFs complete a maximal treadmill test and five task-simulation drills (hose drag, weighted sled pull, forcible entry, victim rescue, & ladder climb) while dressed in fire protective gear and carrying SCBA equipment. These 5 tasks were selected because of the combination of muscular strength, power, and endurance needed to complete them. They were also selected because similar assessments have been used in different laboratories to assess work readiness in FFs. Participants were separated into six weight classifications: (1) <70 kg; (2) 70.0-79.9 kg; (3) 80.0-89.9 kg; (4) 90.0-99.9 kg; (5) 100.0-109.9 kg; and (6) >110.0 kg. The two heaviest groups (100.0-109.9 kg & >110 kg) had lower treadmill performance compared to their peers who had lighter body masses. Peak oxygen consumption was lowest in the lightest weight class and significantly increased in each body mass category. However, when peak oxygen uptake was normalized to total body weight (body mass + PPE), the three lightest categories had similar scores and the scores were lowest in individuals who fell into the >110 kg category. The heaviest individuals (>110 kg) had significantly slower test times on the ladder climb compared to other weight classes. Phillips et al. determined the lightest group (<70 kg) performed significantly worse on weighted sled pull, forcible entry, and victim rescues compared to their heavier counterparts. The two lightest groups (<70 kg & 70.0-79.9 kg) had slower test times for the charged hose advance than the individuals who belonged to the other weight classes. These findings suggest that while maintaining a healthy body mass is important for cardiovascular levels, adequate levels of muscle mass and muscle strength should be maintained to perform optimally during strength and power-based tasks.

Cardiovascular Risk Factors and Disease

In 2016, there were 69 on-duty firefighter deaths. Of those 69 deaths, 26 deaths were caused by sudden cardiac episodes. The National Fire Protection Association (recognizes cardiac health as a serious health issue within the fire service. Since 1977, sudden cardiac death has consistently had the largest share of on-duty deaths compared to all other causes (Fahy, Rita, LeBlanc, Paul, Molis, 2015; Fahy, Fire, Association, & Park, 2012). In 2016, sudden cardiac deaths accounted for 38% of FF deaths on-duty and over the last 10 years cardiac deaths have accounted for 42% of on-duty deaths. While there are genetic factors (e.g., age, family history, sex) that contribute to one's likelihood of experiencing a sudden cardiac event, there are many modifiable risk factors such as smoking, diet, exercise habits, diabetes, cholesterol levels, high blood pressure, and obesity (Scanlon & Ablah, 2008). Physical activity, more specifically exercise, is one highly effective way to reduce one's risk for many these of modifiable risk factors. The National Fire Protection Association has attempted to implement several wellness promotion programs such as the International Association for Fire Chiefs (IFAC)/International Association for Firefighters (IAFF) Service Joint Labor-Management Wellness-Fitness Initiative and NVFC's Heart-Healthy Firefighter Program. The Heart-Healthy Firefighter Program launched in 2003, aimed at addressing heart attack prevention through nutrition and health awareness; however, little follow-up has been done to examine the relative success or failure of the program. Given that cardiac events account for the largest number of on-duty deaths among FFs, it is imperative that preventative strategies are put in place to reduce the number of cardiac deaths.

Many personal and modifiable factors may contribute to firefighters' susceptibility to cardiovascular disease/sudden cardiac events. New hires are required to meet certain physical

standards, however veterans are not held to the same standard (Kales et al., 2003). Kales et al. wanted to identify occupational and personal risk factors that contributed to the on-duty deaths of 52 male FFs whose deaths were investigated and published by the National Institute of Occupational Safety and Health. The comparison cohort was 310 male FFs from Massachusetts who underwent medical examinations and whose professional status as a FF was active. Cardiovascular risk factors included hypertension ($\geq 140/90$ mmHg), current smoking status, high cholesterol (≥ 5.18 mmol/L or 200 mg/dl), and diabetes mellitus as well as whether the individual was taking any medication for any of these risk factors (Kales et al.). When comparing the cardiac deaths to the active FF cohort, the individuals who died had a significantly higher frequency of cardiovascular risk factors. These included age (≥ 45 years; odds ratio= 6.5), current smoking (odds ratio= 7.0), hypertension (odds ratio= 4.7), and prior diagnosis of arterial-occlusive disease (odds ratio= 15.6). Kales et al. concluded that premature deaths could potentially be prevented by promoting improvements in fitness, more frequent medical screenings, and proper medical management among FFs.

Age is a non-modifiable risk factor that contributes to sudden cardiac deaths. Yang et al. (2013) sought to investigate the deaths of young FFs (≤ 45 years) in the United States ($N= 87$). Two age-matched and sex-matched control groups were used: cardiac traumatic FF fatalities ($n=56$) and occupationally active FFs ($n= 915$). Sixty three percent of sudden cardiac death victims were classified as obese ($BMI \geq 30$ kg/m²), while 34% of the control group was classified as obese. Yang et al. also found that 66% of individuals who suffered from sudden cardiac death had cardiomegaly (heart weight >450 g), the individuals who suffered from sudden cardiac death had heavier hearts (522 ± 102 g) compared to the non-cardiac control group (400 ± 91 g). Having hypertension increased the sudden cardiac death risk by 12-fold (95% CI

6.23 to 22.3), hypertension was present in 48% of individuals who experienced sudden cardiac death, while only 20% of the control group had hypertension. Furthermore, a history of cardiovascular disease (odds ratio= 6.89) and smoking (odds ratio= 3.53) increased the odds of experiencing sudden cardiac death (Yang et al.). In order to reduce the risk of sudden cardiac death in younger FFs, the fire service should implement obesity entry standards, promote healthy lifestyles (i.e., advocate against smoking), educate active duty FFs about the modifiable risk factors that contribute to sudden cardiac death, and implement wellness and physical activity agendas (Yang et al.).

As stated previously, there are numerous modifiable risk factors associated with cardiac health and wellness. While some FFs may be aware that cigarette consumption, high blood pressure, cholesterol levels, diabetes, obesity, and physical activity are all risk factors that they have control over, others may be unaware that many of these are modifiable and can be easily changed, leading to better health and job performance (Scanlon & Ablah, 2008). A sample of 730 volunteer FFs were surveyed for both cardiac risk factors and their desire to resolve these risk factors. Only 136 (18.6%) of the participants were classified in the healthy weight category, 301 (41.2%) were considered overweight, and alarmingly 259 (35.5%) were classified as obese (Scanlon & Ablah). Nearly 20% (145 participants) reported having high blood pressure and 135 (18.5%) individuals reported having high levels of cholesterol. Of the 720 FFs surveyed, 327 (44.8%) reported participation in an exercise program (Scanlon & Ablah). Over 17% ($n=129$) of individuals responded that they currently smoke cigarettes. Despite the fact that over three quarters of the sample was overweight or obese, and nearly 40% of the firefighters surveyed reported having high blood pressure, high cholesterol, or both, 57.9% ($n= 423$) “strongly agreed” and 34.0% ($n= 255$) “somewhat agreed” that fire departments should have a larger and more

active role in educating FFs on medical risks of this profession (Scanlon & Ablah). Nearly 45 percent ($n= 333$) of those individuals surveyed were “definitely interested” and another 333 were “somewhat interested” in attending a lecture regarding proper exercise and reducing their risk of experiencing heart attacks if their department would provide it. Over half of the respondents ($n= 415$) reported being “definitely interested” in participating in a fitness program should their department provide it. This research suggests that by educating and providing FFs with health and fitness resources there is definite potential for decreasing cardiac risk factors among FFs.

Physical activity has been noted as a modifiable risk factor for cardiovascular disease. Durand et al. (2011) examined the relationship between physical activity and fitness and cardiovascular disease risk. The sample consisted of 527 career FFs who completed self-report measures of physical activity frequency, duration, and intensity as well as reporting weekly total of aerobic exercise. Durand et al. assessed cardiovascular fitness via an incremental maximal exercise test and measured body composition, blood pressure, and metabolic profiles. During the exercise test, measures of total treadmill time (ETTT), maximum METs achieved (max METs), and 1-minute recovery heart rates (HRR) were taken. Results showed that 51.2% ($n= 270$) of participants were considered overweight and 35.7% ($n= 188$) were considered obese. Almost 50% of the cohort exercised ≤ 3 times a week and only 22% of the sample exercised ≥ 5 times a week (Durand et al.). Individuals who reported greater physical activity frequency, duration, and intensity had significantly better cardiorespiratory fitness compared to their less active peers (after adjusting for age, BMI, and smoking status). Higher levels of physical activity were significantly associated with lower levels of total cholesterol, triglycerides, and glucose. Durand et al. also reported that there was a negative relationship between BMI category and cardiorespiratory fitness, even for those individuals who engaged in regular and intense physical

activity. These findings demonstrate that increases in BMI correspond with reductions in cardiorespiratory fitness. Physical activity should be a priority for all FFs and the focus should be on developing exercise programs that will increase adherence rates and also improve job performance.

The National Fire Protection Association has promoted on-duty exercise among firefighters in the United States. Despite these initiatives, there is still a high prevalence of overweight and obese FFs who are inactive/sedentary (Yu et al., 2015). The relationship between self-reported leisure time physical activity, aerobic fitness (VO_{2max}), cardiovascular risk factors, and cardiovascular workload at work (via heart rate monitoring) in a cohort of 387 male FFs from Hong Kong was examined by Yu et al. Cardiovascular disease risk factors were recorded and included: obesity, hypertension, diabetes mellitus, dyslipidemia, smoking, and any known cardiovascular disease. In order to assess cardiovascular workload at work (i.e., /on duty), the sample underwent real-situation simulated fire scenarios. These situations were: (1) water relay (hose laying and set-up); (2) maze searching (search and rescue); (3) sewage rescue (victim rescue); and (4) mountain rescue ($n= 29$). “A crew of 10 firefighters was deployed to conduct this exercise...They were required to carry the following equipment uphill, perform a rescue, and return to the starting point: descender, four rescue carabiners, one troll tap sling, one short rope (4.5 kg); 150-m line rescue with carrying bag (20.5 kg); stretcher, mesh type, breakaway (9 kg) and rucksack.” (pg. 3). Results showed that 33.9% of this cohort had at least two cardiovascular disease risk factors. Lower resting heart rates, less time working at moderate-intensity cardiovascular workload, and lower average working heart rate were found in those who reported more leisure time physical activity compared to their less active peers. This study validates the benefits of leisure time physical activity on job performance and cardiovascular workload in FFs.

Firefighting is known to be a physically straining and taxing profession, so one would assume that a high level of cardiorespiratory fitness would be essential for a FF (Nogueira et al. 2015). Brazilian firefighters ($N= 4,237$) participated in a physical fitness test that included body composition and cardiorespiratory fitness. Body composition was assessed in three ways: BMI, body adiposity (BAI), and body fat percentage (BF%). Cardiorespiratory fitness was assessed via a 12-minute Cooper Test, which provided an indirect estimate of maximum oxygen consumption (VO_{2max}). Nogueira et al. found that 54.3% ($n= 2,301$) of the sample was overweight and 14.7% ($n= 622$) was classified as obese. VO_{2max} was negatively correlated with age ($r= -0.21$), waist circumference ($r= -0.50$), BMI ($r= -0.45$), and BAI ($r= -0.35$). When examining fitness levels and the relationship with weight, the proportion of obese FFs in the less fit group (METs<12) was 5.5-fold higher than in the fit group (METs ≥ 12 METs). Nogueira et al. concluded that cardiorespiratory fitness was significantly lower in the obese individuals compared with all other non-obese categories regardless of age.

Firefighters not only experience significant strain on the cardiovascular system due to the job requirements, there is also a high prevalence of cardiovascular disease among this population (Seyedmehdi et al. 2015). Coronary heart disease accounts for 45% of fatal work accidents among FFs. Male FFs ($N= 157$) participated in a study that examined the relationship between aerobic fitness and cardiovascular risk factors. The participants were interviewed and a questionnaire was completed that included age, level of education, work history, cigarette smoking status, drug intake, shift work, and history of cardiac disease. Measures of height and weight were taken in order to calculate BMI (kg/m^2). BMI was then used to categorize FFs as underweight or normal weight ($<25 kg/m^2$) and overweight or obese ($\geq 25 kg/m^2$). Aerobic fitness was assessed via the YMCA submaximal cycle ergometer test and was performed following the

ACSM guidelines. Seyedmehdi et al. found that aerobic fitness was significantly and negatively correlated with age, BMI, cigarette smoking, and was positively correlated with reported physical activity. Sixty-six individuals had METs <9, 52 individuals had METs 9-11, and 39 individuals had METs >11 on the submaximal exercise test. The average BMI for those groups was 26.8, 24.9, and 24.6, respectively. Participants who had a higher BMI performed significantly worse on the submaximal exercise than those who had a lower BMI. Identifying and adopting preventative strategies to decrease cardiovascular risk factors is important in promoting FF wellness.

Current Fitness Literature

The National Fire Protection Association promotes the notion that FFs should be allowed, and even encouraged, to engage in exercise while on duty (Dennison et al., 2012). Promoting and encouraging FFs to exercise while on duty should enable FFs to maintain adequate levels of fitness. However, some fear that exerting energy and exercising while on duty would hinder the FF's ability to properly perform fire specific tasks. Some researchers have examined training status (trained vs untrained) in relation to ability to perform simulated fire ground tests. Dennison et al. examined the effects of a single exercise session on the ability to perform simulated fire ground tests. Baseline test times were recorded as well as test times following the acute bout of exercise (Dennison et al.). Out of seven simulated fire tasks, the only significant differences in completion time following exercise were found during the search and rescue tasks. It is important to note that these tasks were performed last. Interestingly, fatigued but trained firefighters reported faster completion times on the simulated fire ground test compared to the baseline time of untrained FFs (Dennison et al.). At baseline, trained FFs were faster than 81% of untrained FFs. Following the exercise bout, 70% of the trained FFs were faster than the

untrained FFs were at baseline. Fatigued but trained FFs were more successful during a simulated fire ground test compared to their untrained counterparts (completion time: 399.9 ± 70.6 seconds vs 422.5 ± 58.7 seconds). These findings suggest that being untrained inhibits job performance more so than exercise-induced fatigue.

Firefighters are often exposed to unpredictable and constantly changing work conditions, which can place a great deal of mental and physical strain on them. Live fire-ground tasks can result in heart rates ranging from 84-100% of predicted HR_{max} (Perroni et al., 2010). During actual emergencies and live fires, workloads requiring 63-97% of estimated maximum oxygen uptake (VO_{2max}) have been reported. It is undeniable that firefighting is a physically demanding occupation that requires adequate levels of health and fitness to perform optimally. Perroni et al. examined the physiological demands of firefighting among 20 Italian firefighters. The FFs performed four consecutive firefighting tasks (child rescue, 250-m run, find an exit, 250-m run). The average VO_{2peak} of the sample was 43.1 ± 4.9 $mL \cdot kg^{-1} \cdot min^{-1}$. The average age for this sample was 32 ± 6 years, making their aerobic fitness levels above average when compared to normative data. As the FFs progressed through the four tasks, their heart rates continued to climb relative to the $\%HR_{peak}$ (child rescue= $77 \pm 11\%$, 250-m Run 1= $88 \pm 5\%$, Find an Exit= $88 \pm 6\%$, 250-m Run 2= $91 \pm 8\%$). The four tasks together took an average ~ 12 minutes to complete. Although the completion time was relatively short, it did require high levels of effort. As the participants in this study exhibited high levels of aerobic fitness, this highlights the need for adequate fitness levels in career FFs.

Rhea, Alvar, and Gray (2004) had 20 career firefighters volunteer to participate in another study that explored the relationship between physical fitness [cardiovascular endurance, anaerobic power, muscular strength, local muscular endurance (i.e., hand grip, maximal effort

bench press, bent-over row, bicep curls, seated overhead press)] and job performance tests (i.e., hose pull, stair climb, simulated victim drag, equipment hoist). Overall fitness scores were significantly associated with better total performance ($r = -0.62$), as well as performance on the hose pull ($r = -0.49$), victim drag ($r = -0.62$), and stair climb ($r = -0.51$). Strength measures were significantly associated with overall performance, hose pull, victim drag, stair climb, and equipment hoist (Rhea et al.). Bench press performance was significantly correlated to overall performance ($r = -0.66$), hose pull, ($r = -0.80$), victim drag ($r = -.65$), stair climb ($r = -0.39$) and equipment hoist ($r = -0.68$). Squat scores were significantly correlated to performance on the hose pull ($r = -0.48$). Hand grip was significantly correlated with overall performance ($r = -0.71$), hose pull ($r = -0.85$), victim drag ($r = -0.68$), stair climb ($r = -.046$) and equipment hoist ($r = -0.66$) performance. Anaerobic endurance (400-m run time) was significantly associated with better total performance ($r = 0.79$), hose pull ($r = 0.67$), victim drag ($r = 0.81$), stair climb ($r = 0.63$), and equipment hoist ($r = 0.59$). Overall muscular endurance, bent over row, shoulder press, and bicep curl scores were significantly associated with better overall performance and better performance on all job performance tests. Establishing the relationship between physical fitness and the ability to safely and efficiently perform job specific tasks is essential to keep FFs safe. Exercise programs should be designed to address the specific and unique needs FFs have regarding their physical fitness.

Measures of strength and aerobic fitness can potentially be used to predict FF performance on physically demanding job-specific tasks. Firefighter recruits from nine fire academy classes were assessed on a wide variety of strength and endurance measurements (Henderson, Berry, & Matic, 2007). In addition to the measures of fitness, height, weight, and skinfold measures were taken and recorded. Sixty of the recruits participated in a FF combat test

while wearing full turnout gear, including SCBA (29.3 kg total). The combat test included the following tasks: (1) 5-story high rise stair-climb with hose pack (20.4 kg); (2) hose (20.4 kg) hoist to the fifth floor of the training tower; (3) forcible entry using a 4 kg sledge; (4) 42.7-m hose (4.5 cm) advance with a charged hose; and (5) simulated victim rescue dragging a dummy (75.2 kg) backwards 30.5-m. Recruits were scored based on time to complete the tasks. Many significant correlations were found between measures of fitness and performance on the combat test (Henderson et al.). Absolute $\text{VO}_{2\text{max}}$ ($\text{L}\cdot\text{min}^{-1}$), bench press (kg), lateral pull down (kg), grip strength (kg), composite strength (bench press, lat pull-down, and hand grip strength), sit-ups (total) were all positively correlated with better performance on the combat test and lean body mass was negatively correlated with better performance on the combat test. A significant relationship was also found between endurance composite score and combat test finish time. These findings highlight the significant impact physical fitness has on firefighting tasks.

One of the high-intensity demands of firefighting is a high energetic peak load (Plat, Frings-Dresen, & Sluiter, 2010). Plat et al. wanted to examine the reproducibility and validity of a stair-climb test and the cardiovascular demands a stair-climb test placed on FFs. The stair-climb required the FFs to ascend a set of stairs that was 20-m high and contained 108, 110, or 117 steps (17-19 cm). During the test, the FFs wore full turnout gear and SCBA equipment (Plat et al.). Heart rate was taken immediately following the stair climb and the mean value was $92\pm 8\%$ of estimated maximum heart rate ($220-\text{age}$). Of the 45 FFs tested, 35 (75% of the sample) reached 85% of estimated HR_{max} , therefore classifying this particular “job” as one that requires a high energetic peak load. These results further support previous research that highlights the need for high levels of physical fitness among FFs.

Currently, less than 30% of fire departments in the US require or implement regular exercise for the FFs they employ despite the National Fire Protection Association recommending regular physical activity and exercise (Storer et al., 2014). Storer et al. investigated the relationship between physical fitness and cardiovascular disease in 51 male FFs. They found that only 36% of these FFs exercised at least 3 days per week or for 30 minutes per day (Storer et al.). Fifty percent of the sample achieved the recommended ≥ 2 days per week of resistance exercise. These findings are consistent with the non-firefighter population. The mean values of aerobic, resistance, and flexibility training were below the recommended values for FFs (Storer et al.). The average BMI of the FFs in this study was $27.7 \text{ kg}\cdot\text{m}^{-2}$, making the majority of this sample of FFs overweight or obese (72% were classified as overweight or obese). Thirty-percent of the FFs in this study had $\text{VO}_{2\text{max}}$ scores that were below the recommended value ($33 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) (Storer et al.). Having a lower aerobic capacity leads to earlier fatigue, greater cardiovascular strain, and overexertion, all of which can lead to sudden cardiac events while firefighting. Insufficient fitness levels can be detrimental to a FF's livelihood and job performance. These low levels of physical fitness and presence of CVD risk factors highlight the need for health and fitness interventions among FFs.

Current Intervention Literature

The high levels of overweight and obesity and inactivity in FFs means the vast majority are not ideally suited for the high physical demands of firefighting. The vigorous demands of firefighting have been well documented and reported. These physical burdens put FFs at a greater danger of experiencing musculoskeletal injuries and cardiac episodes (Rhea, Alvar, & Gray, 2004). These injuries often shorten the careers of many well-trained FFs. It is evident that

training programs need to be implemented in order to enhance FF job performance and reduce the risk of injury.

Previous literature has highlighted the significant relationship between levels of physical fitness and performance during firefighting tasks. However, there is very little research that examines the effects of an exercise intervention on a FF's physical fitness. Overexertion is the leading cause of fatalities (59%) and the second leading cause of musculoskeletal injuries (25%) among FFs (Cornell, Gnacinski, Meyer, & Ebersole, 2017). It is clear that inferior health (i.e., high BMI, lower levels of fitness) is associated with poor job performance, and individuals with diminished health are more likely to experience injury and miss work. Cornell et al. examined the health and fitness changes in 32 male FF recruits during a 14-week fire-training academy. During the 14-week academy, recruits participated in various physical training, including exercise programming (e.g., warm-up, aerobic exercise, total body resistance, cool-down) and technical physical training (e.g., ladder raising, victim rescue, roof ventilation). Measures of physical health (i.e., body composition, BMI, waist and hip circumference, estimated body fat) and physical fitness (i.e., aerobic capacity, muscular power, muscular strength, etc) were recorded at Week-1 and Week-14 of the academy (Cornell et al.). The results indicated significant improvements in health and fitness among the FF recruits during the fire academy. Measures of health and fitness were taken again at the end of the recruit's probationary period, 24 weeks post-academy (Week 38), when daily physical activity was no longer required. Cornell et al. found that by Week 38, all physiological adaptations gained during the academy training were lost as the recruits transitioned to active-duty firefighters.

It is estimated that injury rates are 6.1 injuries per 100 firefighters. Poplin et al. (2014) estimated that FFs who have lower levels of aerobic fitness ($VO_{2max} < 43 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) are 2.2

times more likely to experience a work-related injury than their fit counterparts ($VO_{2max} > 48$ mL·kg⁻¹·min⁻¹). Griffin et al. (2016) evaluated the effects of a fitness intervention for new FFs on injury rates. The Probationary Firefighter Fitness (PFF-Fit) program was implemented over a 17-month period and consisted of functional fitness performed 3 days per week. The workouts consisted of strength, cardiovascular and flexibility training that incorporated movements often associated with emergency situations (e.g., hose pulling, axe swings). Griffin et al. found that the intervention class experienced significantly fewer injuries and filed fewer claims compared to those who did not participate in the PFF-Fit program. The estimated cost for the PFF-Fit program was \$32,192; the benefits were approximately \$33,000 saved in worker's compensation claims. Thus, this PFF-Fit program yielded a 2.4% 1-year return investment. Such research suggests that functional fitness reduces the rates of injuries among new FFs. In addition to reducing injury, the cost of the PFF-Fit program implementation was less than annual claims due to injury.

Fire training academies are an excellent opportunity to improve physical fitness and properly teach job specific tasks. By having recruits engage in daily physical fitness programming, in addition to giving them adequate job specific training, fire departments are able to reduce the risk of injury and potentially increase the work productivity among newly hired FFs. In addition to looking at the relationship between physical fitness and job specific tasks, researchers explored the impact of a 14-week training academy on FF recruits' physical fitness (Henderson et al., 2007). Measure of fitness were taken at Week 1 and Week 14 during the academy and included the following: bench press (kg), lat pull-down (kg), grip strength (kg), sit-ups (60-sec total), relative VO_{2max} (mL·kg⁻¹·min⁻¹), and percent body fat. Henderson et al. found that over the course the 14-week fire academy, recruits showed significant improvements on all strength and endurance measures from Week 1 to Week 14. While these findings are significant

and highlight the effectiveness of a fire-training academy, additional research needs to be conducted to examine how levels of fitness evolve and change throughout a FF's career.

In another study, Beach, Frost, McGill, and Callaghan (2014) sought to examine the effects of two fitness programs on physical fitness among FFs. In addition to the impact each program had on fitness, they also examined the role physical fitness had on low-back loading outcomes. The participants were 60 male FFs from the Pensacola (FL) Fire Department. They were randomly assigned to one of three groups: fitness-oriented exercise; movement-and-fitness oriented exercise; or a control group (Beach et al.). The exercise groups completed three 90-minute sessions per week over the course of 13 weeks. Physical fitness testing occurred prior to and post intervention and included body composition, a measure of cardiorespiratory fitness, maximum push-ups, trunk muscle endurance, upper body power, lower body power, vertical jump, grip strength, sit-and-reach, and a functional movement screening (FMS). Beach et al. found that both exercise groups displayed significant improvements in body composition, cardiorespiratory fitness, muscular strength, power, endurance, and flexibility. Despite these improvements in fitness, FMS scores and low-back loading measures were not significantly affected. Thus, these short-term improvements in fitness may not be significant enough to yield a reduced risk of low-back injury. Future research needs to examine the long-term effects that regular exercise and physical fitness have on injury rates in FFs.

Extraversion and Exercise

Many factors contribute to an individual's physical health and their likelihood of participating in regular physical activity and exercise. Past experience, fitness levels, injury/disability, and psychological factors [e.g., self-efficacy, depression/anxiety, personality (extraversion, neuroticism)] all contribute to an individual's exercise and physical activity habits

(Arai & Hisamichi, 1998). The relationship between Extraversion and the likelihood of engaging in physical activity has been well-documented and supported (Allen & Laborde, 2014; Arai & Hisamichi; Courneya & Hellsten, 1997; Ingledeu, Markland, & Sheppard, 2004; Rhodes & Smith, 2006; Wilson & Dishman, 2014). In order to understand and be able to properly encourage changes in behavior, personality factors need to be understood as well as how they contribute to change. Numerous sources have found that individuals who express high levels of Extraversion are more inclined to engage in physical activity and exercise. Extraverts tend to be sociable, outgoing, assertive, impulsive, energetic, enjoy engaging in group activities, seek excitement, and, overall, experience positive affect (Potgieter & Venter, 1995; Rhodes & Smith). Further examination of the relationship between Extraversion and physical activity may prove beneficial in predicting drop-out rates, exercise adherence, and physical activity patterns.

Over the last 20 years, a great deal of literature has examined the relationship between personality and physical activity. This large body of work has allowed researchers to better understand antecedents to exercise behavior. Rhodes and Smith (2006) reviewed 33 studies from 1969-2006 that examined personality correlates of physical activity. Of the 33 studies examined, 23 samples (representing an $N= 50,721$) evaluated Extraversion. The results imply that Extraversion is a correlate of physical activity, with small-to-medium effects ($r= 0.20$). This means individuals who score higher on Extraversion are generally more physically active than their less extraverted peers.

There is a clear and apparent need to understand and promote changes in activity behavior, but it is equally important to understand the sources of individual differences. Allen and Laborde (2014) reviewed new and current literature examining participation in physical activity and the extent to which it was predicted by personality. Allen and Laborde found that

higher Extraversion scores, among other traits, were associated with greater leisure time activity, higher levels of overall physical activity, greater muscular strength, and greater energy expenditure. Wilson and Dishman (2014) reviewed 64 studies to better understand the relationship between physical activity and personality. The mean effect size r for physical activity and Extraversion was $r = .108$ (95% CI = .091, .124) and multi-level models revealed a mean effect size for Extraversion of $r = .112$ (95% CI = .084, .139). Point biserial r was derived from effect size d for effects that reported as means and standard deviations or independent samples t tests (Wilson & Dishman). After controlling for geographic region, experimental demand, and physical activity definition, the multi-level model still revealed a significant association between physical activity and Extraversion. These findings are consistent with a review mentioned earlier by Rhodes and Smith (2006). Wilson and Dishman propose that this positive association between Extraversion and physical activity is due to the fact that extraverts are naturally inclined to seek out sensory stimulation and excitement. This relationship can further be explained by considering the social nature of extraverts and the fact that physical activity can help fulfill the drive for stimulation and socialization. Personality is complex and understanding its relationship with physical activity and exercise is even more challenging and encompassing. However, these findings help researchers begin to understand the role personality plays in physical activity and exercise patterns.

Firefighter (FF) Personality

Very little research has been done to examine the psychological profile (i.e., personality) of FFs. There are many physical and psychological factors that contribute to firefighting; an individual must be able to process and retain new information as well as remain calm and focused while extreme physical demands are being placed on them (Gnacinski et al., 2015).

Previous studies have looked at the physical and psychological components of firefighting separately, however little research has been done to examine these within the same cohort. Gnacinski et al. examined this relationship in a sample of 34 firefighters-in-training by assessing measures of: height, weight; aerobic fitness/ VO_{2max} (5-minute step test); body composition (skinfold measurements); muscular strength (1RM squat, 1RM bench press test); muscular endurance (push-ups to exhaustion, 1-minute sit-up test); muscular power (counter movement jump); Functional Movement Screen; the Big Five personality (Extraversion, Openness, Conscientiousness, Agreeableness, Emotional Stability); self-efficacy (Self- Efficacy Scale); trait anxiety (20-item Trait Anxiety Scale); and intrinsic motivation. The results revealed several significant relationships, including: muscular strength (1RM squat) with C and self-efficacy, muscular strength (1RM bench press) and muscular endurance (push-ups) with C, O, and self-efficacy, and functional movement with E. The firefighters-in-training exhibited higher levels of Extraversion, Conscientiousness, Emotional Stability, and self-efficacy, as well as lower levels of trait anxiety than the general population (Gnacinski et al.). There is an apparent need for additional research to better understand how personality impacts a FF's physical fitness and activity. Understanding this relationship could lead to increases in physical activity and thus reductions in injuries and activity drop-out rates.

In order to improve both mental and physical health among FFs, initial research has been done and preliminary findings have helped better understand how researchers can improve health. Wagner and Fraess-Phillips (2016) examined the personality and mental health of 41 FFs compared to a cohort of 41 non-rescue controls. The FFs were recruited from a department in British Columbia, Canada between 2005-2015. Personality was assessed via the NEO- Five Factor Inventory (NEO-FFI), Framingham Type A (FTAS), Impact of Events Scale-Revised

(IES-R), Symptom Checklist 90-Revised (SCL-90-R), Zuckerman Sensation Seeking Scale (ZSSS), Physical Risk Assessment Inventory (PRAI), Proactive Coping Inventory (PCI), Satisfaction with Life Scale (SWLS), and Emotional Intelligence Scale (EIS). The control group was a sample from British Columbia and were individually matched to the FF recruits based on age (± 3 years), marital status, sex and ethnicity (Wagner & Fraess-Phillips). The results revealed that FFers had significantly lower Type A scores (FTAS) and Neuroticism and Openness to Experience (NEO-FFI subscales) compared to the control sample. The recruits scored higher on the Extraversion and Conscientiousness subscales than the non-rescue controls. Firefighters are an understudied population and initial findings such as the present study begin to shed knowledge on personality profile of rescue workers. Such findings can help predict which individuals are more or less likely to engage in physical activity, which has important implications for health and well-being.

Exercise Intensity Preference and Tolerance

Individuals often fail to choose an appropriate intensity level when beginning an exercise program. Exercising at too high of an intensity can elicit discomfort and negative affect and even result in overexertion or injury, leading to rates of drop out and avoidance (Ekkekakis, Hall, Petruzzello, & 2005). Similarly, exercising at too low of an intensity may inhibit health and fitness rewards as well as yield boredom, frustration, and ultimately lead to lack of exercise adherence. Tolerance for exercise intensity is highly varied among individuals, which makes exercise prescription challenging (Ekkekakis et al.). In one study, when given the opportunity to self-select an exercise intensity, the chosen intensities ranged from 44% to 92% of $\%VO_{2peak}$ at minute 20 during a bout of exercise (Ekkekakis, Lind, & Joens-Matre, 2006). Many individuals experience declines in affective valence responses as exercise intensity increases (i.e., increases

in discomfort and negative affect, decreases in pleasantness and positive affect). On the other hand, others can tolerate and even prefer higher intensity exercise. Given the high rates inactivity among firefighters, it may be useful to explore individual exercise intensity preference and tolerance in order to better prescribe exercise within this population. Additionally, identifying individual FFs' specific exercise intensity preferences and tolerances may help predict success during physically demanding tasks.

Prescribing exercise in the firefighter population is challenging because of the mismatch in the demands of firefighting and the current physical fitness levels among FFs. Firefighting is rigorous and intense and there is a need for regular exercise (Del Sal et al., 2009; Fogleman & Bhojani, 2005; Griffin et al., 2016, Nogueira et al., 2015; Perroni et al, 2010; Storer et al., 2014). Implementing exercise and physical activity programs is difficult because nearly 50% of all individuals who choose to initiate an exercise program drop out within the few months (Ekkekakis, Hall, & Petruzzello, 2008). Some individuals drop because of boredom, injury, and lack of enjoyment. One of the most common reasons given for ceasing to exercise is the discomfort felt during intense or vigorous exercise, which often results in negative affective responses while engaged in the exercise itself. These negative affective responses often lead to drop out despite positive affective responses experienced post-exercise (Ekkekakis et al., 2008; Ekkekakis, Parfitt, & Petruzzello, 2001; Zenko, Ekkekakis, Ariely, 2016). These negative affective responses and discomfort are often experienced during live-fire suppression. These feelings of discomfort and negative affect may be lessened through engaging in regular exercise done at an appropriate intensity to yield results beneficial to job performance as well as maintaining adherence. Ensuring exercise is prescribed at the intensity one prefers and can tolerate may help moderate dropout rates.

There is wide inter-person variability when it comes to preference for and tolerance of exercise intensity. Ekkekakis et al. (2005) developed a measure that assessed individual differences in preference for and tolerance of exercise intensity. The Preference for and Tolerance of Intensity of Exercise Questionnaire (PRETIE-Q) is a 16-item measure, with each item scored on 5-point Likert scale that ranges from “*I totally disagree*” to “*I totally agree*”. Eight items pertain to tolerance of exercise intensity and include statements such as; “During exercise, if my muscles begin to burn excessively or if I find myself breathing very hard, it is time for me to ease off...I’d rather slow down or stop when a workout starts to get too tough.” (Ekkekakis et al., pg 359). An additional 8 items on the PRETIE-Q pertain to preference for exercise intensity and include statements like: “While exercising, I prefer activities that are slow-paced and do not require much exertion...When I exercise, I usually prefer a slow steady pace.” (pg. 359).

The internal consistency of the PRETIE-Q was initially tested with three samples ($N=287$, $N=184$, $N=64$). Results revealed Cronbach’s alpha coefficients of 0.85, 0.83, and 0.81 for the Preference scales and 0.87, 0.82, 0.86 for the Tolerance scales (Ekkekakis et al., 2005). In order to examine the test-retest reliability of the PRETIE-Q, one sample was tested at baseline and then again 3-months later ($N=58$, 27 males, 31 females) and another sample was tested at baseline and again 4-months later ($N=52$; 23 males, 29 females). Ekkekakis et al. found that the reliability coefficient for the 3-month delay sample was .67 for Preference and .85 for Tolerance. Test-retest coefficients were .80 for Preference and .72 for Tolerance for the 4-month delay. These results suggest that the PRETIE-Q is reliable over time and has high internal consistency.

Identifying an individual’s exercise intensity preference and tolerance may be beneficial in predicting exercise patterns and leisure time physical activity. Exercise intensity preference

refers to the preferred intensity of exercise in order to elicit a more pleasant or positive affective state (Ekkekakis et al, 2005). Alternatively, exercise intensity tolerance refers to the intensity that can be tolerated while still maintaining a pleasant or positive affective state. Ekkekakis, Thome, Petruzzello, and Hall (2008) used the PRETIE-Q and Godin Leisure-Time Exercise Questionnaire (Godin & Shepard, 1985) in a cohort of 601 college-aged females (20.1 ± 1.4 years) to predict exercise participation. Exercise preference was significantly correlated to total exercise score and frequency of strenuous exercise. Tolerance was significantly associated with frequency of strenuous exercise and total exercise score. The number of times women reported exercising “long enough to work up a sweat” was positively correlated to both Preference and Tolerance scores. Women who reported that they work out hard enough to sweat “often” had significantly higher Preference and Tolerance scores compared to the women who answered “never/rarely” (Ekkekakis et al., 2008). Thus, the PRETIE-Q has the ability to predict exercise patterns and behaviors and could be used in many exercise science practices. When implementing exercise programs, the PRETIE-Q could be used as a supplemental tool to prescribe exercise appropriately based on the individual’s needs or preferences.

An individual’s preference for exercise intensity should be just one factor in developing a safe, effective, and productive program. Exercising at too low of an intensity can lead to a lack of results, boredom, and frustration and the combination of these often leads to drop out (Ekkekakis, Lind, Joens-Matre, 2006). Conversely, exercise should not be prescribed too intensely or rigidly in order to avoid injury, overexertion, or event death. Ekkekakis et al. sought to explore the relationship between PRETIE-Q scores and self-selected exercise intensity. Middle-aged women ($N= 23$) completed 3 laboratory sessions: Session 1 consisted of an incremental treadmill test to volitional exhaustion; Session 2 had the individuals complete a 20-

minute bout of self-selected exercise where they were permitted to change the speed at minutes 5, 10, 15; Session 3 involved completing the PRETIE-Q and other self-report questionnaires. Results revealed that Preference accounted for significant variance at minute-15 (17%) and minute-20 (18%) after controlling for age, BMI, and VO_{2peak} (Ekkekakis et al.). It is likely that during minutes 5-15 the participants increased their intensity to one that they ultimately preferred during minutes 15-20. Interestingly, Tolerance did not account for any significant portion of variance. The PRETIE-Q could allow exercise professionals to identify persons who may be likely to choose too low or too high of an exercise intensity when beginning an exercise program.

Ekkekakis, Lind, Hall, and Petruzzello (2007) conducted two studies examining the relationship between PRETIE-Q scores and the time individuals continued exercising during a graded exercise test (GXT) beyond their ventilatory threshold (VT). The first study involved 30 (14 women, 16 men) active college-aged students; the second study tested 24 female participants. The measurements used in Study 1 were the PRETIE-Q, self-reported physical activity, and a GXT on a treadmill; measures taken during Study 2 were the PRETIE-Q and a GXT (Ekkekakis et al.). After controlling for age, BMI, and self-reported physical activity, the relationship between Tolerance and duration of time after participants reached VT was significant and the combination of these measure accounted for 14.0% unique variance. In Study 2, Preference correlated with the duration after VT was reached. Adding Preference in the model after controlling for variance due to VO_{2max} , age, and BMI accounted for 16.2% unique variance. It thus appears that the PRETIE-Q can be used as a screening tool to identify individuals who may be likely to push their bodies past warning signs (discomfort, chest pain, muscular fatigue, etc.) as well as individuals who are likely to cease exercise testing hastily. For firefighters, this

could be helpful in identifying individuals who may overexert themselves during live fire-ground duties and continue working despite warning signs.

There are few measures that accurately screen for exercise intensity preference and tolerance (Hall, Petruzzello, Ekkekakis, Miller, & Bixby, 2014). Five hundred and sixteen individuals (327 women, 189 men) voluntarily participated in a free fitness testing program on a Southeastern college campus. The participants completed the PRETIE-Q and a battery of fitness assessments including: hand grip test (muscular strength), 1-minute push-up test (upper body muscular endurance), 1-minute sit-up test (abdominal muscular endurance), the Forestry Step Test (cardiovascular endurance), and the sit-and-reach test (flexibility). Hall et al. also collected measures of body composition via skinfold calipers at 3 sites (men= chest, abdomen, & thigh; women= triceps, abdomen, & thigh). Physical activity was measured using the Aerobics Center Longitudinal Study Physical Activity Questionnaire. Results revealed significant correlations between both Preference and Tolerance with all measures of fitness (excluding flexibility), body composition, and self-reported physical activity. Even after accounting for age and BMI, the results remained significant and were minimally changed (Hall et al).

Hall et al. (2014) also examined the relationship between PRETIE-Q scores on physical fitness performance in a sample of 42 male recruit firefighters. The recruits were part of 6-week fire training academy. Measures of cardiovascular endurance (1.5-mile run time), upper body muscular endurance (YMCA bench press), abdominal muscular endurance (1-minute sit-up), flexibility (sit-and-reach), body composition (skinfold measurements), perceived physical fitness (Perceived Fitness Index), and exercise intensity preference and tolerance (PRETIE-Q) were taken at Week 1 and Week 6 for the academy. During the course of the academy the recruits took part in physical activity training for 30-minutes, 4 days per week (Hall et al.). At Week 1,

Preference was correlated with performance on the sit-up test and time to complete the 1.5-mile run, but not at Week 6. Results revealed that Tolerance scores were related to performance on the push-up test at Week 1. Body fat, perceived fitness, and performance on sit-ups and 1.5-mile run time were related to Tolerance scores at Week 1 and Week 6 (Hall et al.). These findings suggest that after accounting for age and BMI, the PRETIE-Q could account for significant amounts of unique variance in performance during a fitness test. The PRETIE-Q could thus be used as a supplemental tool for screen candidates for physically demanding occupations and tasks and could highlight individuals who may excel as well as individuals who may require more caution/guidance during demanding tasks.

Conclusions

Given the current physical fitness levels among firefighters it may be beneficial to examine the personality profile of the FF and his/her predisposition to engage in physical activity. Understanding the way FFs may react to certain situations based on their personality profile will allow individuals to avoid potentially dangerous or harmful situations (Gnancinski et al., 2015; Wagner & Fraess-Phillips, 2016). The rapidly changing, high risk, high stress and chaotic situations firefighters are exposed can lead to anxiety, depression, and PTSD. Engaging in regular physical activity can help prevent these negative outcomes or at least lessen their severity or duration. By understanding the personality profile of FFs, researchers and FFs may be able to reduce the risk of stress, injury, early retirement and even death among FFs (Gnancinkski et al.; Wagner & Fraess-Phillips). This knowledge of physical and psychological variables has the potential to improve FF health and job performance. Promoting exercise and physical activity in this population is crucial and should be a top concern for policy makers and department leaders.

The present study sought to explore the relationship between: physical fitness and performance on firefighting tasks; physical fitness and exercise intensity preference and tolerance; physical fitness and personality; exercise intensity preference and tolerance and performance on firefighting tasks; and personality and performance on firefighting tasks in recruit firefighters from the Midwest. The findings of this study should allow better understanding of the role of different fitness parameters and personality factors on FF performance. The findings also provide the opportunity to examine a more functional type of exercise program, utilizing activities that mimic the kinds of tasks that FFs perform as part of their jobs. This study will also potentially provide a better understanding of potential factors leading to greater exercise adherence, and ultimately reduction in injuries in harmful situations, ideally helping firefighters be healthier, safer, and more efficient.

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CHAPTER 3: METHODS

Targeting firefighters (FFs) early in their careers and highlighting the importance of fitness is important for developing healthy and safe FFs. Over a FF's career, physical fitness tends to decrease (Baur, Christophi, Cook, & Kales, 2012). Recent literature has established trends of poor physical health and fitness in career FFs. These patterns of poor physical health have been linked to injury, shortened careers, and even death among career FFs (Smith, 2011). For example, previous research has linked poor cardiovascular fitness to increased risk of diminished health in career FFs (Baur et al.; Leduc & Jahnke, 2015; Mehrdad, Movasatian, & Momenzadeh, 2012; Smith, 2011). The present study used a within-subjects design to examine the effects a 7-week long functional fitness training program on various parameters of physical fitness (cardiovascular endurance, muscular strength and endurance, power, and flexibility) and ability to perform firefighter-specific tasks (i.e., Academy Firefighter Challenge; AFC). This study also examined relationships between individual difference variables and fitness and performance on the AFC.

The functional fitness program was designed to include movements designed to simulate those often seen during a live fire call (e.g., simulated victim rescue, forcible entry, odd object movements). It also highlighted and emphasize the importance of more components of physical fitness than are typically the focus of a training program (e.g., cardiovascular endurance, strength, mobility, and power). This study was designed to examine and potentially highlight the importance of physical fitness in career FFs. This research took place during an already established Basic Firefighting Academy at the Illinois Fire Service Institute (IFSI). In addition to examining the physical benefits of exercise, this research examined the importance of specific individual differences and the impact these might have on fitness and FF performance.

Research Questions

1. Does a 7-week high-intensity functional fitness training program improve both fitness and firefighter ability (assessed via completion time on simulated firefighter tasks)?
2. Do measures of fitness (cardiovascular endurance, muscular strength, muscular endurance, flexibility, and power) correlate with better performance on the AFC at Week 1 and at Week 7?
3. Do specific personality traits predict performance on fitness assessments and performance on the AFC at Week 1 and Week 7?
 - a. Are higher levels of Extraversion and exercise intensity preference and tolerance associated with better physical fitness in firefighters?
 - b. Are higher levels of Extraversion and exercise intensity preference and tolerance associated with a better performance on the AFC?

Basic Assumptions

The current study made several basic assumptions regarding firefighters' physical fitness and ability to fight fires. The first assumption was that the fitness program would have a positive impact on the FF's physical fitness. The program utilized functional fitness designed to improve muscular endurance and strength, aerobic capacity, flexibility, and power. Furthermore, the present study assumed that fitness correlates with improved firefighting ability (as demonstrated by performance on the AFC). Due to the physical demands placed on a FF, it would be predicted that better physical fitness would correlate with better performance on an ability test like the AFC.

The proposed study also assumed that individual differences, such as exercise intensity preference and tolerance and Extraversion, would correlate with both better fitness levels and

performance on the AFC. Both exercise and firefighting put physical and mental demands on the body, that is, the ability to handle stress, face challenges, and respond to a constantly changing environment. It is assumed that individuals who prefer and can tolerate higher levels of exercise intensity would (a) be more likely to engage in regular exercise as reflected in higher levels of fitness and (b) perform better during firefighting tasks. The inability to perform under these extreme physical demands can result in injury or even death.

Research Design

Firefighters (FFs) are expected to perform extreme and physically demanding tasks (e.g., forcible entry, victim rescue, throwing ladders, transporting equipment) while wearing protective clothing that restricts movement and adds additional weight (~45-55lbs) and restricts movement to some extent. These physical demands are more easily handled if the FF is in better physical shape, with high levels of aerobic fitness, muscular strength and endurance, power, agility, and flexibility. This research sought to determine whether higher levels of physical fitness (aerobic capacity, muscular strength and endurance, flexibility, and lower body power) predict performance (faster completion time) on the AFC. Recruit FFs were tested using a 1.5-mile timed run test, 60 s sit-ups test, 60 s push-ups test, YMCA bench press test, sit and reach test, and vertical jump test at baseline (Week 1) and post (Week 7) during a 7-week training academy. In order to examine the relationship between fitness and firefighting ability, the FFs also completed the AFC at Week 1 and Week 7. This test consisted of six tasks, modified from the Candidate Physical Abilities Test (CPAT). The study also examined individual differences (i.e., specific personality factors) to determine whether they could predict differences in physical fitness and firefighting ability among the participants. The research followed a within-subjects,

pre-test/post-test design, with a 7-week high-intensity functional training program being used to modify the various parameters of fitness under study.

Methods and Field Procedures

Newly hired FFs from across the state of Illinois (with the exception of the city of Chicago) reported to a 7-week Basic Firefighter Academy/National Fire Protection Agency (NFPA) training course (i.e., Academy) at the Illinois Fire Service Institute (IFSI) located in Champaign-Urbana. This Academy course is held twice a year (Fall and SFF firefighters were observed multiple times throughout the Academy in a variety of settings. They were observed during: (1) the Academy Physical Fitness Test (3 times during Academy: Wk 1, Wk 4, Wk 7); (2) research lab data collection (2 times during Academy: Wk 1, Wk 7); (3) Academy Firefighter Challenge (AFC; 2 times during Academy: Wk 1, Wk 7); and (4) daily physical training (PT). One of the main dependent variables of the present study was the FF's fitness levels. Measures of fitness (aerobic capacity, muscular strength and endurance) were collected at baseline (Week 1), mid-Academy (Week 4), and during the final week of Academy (Week 7). The personality variables of extraversion, exercise intensity preference, and exercise intensity tolerance were measured at baseline via self-report questionnaires. Another primary main dependent variable was the FF's firefighting ability, as demonstrated on the AFC. Firefighting ability was measured at Week 1 and Week 7 via the AFC and was reflected in the time it took to complete the series of tasks comprising the AFC (i.e., faster completion time was indicative of better performance).

The study was explained to the recruit FFs during the first week of Academy at IFSI. On the first day, these individuals were given a questionnaire packet including demographic information, measures of personality, and firefighting experience. Basic descriptive and fitness measures were also taken during this first week. Descriptive measures included height, weight,

and waist and hip circumferences measurements. Fitness parameters were assessed using the YMCA bench press test, sit and reach, and vertical jump. The firefighters participated in baseline physical fitness field tests on the second day of the Academy. The Academy Physical Fitness Test is a three-part test measuring muscular endurance (number of repetitions completed during a 60-s push-ups and 60-s sit-ups test) and cardiovascular endurance (1.5-mile timed run). During Week 1 of Academy, the firefighters completed a six-task AFC to examine their firefighting capabilities.

During the 7-week Academy, the FFs participated in daily 60-minute physical training (PT). The training program focused on multiple components of fitness including (but not limited to) muscular strength, muscular endurance, cardiorespiratory endurance, power, and flexibility. Each training session began at the IFSI in Champaign-Urbana, IL. The FFs reported to the IFSI “dirty classroom” (simulated firehouse) at 0630 in their assigned PT uniforms. An IFSI instructor or research staff member provided the FFs with instructions for the day. At 0630 all FFs reported to their assigned companies (designated Alpha, Bravo, Charlie, Delta) where roll call was taken, on-duty deaths for the day were acknowledged, and any other pertinent information was provided. A warm up, including dynamic stretches (approximately 10 minutes duration), were led by a designated FF and supervised by an IFSI staff member. Daily PT varied from day to day, but highlighted multiple aspects of fitness and lasted approximately 40 minutes. The overall program and daily workouts were designed by a kinesiologist, a researcher at IFSI, and a certified CrossFit® coach. Ten minutes were allotted for a cool down and stretching period to ensure heart rate and bodily exertion were decreased to near resting levels. After each PT session, the FFs reported back to the “dirty classroom”.

Midpoint testing during the 7-week Academy was done to examine fitness improvements during the first half of the 7-wk Academy. During Week 4 of the Academy the FFs participated in the Academy Physical Fitness Test for the second time. They reported to IFSI as normal, however instead of PT on Week 4 Day 1 they were retested on the 1.5-mile timed run, 60-second push-ups, and 60-second sit-ups tests. The same testing procedures as Week 1 were followed. Once fitness testing was completed, the FFs reported back to the “dirty classroom”.

The Academy Physical Fitness Test and the Academy Firefighter Challenge (AFC) were completed once more during the final week of Academy (Week 7). Firefighters completed the Academy Physical Fitness Test on Day 1 of Week 7 following the same procedure as Week 1 and Week 4. The AFC was held on Day 3 of Week 7 following the same procedure as Week 1. These repeated measures allowed for fitness and performance changes to be measured during the 7-week Academy.

Participants

Participants were new career firefighters (recruits enrolled in the Basic FF Academy at the IFSI. Those enrolled in this program are males and females, although predominantly male. The age of the participants can range from 18-64 years. Prior to giving consent, the study was explained both verbally and in writing to the potential participants. The written consent was given during the first week of Academy and the FFs had 24 hours to return their written consent. All trainees participated in the same Academy training and fitness program; however, only data from those who had given consent were examined and analyzed. The University Institutional Review Board (IRB) approved this study prior to data collection.

Measures

Descriptive Measures

Measures of age, height, weight, BMI, waist and hip circumference, were taken at the start of the Academy; participant sex and race/ethnicity were also recorded. During Week 7 measures of weight, BMI, waist, and hip circumference were recorded again to determine whether changes occurred.

Physical Fitness Measures

Various measures of physical fitness were taken at baseline (Week 1), mid-Academy (Week 4), and post-Academy (Week 6 Day 5 and Week 7). These measures included aerobic capacity (1.5-mile timed run), muscular endurance (60-second push-ups, 60 second sit-ups with total number of repetitions recorded), muscular strength (YMCA Bench Press), and lower body power (Vertec Vertical jump).

Firefighting Ability Measures

The Academy Firefighter Challenge (AFC) was performed at baseline (Week 1) and during the final week of the Academy (Week 7). This test is modified from the Candidate Physical Abilities Test (CPAT). It includes six stations done individually for time and then compiled into a total time. The stations included simulated forcible entry (using the Keiser[®] sled), the self-contained breathing apparatus maze (search), simulated victim drag (dragging a 165 lb mannequin 50 ft in one direction and then back), charged hose drag (dragging or pulling a charged 1.75" hose line 75 ft), equipment carry (saw carry 50 ft and back), and ladder raise (35 ft fixed ladder raise).

Individual Difference Measures

International Personality Item Pool (IPIP). This is a 50-item questionnaire which uses a

5-point Likert scale (1 = very inaccurate; 2 = moderately inaccurate, 3 = neither inaccurate nor accurate; 4 = moderately accurate, 5 = very accurate) to assess various aspects of personality (Goldberg et al., 2006). Ten of the 50 items are used to determine each of the Big 5 personality factors (Extraversion, Emotional Stability, Conscientiousness, Agreeableness, and Intellect/Imagination).

Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q).

The PRETIE-Q (Ekkekakis, Hall, & Petruzzello, 2005) is a 16-item questionnaire designed to discern an individual's preference and tolerance of exercise intensity. A 5-point Likert scale, ranging from 1 (I totally disagree) to 5 (I totally agree), is used to establish the respondent's preference for (8 items) and tolerance of (8 items) exercise intensity. Ekkekakis, Thome, Petruzzello, and Hall (2008) validated this questionnaire in a sample of college-aged women and it has also been used to examine relationships with fitness parameters in both college-aged participants and firefighters (Hall et al., 2014).

Procedures

All testing took place at the IFSI located in Champaign-Urbana, IL. Participants were enrolled in a 7-week Basic Firefighting Academy. During the first week of the Academy, Exercise Psychophysiology Laboratory Staff assisted the IFSI research staff in conducting and carrying out various measures of health and fitness in the recruit firefighters.

Research Lab Data Collection

The firefighters reported to the “dirty classroom” where they were briefed on the testing that was going to occur. The lead investigator of the current study provided the FFs with a brief synopsis of the study. The main research questions being addressed were discussed, and any questions were answered. Firefighters were reminded that their participation was voluntary, and

that they could withdraw from the study at any point during the 7-week Academy. All FFs were given two informed consent documents (ICDs) as well as a questionnaire packet that included the following measures: health and physical activity history, age, and personality (IPIP, PRETIE-Q; see Measures). They were given 24 hours to complete the questionnaires and return the ICDs to their instructors.

Following the classroom briefing, the FFs were escorted to another section of the IFSI campus where laboratory testing occurred. They were uniformed in a cotton shirt, athletic shorts and pants, socks, and gym shoes. The lab staff took measures of height, weight, flexibility (sit and reach), hip and waist circumference, and muscular strength (YMCA Bench Press; see description below). Height (without shoes) was measured to the nearest ½ centimeter.

Weight, Height, and Hip & Waist Circumference

Weight (without shoes) was recorded in kilograms on a Seca 284 digital scale. Waist circumference was taken above the belly button and below the rib cage of the participant. Firefighters were instructed to remove any additional clothing items (sweatshirt, heavy sweatpants) that may obstruct the measures. Lab staff instructed the FFs to refrain from “sucking in” or “sticking out” their abdomen while this measure was being recorded. Lab staff took the measurement twice and record both scores. Lab staff recorded hip circumference by placing the tape measure on one hip and wrapping the tape measure around the rear, around the other hip, and back to where they started. The tester made sure the tape went around the largest part of the buttocks and that the tape measure was level in the back. Measures were taken twice and both scores were recorded. For both the hip and waist measurements, a lab staff member stood off to the right side of the FF to record these measures.

The Sit and Reach Test

The Sit and Reach test is a common measure of flexibility, specifically flexibility of the lower back and hamstrings. Following ACSM (2000) guidelines, a lab staff member instructed the FF to sit on the floor with legs stretched out straight ahead. Shoes were removed to ensure proper recordings were taken. The FF placed the soles of their feet flat against the sit and reach box. Their knees were pressed flat on the floor, with the tester providing assistance if requested. The FF placed their hands one on top of the other with palms facing down on top of the box. Once in position, they were instructed to reach forward as far as possible in one smooth motion, pushing a metal slide as far as comfortably possible. The distance the slide moved was recorded. Trials where the task was performed with jerky or choppy movements were not scored. The FF was asked to hold their position for 2 seconds to allow the lab staff member to record their score. The best of the two attempts were recorded.

YMCA Bench Press

The YMCA Bench Press test is a measure of muscular endurance. A metronome was set to 60 beats per minute ($b \cdot \text{min}^{-1}$) prior to the start of the test. The barbell and weights totaled 80 lbs (36 kg) for males and 35 lbs (16 kg) for females. The FF was cued to lie supine on the bench with knees bent and feet flat on the floor. The barbell was handed to the FF by two spotters. The FF assumed an overhand grip on the bar with hands shoulder width apart. Following the beat of the metronome, the bar was lowered to the chest on the first beat, and pressed upward on the next beat, with arms fully extended at the top. The test was stopped when the FF could no longer keep the pace of the metronome or if they reached a total of 60 repetitions. A lab staff member recorded the successful number of repetitions.

Vertical Jump (National Strength and Conditioning Association)

The Vertical Jump test is a measure of leg muscle power. The FF stood near the Jump USA Vertec Vertical Jump System with one arm fully extended so their standing height could be recorded. They then jumped up and touched the highest possible vane of the Vertec System. The jump height was recorded as the difference between standing height and jump height. The FF was allowed to use both arms and legs to assist in propelling their body vertically. They jumped off both feet standing directly underneath the Vertec System. They were allowed one practice attempt and then their second attempt was scored by the lab staff.

Academy Physical Fitness Test

On the third day of the Academy, the FFs took part in the Academy Physical Fitness Test. They reported outside of the “dirty classroom” in their PT uniforms (cotton shirt, athletic shorts, socks, and gym shoes) with their water bottles and jump ropes. Prior to the Academy Physical Fitness Test, they were led through a 5-10 minute dynamic warm-up.

The Push-Up Event

The push-up event measured the endurance of the chest, shoulder and triceps muscles. On the command “Get set”, the FF assumed the front-leaning position by placing their hands just outside the shoulders. Their feet were either together or up to 12 inches apart. When viewed from the side, their body formed a generally straight line from their shoulders to their ankles. On the command “Go”, they began the push-up by bending their elbow and lowering their entire body as a single unit until their upper arms were at least parallel to the ground. They then returned to the starting position by raising their entire body until their arms were fully extended. Their body had to remain rigid, in a generally straight line, and moved as a unit while performing

each repetition. At the end of each repetition, a lab staff member stated and recorded the number of correct repetitions that were completed.

If the FF failed to keep their body generally straight, did not lower their whole body until their upper arms were at least parallel to the ground, or did not extend their arms completely, that repetition did not count. An altered, front-leaning rest position was the only authorized rest position. They were allowed to sag in the middle or flex their back, but they were not allowed to rest on the ground or raise either hand or foot from the ground. If they did, that concluded the event and their score was recorded. Correct performance was important. They had 60 seconds to perform as many repetitions of the push-up as they could. They were provided with a demonstration and allowed to ask any questions prior to the start of the event.

The Sit-Up Event

The sit-up event measures the endurance of the abdominal and hip-flexor muscles. On the command “Get set”, the FF assumed the starting position by lying on their back with their knees bent at a 90-degree angle. Their feet could be together or up to 12 inches apart. Another person held their ankles with the hands only. No other method of bracing or holding the feet was authorized. The heel was the only part of their foot that had to stay in contact with the ground. Their fingers had to be interlocked behind their head and the backs of their hands had to touch the ground on each repetition.

On the command “Go”, they began raising their upper body forward to, or beyond, the vertical position. The vertical position meant that the base of their neck was above the base of their spine. After they reached or surpassed the vertical position, they lowered their body until the bottom of their shoulder blades touched the ground. Their head, hands, arms, or elbows did not have to touch the ground. At the end of each repetition, a lab staff member stated and

recorded the number of repetitions they correctly completed. Repetitions did not count if they failed to reach the vertical position, failed to keep their fingers interlocked behind their head, arched or bowed their back, raised their buttocks off the ground, or let their knees exceed a 90-degree angle.

The up position was the only authorized rest position. If they stopped and rested in the down position, used their hands or any other means to pull or push them self to the up position or to hold themselves in the rest position, that concluded the event, and their score was recorded. Correct performance was important. They had 60 seconds to perform as many sit-ups as they could. They were provided with a demonstration and allowed to ask any questions prior to the start of the event.

The 1.5-Mile Run

The 1.5-mile run was used to assess aerobic fitness and leg muscle endurance. The FF had to complete the run without any physical help. At the start, all candidates lined up behind the starting line. On the command “Go”, the clock was started and they began running at their own pace. To run the required 1.5 miles, they needed to complete 5.25 laps around a pre-designated outdoor course. Their goal was to complete the course in the shortest time possible. Although walking was allowed, it was discouraged. If they were physically helped in any way (e.g., pulled, pushed, carried), or left the designated running course for any reason, their run time was not recorded. When the run was completed, the FF returned to the station pad for the cool-down, stretch, and score recording. As they crossed the finish, their time was read aloud and recorded by a lab staff member. The FF was then instructed to move away from the finish line so as not to interfere with others completing their run. They were allowed to ask any questions they may have had prior to the start of the 1.5-mile run.

Academy Firefighter Challenge

The Academy Firefighter Challenge (AFC) is a six-event physical performance test used to assess cardiorespiratory fitness and muscular endurance. Performance on the AFC is directly linked to the candidate's fitness level and their ability to perform physically demanding tasks on the fire-ground. The FF wore full turnout gear which included: helmet, bunker pants, bunker coat, boots, gloves, and SCBA equipment. The Academy FF Challenge (AFC) consisted of the following events: Keiser® Sled, Crawl, Victim Drag, Hose Advance, Equipment Carry, and Ladder Raise and extension. Overall performance on the AFC was a summation of the time to complete each of the stations comprising the AFC.

Station 1: Forcible Entry

This event is designed to test the ability to complete a critical task, such as opening a locked door or breaching a wall. The event also tests aerobic capacity, muscular strength and endurance, balance, grip strength, and anaerobic endurance. The forcible entry event requires the use of a 10-pound (4.54 kg) sledgehammer to strike the measuring device (Keiser® Sled) until the sled was moved 5-feet forward. The FF's feet remained outside the toe-box at all times. After the 5-ft distance was reached, the station was completed. The FF then placed the sledgehammer on the ground and advanced to the next station. The performance score was the time it took to successfully complete the task. There was a 90-second time cap for this event; if the FF did not complete the task in 90-seconds they received a score of DNF (did not finish). Failure to control the sledgehammer (e.g., releasing it from both hands) while swinging also ended the test and a score of DNF was given. If the FF stepped inside the toe-box, one warning was given. The second infraction resulted in failure, the test ended, and a score of DNF was given.

Station 2: The Crawl

The FF crawled through the self-contained breathing apparatus (SCBA) “can”, a sea-land container modified specifically for this task. The FF started by standing outside the entry door. An instructor gave a “Ready...Go” command. The FF then entered the can and crawled through the course on hands and knees. The task was complete when the FF exited the can. Once through the can, the FF advanced to the next station. The performance score was the time it took to successfully complete the task.

Station 3: Victim Drag

This event is designed to simulate the critical task of safely transporting an injured person or victim from a dangerous scenario. This is a test of aerobic capacity, muscular strength and endurance, grip strength, and anaerobic endurance. The FF was required to carry or drag a 165-pound (74.84 kg) mannequin 50-ft to a pre-marked turn-around point. Once the turn-around point was reached, they made a 180 degree turn and continued transporting the mannequin back to the starting line. They were allowed to grasp the mannequin in any manner they preferred.

The performance score was the time it took to successfully complete the task. If the FF reached for, or rested on, any objects for support at any time, one warning was given. The second infraction constituted a failure, the test was concluded, and the FF failed this portion of the test and a score of DNF was given.

Station 4: Hose Advance

The hose-drag event simulates one of the critical tasks FFs complete on a daily basis: pulling a hose line from a fire apparatus to a fire scene. The hose-drag challenges aerobic capacity, muscular endurance and strength, grip strength, and anaerobic endurance. This event required the FF to grasp a 100 ft (30 m) 1¾ inch (44-mm) charged hose and drag the hose 75 feet

to a prepositioned cone. They were allowed to place the hose line over their shoulders or across their chest, however no more than 8-ft of the hose was allowed to be placed over their body. The performance score was the time it took to successfully complete the task. They were permitted to run during this event. If they failed to go past, or went outside, the marked path (marked by cones), the test was concluded and they failed the test. This resulted in a score of DNF.

Station 5: Equipment Carry

The equipment carry test is designed to simulate the removal of tools from a fire truck, carrying them to an emergency scene, and returning them back to the truck. This event challenges aerobic capacity, muscular strength and endurance, grip strength and endurance, and balance. The FF lifted two saws from the ground, picking up one in each hand, and carrying them 50-ft to a designated turn-around point. They were permitted to place the saw(s) on the ground and adjust their grip. Once they returned to the starting line, they placed each saw on the ground, which concluded the challenge. Their performance score was the time it took to successfully complete the task. If either saw was dropped on the ground during the carry, the test was stopped and the test was failed. They received one warning, and the second infraction resulted in failure of the test and a score of DNF.

Station 6: Ladder Raise and Extension

This event is designed to simulate extending a ladder to the top of a window or a roof. This event tests aerobic capacity, upper body muscular strength, balance, grip strength, and aerobic capacity. The FF approached a prepositioned fixed ladder. They were instructed to raise the ladder as quickly as possible from the ground to a fixed vertical position. Their performance score was the time it took to successfully complete the task. If they lost control over the ladder the test was concluded, resulted in a failure, and a score of DNF was given.

Daily Physical Training

Firefighters reported to the IFSI at 0630 every morning of the Academy for daily physical training (PT). They lined up in numerical order within their company (Alpha, Bravo, Charlie, Delta) and roll call was taken by either an IFSI staff member or a nominated FF selected by the IFSI staff supervisors. Daily PT began with a dynamic warm-up that included jumping jacks, jump rope, and dynamic stretching. Roll call and the warm-ups took approximately 10 minutes.

Following the warm up, the group was led through an approximate 40-minute high intensity functional training (HIFT) regimen. The activities varied from day to day and highlighted the aspects of fitness required for safe and efficient firefighting: aerobic capacity, muscular strength and endurance, power, flexibility, and agility. The HIFT program gradually incorporated movements and equipment that are commonly seen during firefighting. The program incorporated high intensity bouts of work where the recruits were asked to work as hard as they could in given time or complete a specific task as quickly and safely as possible. High intensity was defined as working at a heavy to severe intensity (above what be the lactic threshold, even though this was not assessed). These short, intense bouts of work were typically followed by a rest period while a partner or a different company completed the assigned task. The PT sessions were led and supervised by IFSI staff members. Staff members from the University of Illinois Exercise Psychophysiology Lab (ExPPL) assisted with data collection and set-up and teardown required during daily PT. The PT schedule was designed by an exercise specialist and firefighter expert in consultation with a certified CrossFit® coach. A detailed outline of the PT schedule is provided in Figure 3.1 below. Please refer to Appendix A for work out descriptions, equipment needed, and set-up of the workouts listed in Figure 3.1.

Column	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	5-Mar No PT	6-Mar Academy Physical Fitness Test	7-Mar Extended Warm Up & Research Data Collection (in 1173)	8-Mar Team Challenge - Circle Dr. Battle Hose (x40, 1 3/4") Air Squat (x15) Tire Triceps Dips (x15) Team Pushups (x20)	9-Mar Firefighter Challenge
Week 2	12-Mar 4 Stations Stair Run 2.5" Hose Drag Litter Carry Bear Crawl/Plank	13-Mar Standard Circuits	14-Mar Ability Group Run 15 mins + Mobility & Flexibility	15-Mar Partner Circuits Wall Ball (x20) / Plank Burpee (x10) / Wall Sit Tire Drag / Lunge & Press Straw Box Step (x20) / Wall Ball Slam	16-Mar Team Challenge - Circle Dr. Battle Hose (x50, 2 1/2") Air Squat (x20) Tire Triceps Dips (x20) Team Pushups (Over/Under)
Week 3	19-Mar Battle Hose Stations Alternate Arms / Air Squat Hip-to-Hip / Pushup Slam to burpee / Hip Squeeze Jumping Jack / Hand/Shoulders	20-Mar Standard Circuits	21-Mar Ability Group Run 20 mins + Mobility & Flexibility	22-Mar Partner Circuits Wall Ball (x20) / Plank Sledge Strike (x20ea) / Wall Sit Tire Drag / Lunge & Press Straw Box Step (x20) / Wall Ball Slam	23-Mar Team Challenge - Victim Rescue Alternate Dummy Drag (Distance) 2 Laps Litter w Dummy (3 people on Litter) 10 burpees / person per team
Week 4	26-Mar Academy Physical Fitness Test	27-Mar 4 Corners Army Crawl - Rest Bear - Inchworm Crab - Jump Rope Lunge/Twist- Spiderman	28-Mar Ability Group Run 20 mins + Mobility & Flexibility	29-Mar 4 Corners High Plank Hose Drag Hurdles - Rest Boat Position Med Ball Handoff Hurdles - Rest	30-Mar Stadium Stair Run
Week 5	2-Apr 4 Stations Stair Run 2.5" Hose Drag Litter Carry Bear Crawl/Plank	4-Apr Partner Circuits Battle Hose (x80) / Push-up Farmer Carry (2 1/2" - Taxpayer) / Tire Dips Hose Pull & Bear Crawl Drag / Rest Straw Box Step (x20) / Bicycle	4-Apr Ability Group Run 20 mins (off Campus) + Mobility & Flexibility	5-Apr Partner Circuits Sledge Strike (x20ea) / Wall Sit High Rise Bundle Carry (x1) / Crunches Surge Front Squat (x20) / Hand/Shoulder Burpees (x20) / Flutterkick	6-Apr Team Challenge - Power Tire Drive (Distance) Victim Drag (Distance) 1 Lap Circle Drive Battle Hose (x50) Surge Front Squat (x10)
Week 6	9-Apr Battle Hose Stations Alternate Arms / Air Squat Hip-to-Hip / Pushup Slam to burpee / Hip Squeeze Jumping Jack / Plank Shoulders	10-Apr Partner Circuits Hose Hold Side Lunge (x20) / Jump Rope Surge Squat to Shoulder (x20) / Jumping Jack Bear Crawl Drag / Rest Straw Box Step (x20) / Bicycle	11-Apr Ability Group Run 20 mins (off Campus) + Mobility & Flexibility	12-Apr Stadium Challenge	13-Apr Research Lab Data Collection
Week 7	16-Apr Academy Physical Fitness Test	17-Apr Recovery and Motivation	18-Apr Firefighter Challenge	19-Apr Evals	20-Apr No PT

Figure 3.1. The physical training (PT) schedule for the 7-Wk Academy. (Note. See Appendix A for further details).

Data Analysis and Interpretation

All statistical analyses were performed using SPSS[®] 23.0.0.0 (SPSS Inc., Chicago, IL). Relationships among primary outcome variables of physical fitness (muscular strength and endurance, cardiovascular endurance, flexibility, and lower body power), individual difference variables (preference and tolerance for exercise, personality) and firefighting ability were examined. Descriptive measures of central tendency and variability were calculated to specify the sample (Aim 1).

Correlations among physical fitness parameters (1.5-mile run time, number of repetitions of 60-s push-ups, 60-s sit-ups, and YMCA bench press, sit and reach distance, and vertical jump height) and indicators of firefighter ability (i.e., time of AFC) were calculated and reported as Pearson Product Moment correlations (Aim 2). Correlations among individual characteristics that were identified (exercise intensity preference and tolerance, extraversion) and indicators of AFC performance (i.e., times to complete Keiser[®] Sled, Crawl, Victim Drag, Hose Advance, Equipment Carry, and Ladder Raise and extension as well as total completion time), were examined and reported as Pearson Product Moment correlations (Aim 5).

Pre (Week 1) and post (Week 7) measures from the Academy Physical Fitness Test, Academy Firefighter Challenge (AFC), and individual difference were compared. Repeated measures analyses of variance (MANOVAs) were run to examine any changes or differences from Week 1 to Week 7 of the Basic Firefighter Academy (Aims 3 and 4). Statistical significance was set at $p \leq 0.05$ and effect sizes [either as partial η^2 (η^2_p) or as Cohen's d] are reported where appropriate.

Conclusions

Assessing physical fitness and firefighting ability at baseline and at the end of a 7-week

Basic Firefighter Academy of recruit FFs could provide information on the effectiveness of HIFT during an already established training Academy. Additionally, exploring the impact fitness has on firefighter ability (i.e., as indexed by the AFC) should provide insight as to which components of fitness are, or are not, critical for job performance in FFs. If individual differences (exercise intensity preference and tolerance, extraversion) and physical fitness are found to be moderators of firefighting ability, new screening tools and training programs can be implemented to ensure competent, skilled, and qualified FFs are hired. By improving the job-related capabilities and proficiency of FFs on the force, job-related injuries, deaths, and other health problems will potentially be reduced.

Summary of Methods

Recruit FFs enroll in a Basic Firefighter Academy biannually at the IFSI. As part of the Academy, the FFs participated in the Academy Physical Fitness Tests, the AFC research lab data collection, and daily physical training (PT). The Academy Physical Fitness Test was held at Week 1, Week 4, and Week 7 to assess fitness among the FFs. The AFC was held at Week 1 and Week 7 to measure improvements in the firefighter's firefighting ability. Research lab data collection, including recording height, weight, sit and reach, vertical jump, hip and waist circumference, and bench press performance, was done at the beginning, at the midpoint, and at the end of the Academy. High-Intensity Functional Training (HIFT) was held daily (60 min total duration) during the 7-week Academy.

The principal aims of this dissertation were to: (a) determine the effectiveness of a HIFT program on both physical fitness and firefighter ability; (b) establish the relationship between levels of physical fitness and firefighting capabilities; (c) establish the effect individual differences (i.e., personality) have, or do not have, on physical fitness; and (d) determine the

manner in which ability to perform FF tasks is or is not, altered by such individual differences.

This research examined the importance of physical fitness in FFs and its role in FF performance.

The data presented herein have the potential to establish the role individual differences have on both physical fitness and the ability to perform in recruit firefighters.

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CHAPTER 4: CHANGES IN FITNESS AND FIREFIGHTER ABILITY

Abstract

Firefighting is a highly physical profession requiring at least adequate levels of fitness. As such, providing firefighters (FFs) with a safe and effective fitness program is essential for optimal performance on the fire ground. The purpose of this project was to examine changes in various parameters of physical fitness and FF ability following a 7-week high intensity functional training (HIFT) program instituted as part of the Illinois Fire Service Institute's Basic Firefighter Academy. Participants were male FF recruits ($N=53$; age= 26.9 ± 4.1 yrs) enrolled in the Basic Firefighter Academy at the Illinois Fire Service Institute during Spring and Fall of 2018. Physical fitness was assessed (1.5-mile run time, # of repetitions of 60 s sit-ups, push-ups, and YMCA bench press test, vertical jump height, and flexibility) as was FF ability (via the Academy Firefighter Challenge) at Weeks 1 and 7 of the Academy. Results revealed significant improvements in both physical fitness and FF ability following a 7-week HIFT program. Specifically, fitness (weight, cardiovascular fitness, muscular endurance) yielded significant improvements from Week 1 to Week 7 [Hotelling's $T^2= 8.79$, $F(5, 48)= 3.18$, $p<0.001$, $\eta^2_p= 0.90$]. Overall FF ability improved significantly as well [Hotelling's $T^2= 4.44$, $F(7, 46)= 29.15$, $p< .001$, $\eta^2_p= 0.82$]. Following a 7-week Basic Firefighter Academy that included daily HIFT, significant increases in physical fitness and firefighter ability were observed. At baseline, nearly 60% of the sample failed to meet the recommended aerobic capacity for safe firefighting; by Week 7 of HIFT that number was reduced to 30%. Additionally, there was an overall 13.3% improvement in firefighter ability. These findings suggest that HIFT appears to be an effective means of improving fitness and firefighter ability in FFs.

Introduction

The National Fire Protection Association (NFPA) has recommended that all municipal departments conduct annual physical fitness testing and provide their firefighter (FF) employees with a physical activity or wellness initiative (NFPA 1500, 2018; NFPA 1583, 2015). Despite these recommendations, nearly 70% of municipal departments do not require their employees to maintain physical fitness standards nor do they provide them with an exercise program (Storer, Dolezal, & Abrazado, 2014). The majority of current full-time FFs do not meet the recommended aerobic capacity ($VO_{2max} = 42 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) to perform job-related duties safely and efficiently (Drew-Nord et al., 2011; Gnacinski et al., 2016; Poplin, Roe, Peate, Harris, & Burgess, 2014). This profession requires FFs to be able to complete tasks that require cardiovascular endurance, muscular strength and endurance, power, and agility on a regular basis (Atalin, Seng, Ooper, Phaser, & Roup, 2014; Fogleman & Bhojani, 2005; Jahnke et al., 2015; Phillips, Scarlett, & Petersen, 2017; Roberts, O'Dea, Boyce, & Mannix, 2002; Smith, 2011). When FFs do not possess adequate levels of physical fitness, they jeopardize their own lives, their shift mates, and the community they serve.

Furthermore, obesity and low levels of physical activity are of growing concern in the fire service. Approximately, 50% of FFs are classified as overweight with an additional 25% being classified as obese (Anderson, Yoo, & Franke, 2016; Kuehl et al., 2012; Jitnarin, Poston, Haddock, Jahnke, & Day, 2014). Overweight and obese FFs are at higher risk of experiencing injury, missing work, suffering from chronic illness, and experiencing a cardiac incident compared to their healthy weight peers (Kuehl et al., 2012; Patterson, Smith, & Hostler, 2016; Phillips et al., 2017; Seyedmehdi et al., 2016). Combined with the lack of physical fitness, overweight and obese FFs create an even greater level of concern. Providing FFs with physical

activity and fitness initiatives could prove beneficial in preventing many of the risk factors that often shorten their careers.

Targeting FFs early in their careers is essential for reducing the risk injury, disease, and potentially preventing line of duty deaths due to cardiac incidents and overexertion (Gnacinski et al., 2016; Seyedmehdi et al., 2016; Soteriades, Smith, Tsismenakis, Baur, & Kales, 2011). By providing FFs with fitness initiatives and physical activity programs, municipal departments could reduce the risk of cardiovascular incidents and chronic diseases (i.e., hypertension, diabetes, anxiety, depression, etc.) (Gnacinski et al., 2016; Griffin et al., 2016a; Moore, 2003; Poston, Jitnarin, et al., 2011; Pozuelo-Carrascosa et al., 2017; Yang et al., 2013). Previous findings suggest that workplace wellness programs can be beneficial in preventing cardiovascular events among FFs, as well as remaining cost effective (Griffin et al., 2016; Moe et al., 2002; Patterson et al., 2016). Additionally, research has begun to explore the relationship between physical fitness and performance on FF specific tasks. These findings suggest the individuals who possess higher levels of physical fitness are able to perform simulated FF drills more efficiently when compared to their less fit peers (Kesler et al., 2017; Pawlak, Clasey, Palmer, Symons, & Abel, 2015). Firefighters who possessed higher levels of physical fitness performed better on simulated fire-ground tasks, indicating that there is a relationship between fitness level and ability to firefight. It is imperative to provide FFs with functional physical training programs that are designed to not only improve physical fitness, but that also improve job performance.

One form of physical training that could prove beneficial to FFs is High Intensity Functional Training (HIFT). HIFT can be defined as a training style that utilizes a variety of training modalities which are performed at a high-intensity and are designed to improve the

various parameters of general physical fitness (Crawford, Drake, Carper, DeBlauw, & Heinrich, 2018; Feito, Heinrich, Butcher, & Poston, 2018; Haddock, Poston, Heinrich, Jahnke, & Jitnarin, 2016). HIFT varies from traditional exercise programming and high-intensity interval training because these other training styles are unimodal and often only focus on one aspect of fitness in a workout. HIFT targets multiple facets of fitness in a single work out (i.e., strength, aerobic capacity, power, etc.). Functional movements can be defined as movements that involve the whole body, universal motor recruitment patterns, and exercises performed in different planes of movement (i.e., frontal, sagittal, and transverse) (Feito et al., 2018; Heinrich, Spencer, Fehl, & Carlos Poston, 2012; Poston et al., 2017). Universal motor recruitment patterns can also be defined as patterns that are used everyday life and needed for normal function. Simply put, universal motor recruitment patterns involve the use of all muscles moving in symphony efficiently, effectively, and quickly to complete a given task. This involves everything from large main muscles used in a specific movement to all the small supporting muscles that stabilize the movement.

For FFs specifically, this requires them to be able to possess multiple aspects of fitness, as well the ability to use both type I (slow twitch) and type II (fast twitch) muscle fibers. Movements such as forcible entry, ladder raise, and hose line advance, require short powerful bouts of work (~10 sec) and require the phosphagen energy system. Tasks such as stair climb, search, overhaul, and hose operation require longer bouts of work and utilize oxidative energy systems (>120 sec; Abel, Palmer, & Trubee, 2015). Firefighters face physical challenges on a regular basis and should possess an adequate and well-rounded battery of physical fitness attributes (cardiovascular endurance, muscular strength, muscular endurance, flexibility, etc). HIFT may prove to be an effective training modality given its constantly varied and dynamic

nature. Previous work has highlighted the effectiveness of HIFT in military populations. Following HIFT, soldiers in boot camp had an increased number of push-ups, bench-press repetitions, and increased flexibility, as well decreased 2-mile run time and step test heart rate compared to soldiers completing the more traditional Army Physical Readiness Training (APRT) program (Heinrich et al., 2012). HIFT has been shown to be effective in improving fitness in several military samples (Crawford et al., 2018; Feito et al., 2018; Haddock et al., 2016; Heinrich et al., 2012).

Given that there are abundant evidence-based benefits for HIFT programs in military personnel, there are no pressing reasons why the numerous benefits would not be applicable to other tactical athletes such as FFs. HIFT exercise programs include shorter training times and volumes, constantly varied training modalities, simulated work tasks, and lower equipment costs (Feito et al., 2018; Haddock et al., 2016; Heinrich, Patel, O'Neal, & Heinrich, 2014). Given that HIFT utilizes 25-80% lower training volumes and more variation than traditional military style training programs, the risk of experiencing boredom and injury may potentially be reduced when compared to traditional training programs (Haddock et al., 2016; Heinrich et al., 2012). When comparing HIFT to traditional physical training there were significant reductions in injuries in military personnel (Feito et al., 2018). HIFT may lead to reductions in injuries, increased fitness levels, and may reduce the number of line of duty deaths due to cardiac incidents and overexertion. Given that there is a link between fitness and job performance in FFs, using HIFT to increase fitness may also lead to increases in FF ability.

While previous research had shown the effectiveness of HIFT in military populations, little to no research has shown its effects in FFs. Additionally, previous research has shown that improvements in physical fitness often lead to increases in FF ability, however, the present study

is one of the first to examine the effectiveness of HIFT for increasing FF ability, which should translate to better job performance. The purpose of the present study was to examine the changes in physical fitness and FF ability in recruit FFs following a 7-week Basic Firefighter Academy that incorporated 60-minute (5 days per week) of HIFT. It was hypothesized that both fitness (cardiovascular endurance, muscular endurance, vertical jump, and flexibility) and FF ability (performance on the Academy Firefighter Challenge) would significantly improve following the 7-week training Academy and the HIFT program that was an integral part of it.

Methods

Participants

The present study was approved by the University of Illinois Institutional Review Board. The participants were FF recruits enrolled in the Basic Firefighter Academy held at the University of Illinois Fire Service Institute (IFSI) in Champaign, Illinois. Academies are held biannually each year (Fall, Spring); data for this project were collected during the Spring 2018 and Fall 2018 Academies. The participants were newly hired FFs ($N=53$) from the state of Illinois. Due to the low number of female FF recruits during this period ($n=1$), only males were included in the data analysis. See Table 4.1 for descriptive data.

Procedures

Daily HIFT

As part of the 7-week Academy program, participants took part in a daily HIFT program ($60 \text{ min} \cdot \text{d}^{-1}$; $5 \text{ d} \cdot \text{week}^{-1}$) designed to improve both fitness and FF ability. HIFT took place on the IFSI training grounds. The functional fitness program was developed jointly by the head of research at IFSI and members of the Exercise Psychophysiology Laboratory (ExPPL) of the University of Illinois Urbana Champaign. The program incorporated high intensity bouts of

work where the recruits were asked to work as hard as they could in given time or complete a specific task as quickly and safely as possible. High intensity was defined as working as at a heavy to severe intensity (at or above lactic threshold). Heavy intensity exercises were sustained for less than 30 minutes, while severe intensity exercises lasted for less than 10 minutes at a time. These short intense bouts of work were typically followed with a rest period while their partner or a different company completed the assigned task.

Table 4.1
Week 1 Descriptive Statistics

Sample (<i>n</i>)	53
Age (years)	26.9±4.1
Height (meters)	1.78±0.07
Weight (kilograms)	89.73±17.4
BMI (kg/m ²)	28.18±4.54
<i>Underweight</i> *	--
<i>Normal</i> *	22.6%(12)
<i>Overweight</i> *	49.1%(26)
<i>Obese</i> *	28.3%(15)
Estimated VO _{2Max} (ml·kg ⁻¹ ·min ⁻¹) †	41.15±5.07
<i>Very poor</i> **	11.3%(6)
<i>Poor</i> **	56.6%(30)
<i>Fair</i> **	28.3%(15)
<i>Good</i> **	3.7% (2)
<i>Excellent</i> **	--
<i>Superior</i> **	--

Note. *ACSM Body Mass Index classification †Estimated VO_{2Max};
**ACSM Cardiorespiratory Fitness classifications

Firefighter recruits reported to the IFSI campus at 0630 every weekday morning of the 7-week Academy for daily physical training (PT). Daily PT began with roll call and a dynamic warm-up (which took approximately 10 min). This included jumping jacks, jump rope, and dynamic stretching. Following the warm up, the recruits were led through approximately 40-min of HIFT. The activities varied on a daily basis and highlighted aspects of fitness required for safe and efficient firefighting: aerobic capacity, muscular strength and endurance, power, flexibility, and agility. The program gradually incorporated movements and equipment commonly used during firefighting tasks (e.g., hoses, sledge hammer). The PT sessions were led and supervised by IFSI staff members. The PT schedule was designed by an exercise specialist and FF expert who consulted with a certified CrossFit® coach and is detailed in Figure 4.1 below.

Column	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	5-Mar No PT	6-Mar Academy Physical Fitness Test	7-Mar Extended Warm Up & Research Data Collection (in 1173)	8-Mar Team Challenge - Circle Dr. Battle Hose (x40, 1 3/4") Air Squat (x15) Tire Triceps Dips (x15) Team Pushups (x20)	9-Mar Firefighter Challenge
Week 2	12-Mar 4 Stations Stair Run 2.5" Hose Drag Litter Carry Bear Crawl/Plank	13-Mar Standard Circuits	14-Mar Ability Group Run 15 mins + Mobility & Flexibility	15-Mar Partner Circuits Wall Ball (x20) / Plank Burpee (x10) / Wall Sit Tire Drag / Lunge & Press Straw Box Step (x20) / Wall Ball Slam	16-Mar Team Challenge - Circle Dr. Battle Hose (x50, 2 1/2") Air Squat (x20) Tire Triceps Dips (x20) Team Pushups (Over/Under)
Week 3	19-Mar Battle Hose Stations Alternate Arms / Air Squat Hip-to-Hip / Pushup Slam to burpee / Hip Squeeze Jumping Jack / Hand/Shoulders	20-Mar Standard Circuits	21-Mar Ability Group Run 20 mins + Mobility & Flexibility	22-Mar Partner Circuits Wall Ball (x20) / Plank Sledge Strike (x20ea) / Wall Sit Tire Drag / Lunge & Press Straw Box Step (x20) / Wall Ball Slam	23-Mar Team Challenge - Victim Rescue Alternate Dummy Drag (Distance) 2 Laps Litter w Dummy (3 people on Litter) 10 burpees / person per team
Week 4	26-Mar Academy Physical Fitness Test	27-Mar 4 Corners Army Crawl - Rest Bear - Inchworm Crab - Jump Rope Lunge/Twist- Spiderman	28-Mar Ability Group Run 20 mins + Mobility & Flexibility	29-Mar 4 Corners High Plank Hose Drag Hurdles - Rest Boat Position Med Ball Handoff Hurdles - Rest	30-Mar Stadium Stair Run
Week 5	2-Apr 4 Stations Stair Run 2.5" Hose Drag Litter Carry Bear Crawl/Plank	Bear Partner Circuits Battle Hose (x80) / Push-up Farmer Carry (2 1/2" - Taxpayer) / Tire Dips Hose Pull & Bear Crawl Drag / Rest Straw Box Step (x20) / Bicycle	4-Apr Ability Group Run 20 mins (off Campus) + Mobility & Flexibility	5-Apr Partner Circuits Sledge Strike (x20ea) / Wall Sit High Rise Bundle Carry (x1) / Crunches Surge Front Squat (x20) / Hand/Shoulder Burpees (x20) / Flutterkick	6-Apr Team Challenge - Power Tire Drive (Distance) Victim Drag (Distance) 1 Lap Circle Drive Battle Hose (x50) Surge Front Squat (x10)
Week 6	9-Apr Battle Hose Stations Alternate Arms / Air Squat Hip-to-Hip / Pushup Slam to burpee / Hip Squeeze Jumping Jack / Plank Shoulders	10-Apr Partner Circuits Hose Hold Side Lunge (x20) / Jump Rope Surge Squat to Shoulder (x20) / Jumping Jack Bear Crawl Drag / Rest Straw Box Step (x20) / Bicycle	11-Apr Ability Group Run 20 mins (off Campus) + Mobility & Flexibility	12-Apr Stadium Challenge	13-Apr Research Lab Data Collection
Week 7	16-Apr Academy Physical Fitness Test	17-Apr Recovery and Motivation	18-Apr Firefighter Challenge	19-Apr Evals	20-Apr No PT

Figure 4.1. Daily training schedule over the course of the 7-Week training Academy. (Note: Some days had to be modified due to inclement weather).

Outcome measures were taken over the course of three days during Weeks 1 and 7. These included: (a) age, height, weight; (b) fitness (1.5-mile run time, number of push-ups completed in

60-s, number of sit-ups completed in 60-s, number of repetitions completed during the YMCA Bench Press test, sit and reach, and vertical jump height); and (c) FF ability (time to complete the Academy Firefighter Challenge, AFC). Baseline testing took place on three days during Week 1 and post testing took place during Week 7 of Academy. Day 1 of testing consisted of the 1.5-mile run, 60-s push-ups, and 60-s sit-ups; Day 2 consisted of measures of height, weight, vertical jump, YMCA bench press, and sit and reach; and Day 3 consisted of the AFC. Mid-point measures of cardiovascular fitness (1.5-mile run) and muscular endurance (60-s push-ups, 60-s sit-ups) were also obtained at Week 4.

Physical Fitness Testing

Health and physical fitness measurements were taken at Weeks 1 and 7. The data collection was supervised by IFSI instructors and the ExPPL research staff assisted. Rest time was given between physical fitness assessments on Day 1 and Day 2 of testing to reduce the likelihood of muscular fatigue.

Day 1. For the assessment of muscular endurance, recruits were instructed to complete as many push-ups as possible in 60 s and then as many sit-ups as possible in 60 s (following a period of rest between). Their partner kept track of the number of correctly completed repetitions and the scores were recorded. For the push-up event, a correct repetition required the recruit to bend their elbow and lower their entire body as a single unit until their upper arms were at least parallel to the ground. Then, they returned to the starting position by raising their entire body until their arms were fully extended. For the sit-up event, they were instructed to assume the starting position by lying on their back with their knees bent at a 90-degree angle. Their feet were allowed to be together or up to 12 inches apart. No other method of bracing or holding the feet was authorized. The heel was the only part of their foot that had to stay in contact with the

ground. Their fingers had to be interlocked behind their head and the backs of their hands had to touch the ground on each repetition. On the command “Go”, they began raising their upper body forward to, or beyond, the vertical position (i.e., the base of their neck was above the base of their spine). After they reached or surpassed the vertical position, they lowered their upper body until the bottom of their shoulder blades touched the ground. Their head, hands, arms, or elbows did not have to touch the ground. At the end of each repetition, a lab staff member stated and recorded the number of repetitions they correctly completed. Repetitions did not count if they failed to reach the vertical position, failed to keep their fingers interlocked behind their head, arched or bowed their back, raised their buttocks off the ground, or let their knees exceed a 90-degree angle. For assessment of aerobic capacity, the recruits completed a 1.5-mile run on a pre-determined course. They were instructed to complete the course as quickly as they could, but the pace was self-selected. Estimated aerobic capacity was determined using the formula: $(3.5 + (483 \cdot 1.5\text{-mi run time}^{-1}))$ (American College of Sport Medicine, 2000; Cooper, 1968).

Day 2. Weight (i.e., body mass) and height (without shoes) were recorded in kilograms and centimeters, respectively, on a Seca 284 digital scale. Body Mass Index was calculated using the formula ($\text{kg} \cdot \text{m}^{-2}$; American College of Sport Medicine, 2000). Muscular endurance was assessed with the YMCA bench press protocol (Golding et al., 1989). The participants were told to complete as many repetitions as possible, raising and lowering the barbell to the beat of a metronome set to $60 \text{ b} \cdot \text{min}^{-1}$ or until they reached a maximum of 60 repetitions. The total weight of the barbell was 80 lbs (36 kgs) for males. Hamstring and lower back (trunk) flexibility was assessed using a sit and reach box. The participants sat on the floor with legs stretched out, backs of the knees flat on the floor, and soles of the feet (without shoes) flat against the back of the sit-and-reach box. With hands placed one on top of the other, they were instructed to reach as far

forward as possible in one smooth motion. Vertical jump was assessed as a measure of power. Each recruit stood near the Jump USA Vertec Vertical Jump System with one arm fully extended so the tester could record their standing height. They then jumped up and touched the highest possible vane of the Vertec System. The jump height was the difference between standing height and jumping height.

Day 3. Firefighter ability was assessed at Weeks 1 and 7 via the Academy Firefighter Challenge (AFC). The AFC is a six-event physical performance test used to assess cardio-respiratory fitness and muscular endurance. The FFs wore full turnout gear including: helmet, bunker pants, bunker coat, boots, gloves, and Self-Contained Breathing Apparatus (SCBA) equipment. The AFC consisted of the following events: Forcible Entry, Crawl, Victim Drag, Hose Advance, Equipment Carry, and Ladder Raise and extension. An ExPPL research staff member recorded the time to complete each event and the overall time, while also directing the recruit between stations.

Station 1: Forcible Entry. The forcible entry event required the recruits to use a 10-pound (4.54 kg) sledgehammer to strike the measuring device (Keiser® Sled) repeatedly until the sled was moved a distance of 5-feet. There was a 90-s time cap for this event.

Station 2: The SCBA Crawl. The recruits entered the SCBA course, laid out in a sea land shipping container, and crawled through the darkened course on hands and knees. Besides low visibility, the course was cleared of any obstacles (i.e., hose, confined entryways, etc.), however the height and width of the maze varied as the recruits progressed through the maze.

Station 3: Victim Drag. The recruit FFs were required to carry or drag a 110-pound (49.90 kg) mannequin 100-ft to a pre-marked end-point. They were allowed to grasp the mannequin in whichever manner they preferred.

Station 4: Hose Advance. This event required the recruits to grasp a 100 ft (30 m), 1¾ inch (44-mm) charged hose and drag the hose 75 feet to a prepositioned cone. They were allowed to place the hose line over their shoulders or across their chest, but no more than 8-ft of the hose was permitted to be placed over their body.

Station 5: Equipment Carry. The recruits picked up two chainsaws (~15 lbs per saw), one in each hand, and carried them 50-ft to a designated turn-around point. They were permitted to place the saw(s) on the ground and adjust their grip if needed. Once the FF returned to the starting line, they placed each saw on the ground and proceeded to the final station.

Station 6: Ladder Raise and Extension. The recruits approached a prepositioned fixed ladder. They were instructed to raise the ladder as quickly as possible from the ground to a fixed vertical position (90 degrees) against a building.

Data Analysis

Descriptive statistics were calculated for each of the variables under consideration. To assess changes over the course of seven weeks, separate repeated measures MANOVAs were conducted: (a) one included body mass, muscular endurance variables (i.e., YMCA bench press, 60-s push-ups, 60-s sit-ups), and cardiovascular endurance (1.5-mile run time); and (b) one for firefighting ability (Keiser sled, SCBA crawl, victim drag, hose advance, equipment carry, ladder raise, and total completion time). Variables that had a moderate correlation (.3-.7) were grouped together for the MANOVAs in order to reduce Type I error (Maxell, 2001). Variables with a correlation <0.3 were considered to be unrelated and anything >0.7 was interpreted as indicative of redundancy. Statistical analyses were conducted using SPSS 24.0 for Windows (SPSS, Chicago, IL). A significance level of $\alpha < 0.05$ was chosen to denote statistical significance. Partial η^2 (η^2_p) was calculated as a measure of effect size (0.02= small effect; 0.13= medium

effect; 0.26= large effect). Following a significant MANOVA, univariate tests were conducted to determine which of the dependent measures changed significantly and to what extent. Univariate repeated measures ANOVAs were run for flexibility (sit and reach) and vertical jump due to the uniqueness of each variable. A final MANOVA was run to determine the time effect from Week 1 to Week 4, and Week 4 to Week 7 for the following measures: cardiovascular endurance, push-ups, and sit-ups. Cohen's d (d) was calculated as measure of effect size (0.20=small effect size; 0.50=medium effect size; 0.80=large effect size) for these variables.

Results

A repeated measures MANOVA including body mass, cardiovascular endurance (1.5-mile run time), and muscular endurance (# of repetitions of push-ups, sit-ups, and YMCA bench press) revealed significant improvements from Week 1 to Week 7 [Hotelling's $T^2= 8.79$ $F(5, 48)= 3.18, p< 0.001, \eta^2_p= 0.90$; see Table 4.2]. Univariate tests for each dependent measure revealed that each changed significantly from Week 1 to Week 7 (body mass: [$F(1, 52)=7.73, p< 0.05, d= -0.05$]; 1.5-mile run time: [$F(1, 52)=27.52, p< 0.001, d= -0.59$]; push-ups: [$F(1, 52)=196.85, p< 0.001, d= 1.95$]; sit-ups: [$F(1, 52)=70.18, p< 0.001, d= 0.93$]; bench press: [$F(1, 52)=29.71, p<0.001, d= 0.40$]). Univariate repeated measures ANOVAs were run for flexibility (sit and reach) and lower body power (vertical jump). Time effects for flexibility revealed significant changes from Week 1 to Week 7 [$F(1,52)=20.86, p<0.001, d= 0.26$]. Time effects for lower body power were insignificant ($p> .05$).

A MANOVA revealed significant ($p\leq .001$) time effects from Week 1 to Week 4 and Week 4 to Week 7 for cardiovascular endurance and muscular endurance [Hotelling's $T^2= 8.03$ $F(6, 43)= 57.55, p< 0.001, \eta^2_p= 0.89$]. Univariate tests revealed significant ($p< 0.001$) time effects for cardiovascular endurance ($\eta^2_p= 0.47$), push-ups ($\eta^2_p= 0.70$), and sit-ups ($\eta^2_p= 0.45$).

Cardiovascular endurance significantly changed from Week 1 to Week 4 [$p < .001$, $d = -0.44$] and again from Week 4 to Week 7 [$p < .001$, $d = -0.34$]. Time effects for push-ups were also significant from Week 1 to Week 4 [$p < .001$, $d = 0.80$] and from Week 4 to Week 7 [$p < .001$, $d = 0.72$]. Finally, a significant time effect for sit-ups was shown from Week 1 to Week 4 [$p = .001$, $d = 0.31$] and from Week 4 to Week 7 [$p < .001$, $d = 0.56$].

A final repeated measures MANOVA was run to examine the change in both firefighting ability (time for each of Keiser[®] sled, SCBA crawl, victim drag, hose advance, equipment carry, ladder raise, and total completion time) from Week 1 to Week 7 [Hotelling's $T^2 = 4.44$, $F(7, 46) = 29.15$, $p < 0.001$, $\eta^2_p = 0.82$]. Univariate tests for each dependent measure revealed significant improvements in completion time for the SCBA crawl [$F(1, 52) = 25.56$, $p < 0.001$, $d = -0.39$], victim drag [$F(1, 52) = 16.29$, $p < 0.001$, $d = -0.41$], hose advance [$F(1, 52) = 6.86$, $p = 0.01$, $d = -0.35$], equipment carry [$F(1, 52) = 12.57$, $p = 0.001$, $d = -0.55$], and total completion time [$F(1, 52) = 140.28$, $p < 0.001$, $d = -0.83$] from Week 1 to Week 7. Time effects were insignificant for both the Keiser[®] sled [$F(1, 52) = 1.06$, $p = 0.31$, $d = -0.09$] and Ladder raise [$F(1, 52) = 1.00$, $p = 0.32$, $d = -0.15$].

Additionally, at baseline nearly 70% of the present sample were classified as having “poor” or “very poor” aerobic fitness based on ACSM Fitness Category determined from their estimated VO_{2Max} . Less than 30% of the sample was classified as “fair” and less than 4% possessed “good” aerobic fitness. Following the 7-week HIFT program, nearly 20% of the sample was classified as having “excellent” or “good” aerobic fitness. Additionally, the number of individuals who were classified as “poor” or “very poor” was reduced by 20% following the 7-week intervention (see Table 4.3 for specifics).

Table 4.2

Changes in Fitness and Firefighter Ability from Week 1 to Week 7

Variable	Pre (<i>M</i> ± <i>SD</i>)	Post (<i>M</i> ± <i>SD</i>)	Mean Difference (post-pre)	% Change	<i>p</i> - value	<i>Effect size (Cohen' s d)</i>
Weight (kg)	89.7±17.4	88.8±16.2	-0.9	-1.0%	<.01	-0.05
BMI	28.2±4.5	27.9±4.1	-0.3	-1.1%	<.01	-0.07
1.5-mile run (min.s)	13.06±1.78	12.04±1.70	-1.02	-8.5%	<.001	-0.59
Estimated VO _{2max} (ml·kg ⁻¹ ·min ⁻¹)	41.2±5.1	44.4±4.1	3.2	7.8%	<.001	-0.70
Push-ups (reps)	42.9±9.9	58.4±5.6	15.5	36.1%	<.001	1.95
Sit-ups (reps)	31.7±5.9	38.1±7.9	6.4	20.2%	<.001	0.93
YMCA bench press (reps)	29.6±12.1	34.4±11.9	4.8	16.2%	<.001	0.40
Flexibility (cm)	7.7±7.7	9.6±7.2	1.9	24.7%	<.001	0.26
Vertical Jump (in)	24.3±3.9	24.3±4.2	0	--	>.05	--
Kiser Sled (s)	38.3±13.4	37.1±12.3	1.2	-3.1%	>.05	-0.09
SCBA Crawl (s)	45.3±12.8	38.4±9.2	-6.9	-15.2%	<.001	-0.63
Victim Drag (s)	21.7±6.7	19.3±5.0	-2.4	-11.0%	<.001	-0.41
Hose Advance (s)	15.2±3.7	13.9±3.7	-1.3	-8.6%	<.05	-0.35
Equipment Carry	21.0±3.5	19.2±3.1	-1.8	-8.6%	<.01	-0.55
Ladder Raise	6.9±1.9	6.7±1.6	-0.2	-2.9%	>.05	-0.12
Challenge Total (s)	246.4±40.1	213.7±39.3	-32.7	-13.3%	<.001	-0.83

Note: Cohen's *d* effect size: 0.2=small effect size; 0.5=medium effect size; 0.8=large effect size

Table 4.3

Weeks 1 & 7 ACSM Fitness Categories

†ACSM Fitness Category (ml·kg ⁻¹ ·min ⁻¹)	Week 1	Week 7	Change
Superior*	--	--	
Excellent*	--	2 (3.8%)	+2
Good*	2 (3.7%)	8 (15.1%)	+6
Fair*	15 (28.8%)	17 (32.1%)	+2
Poor*	30 (56.6%)	23 (43.4%)	-7
Very Poor*	6 (11.3%)	3 (5.7%)	-3

Note. †Estimated VO_{2Max}; *ACSM Cardiorespiratory Fitness Classifications

In a secondary analysis, we examined whether any group effect occurred between the current HIFT program and the physical training (PT) program that was previously implemented at IFSI during the Basic Firefighter Academies (See Table 4.4). This original PT program was a more traditional training program, with a heavy emphasis on cardiovascular training. From a sample of 500+ individuals who were previously enrolled in the Basic Firefighter Academy and had participated in the PT program, we found age and estimated VO_{2max}-matched controls for each individual who participated in the HIFT program used in the current study. If multiple matched controls were found per participant, they were then best matched on BMI. A repeated measures MANOVA including body mass, cardiovascular endurance (1.5-mile run time), and muscular endurance (push-ups, sit-ups, and YMCA bench press) revealed no significant group differences when comparing HIFT to PT [Hotelling's $T^2=0.175$ $F(5,48)=1.68$, $p=0.16$, $\eta^2_p=0.16$]. Univariate tests for each dependent measure revealed only push-ups were different for the two types of training ($[F(1, 52)=6.76$, $p<0.05$, $\eta^2_p=0.12$). A repeated measures ANOVA for

flexibility (sit and reach) also revealed no significant differences between training groups.

Discussion

The present study had two primary goals: (a) examine changes in physical fitness following a 7-week HIFT program; and (b) examine changes in FF ability following a 7-week HIFT program. Results revealed significant improvements in weight (i.e., body mass) and BMI as well as various aspects of physical fitness (cardiovascular endurance, muscular endurance, and flexibility). Additionally, significant improvements in FF ability (SCBA crawl, victim drag, hose advance, equipment carry, and total completion time on the AFC) were observed following the 7-week Basic Firefighter Academy that included the HIFT program. These findings highlight and support previous research which showed that HIFT can be an effective and efficient training style to improve both fitness and job performance (Crawford et al., 2018; Griffin et al., 2016; Haddock et al., 2016; Poston et al., 2017).

Firefighting is a profession that requires a high level of physical fitness for optimal performance in the fire-ground. The majority of career FFs do not meet the required aerobic capacity or physical fitness needed to most effectively perform work-related duties (Gnacinski et al., 2016; Kesler et al., 2017; Smith, 2011; Staley, Weiner, & Linnan, 2011). Previous work has suggested that a VO_{2max} of $>42 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ is needed to perform firefighting tasks safely and effectively (Poplin et al., 2016). At Week 1 of the present study, nearly 60% of the participants (31 of 53) did not possess the suggested minimum level of VO_{2max} (estimated), with the average estimated VO_{2max} being $41.2 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$. By Week 7, the average estimated VO_{2max} was $44.4 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$. The number of recruits not having the suggested minimal level of aerobic fitness was reduced by nearly 50%, with only 16 out of the 53 (~30%) not meeting the recommended VO_{2max} . From Week 1 to Week 7, the number of participants who were classified as “excellent”,

Table 4.4

Changes in Fitness During HIFT and Traditional PT (PT)

Variable	Pre (<i>M</i>±<i>SD</i>) HIFT	Post (<i>M</i>±<i>SD</i>) HIFT	% Δ	<i>Effect size</i> (<i>Cohen's d</i>)	Pre TPT (<i>M</i>±<i>SD</i>)	Post TPT (<i>M</i>±<i>SD</i>)	% Δ	<i>Effect size</i> (<i>Cohen's d</i>)	HIFT vs TPT
Weight (kg)	89.7±17.4	88.8±16.2	-1.0%	0.05	89.6±11.7	87.3±10.2	-2.6%	0.21	ns
BMI	28.2±4.5	27.9±4.1	-1.1%	0.07	27.9±3.1	27.2±2.7	-2.5%	0.24	ns
1.5-mile run (min.s)	13.06±1.8	12.04±1.7	-8.5%	0.59	13.2±1.7	12.1±1.4	-8.3%	0.71	ns
Estimated VO _{2max} (ml·kg ⁻¹ ·min ⁻¹)	41.2±5.1	44.4±4.1	7.8%	-0.70	40.8±4.7	44.0±4.8	7.8%	-0.68	ns
Push-ups (reps)	42.9±9.9	58.4±5.6	36.1%	-1.95	39.0±12.1	52.6±13.9	34.5%	-1.05	<0.05
Sit-ups (reps)	31.7±5.9	38.1±7.9	20.2%	-0.93	31.8±8.3	36.9±7.7	16.0%	-0.64	ns
YMCA bench press (reps)	29.6±12.1	34.4±11.9	16.2%	-0.40	28.8±10.2	31.5±9.9	9.3%	-0.27	ns
Flexibility (cm)	7.7±7.7	9.6±7.2	24.7%	-0.26	8.2±7.0	10.9±6.9	32.9%	-0.39	ns
ΔOverall Fitness	--	31.8±11.5	--	--	--	27.2±13.0	--	--	ns

Note. The final column compares the post means for the HIFT and TPT program for the age and VO_{2max} matched controls
Cohen's *d* effect size: 0.2=small effect size; 0.5=medium effect size; 0.8=large effect size

“good”, and “fair” for aerobic fitness increased and the number of individuals classified as “poor” and “very poor” decreased (refer back to Table 4.3 for specifics). These results highlight the effectiveness of HIFT training and highlights that constantly varied functional training can increase aerobic capacity, along with other components of fitness. Our findings support previous work showing HIFT results in significant improvements in aerobic capacity (Feito et al., 2018; Haddock et al., 2016; Heinrich et al., 2014, 2012; Poston et al., 2017).

Similar to the present study, Cornell et al. (2017) had 27 male FF recruits (29.9 ± 4.1 years; 179.8 ± 4.6 cm; 87.2 ± 9.7 kg) enrolled in a 14-week training academy, part of which included a physical training component. They showed significant changes from Week 1 to Week 14, with decreases in body mass (3%), waist-to-hip ratio (2%), and estimated body fat (31%). There was also a 4% increase in fat-free mass, a 28% increase in relative VO_{2max} , increases in muscular strength (9% for bench press, 32% for squat), and increased muscular endurance (36% increase in maximum push-ups). Cornell et al. utilized a more traditional physical training program that focused on aerobic capacity, with ability group runs taking place 2-3 times per week. On weeks when the recruits only ran 2-times, they completed a 30-minute stair climb run. The training program also incorporated traditional weight training, which followed a linear progression of three sets of 8 to 10 repetitions at 60-80% of the individuals estimated one-repetition maximum (1-RM) 2-3 times per week (Cornell et al., 2017). Our programming utilized HIFT during a 7-week training Academy and saw similar fitness improvements. We observed a 7.8% increase in aerobic capacity along with significant increases in muscular endurance (specifically, a 36.1% increase in push-ups, a 20.2% increase in sit-ups, and a 16.2% increase in number of YMCA bench press repetitions). Additionally, we observed a 24.7%

increase in flexibility. The HIFT program in the present study incorporated equipment and movements that are often used in the fire service. Significant improvements in cardiovascular and muscular endurance were seen in from Week 1 to Week 4, with small to moderate increases based on effect sizes ($d_s= 0.34 - 0.44$). These results suggest that fitness may improve in as little as 4 weeks using HIFT. Significant improvements continued from Week 4 to Week 7 in our HIFT programming.

HIFT has shown to be an effective means to improve fitness in military personnel. Heinrich et al. (2012) utilized a HIFT program and compared its effectiveness to the standard Army Physical Readiness Training (APRT) program. Thirty-four active duty personnel were assigned to a HIFT program and 33 were assigned to the APRT program. The training programs occurred 2-times per week over the course of 8 weeks. The participants who engaged in HIFT significantly improved their push-ups by an average of 4.2 (± 5.4) compared to 1.3 (± 5.9) push-ups for the APRT group (Heinrich et al., 2012). Additionally, the HIFT group had significantly greater improvements in 2-mile run times, bench press strength, and flexibility when compared to the APRT group. The HIFT group experienced significant decreases in heart rate (-17.0 ± 15.0 $\text{b} \cdot \text{min}^{-1}$ vs -9.0 ± 16.1 $\text{b} \cdot \text{min}^{-1}$) on the step test compared to the APRT group. We found similar increases in fitness in FFs using HIFT over the course of 7-weeks during a Basic Firefighter Training Academy. Taken together these findings suggest that HIFT may be an effective form of training for tactical athletes like firefighters.

Roberts, O'Dea, Boyce, and Mannix (2002) utilized a 16-week traditional aerobic training program as a means to increase aerobic capacity in a large group of FFs ($N=115$). The results revealed that prior to the initiation of the fitness program, aerobic capacity (average= 35 ± 7 $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) was 20% lower than what is deemed sufficient for safe firefighting. Roberts et al.

found that following the 16-week program, aerobic capacity was increased by 28% to an average of $45 \pm 6 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$. The FFs in our study started at an average baseline estimated $\text{VO}_{2\text{max}}$ of 41.2 ± 6.1 and after 7-weeks of HIFT it was increased to $44.4 \pm 4.1 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$. Our cohort had higher baseline fitness levels but was still able to significantly increase their aerobic capacity to similar levels in just seven weeks of HIFT compared to 16 weeks of aerobic training.

Additionally, the HIFT program increased muscular endurance and flexibility by 36.1% and 24.7% compared to 19.6% and 2.9%, respectively, in the 16-week intervention. Significant changes in both cardiovascular ($d = -0.44$) and muscular endurance (push-ups: $d = -0.44$; sit-ups: $d = -0.31$) were observed in as little as 4 weeks using HIFT in our study. Our findings suggest that HIFT may be a potentially more effective means of improving various components of fitness among FFs than traditional aerobic training programs used in the past.

We also hypothesized that FF ability would improve significantly following the 7-week HIFT program. Very little research has examined the impact of a fitness intervention on FF ability. However, similar findings have been observed in military personnel. Our findings add to the growing body of evidence that suggests improvements in physically demanding job performance can be observed following a non-traditional physical fitness training program (Feito et al., 2018; Gnacinski et al., 2015; Haddock et al., 2016; Peterson, Dodd, Daniel, Alvar, Rhea, & Favre, 2008; Poston et al., 2017). Besides increased fitness, our results also revealed significant improvements in FF ability (i.e., FF-specific tasks routinely performed on the fire-ground). Specifically, we observed improvements in performance on the SCBA crawl (-15.2%; negative percentage indicated faster Week 7 times compared to Week 1), victim drag (-11%), hose advance (-8.6%), equipment carry (-8.6%), and total AFC completion time (-13.3%). These findings are noteworthy because of the physical demands that accompany firefighting. When

FFs fail to maintain adequate fitness levels they jeopardize not only their own well-being, but their co-workers and the victims they are responsible for (Del Sal et al., 2009; Smith, 2011; Soteriades et al., 2011; Yang et al., 2013). Improving physical fitness has the potential to improve worksite productivity, efficiency, and safety of FFs by increasing their ability and reducing the risk of experiencing injury while on duty. However, because the FFs were participating in the Basic Firefighter Academy as well as the HIFT program, it is challenging to determine if the increases in FF ability were due the HIFT, the training academy, or a combination of both.

Previous work has examined improvements in FF job performance following a fitness intervention. Fourteen well-trained FF academy attendees (21.9 ± 1.8 years; 180.9 ± 5.7 cm; 85.6 ± 9.9 kg) took part in a 9-week physical fitness intervention (Peterson et al., 2008). During the 9-week training program (60-90 min; 3 times \cdot wk⁻¹), the FFs were separated into either undulation training (UT) or standard training groups. Measures of physical fitness and FF ability (Grinder performance) were taken at baseline and post-intervention. The UT followed a 3-day upper and lower body program that varied the focus (i.e., endurance/hypertrophy, strength, or power and speed) of exercises each day and the standard training incorporated three 3-week mesocycles that each focused on different aspects of fitness (i.e., endurance/hypertrophy, strength, power and speed) (Peterson et al., 2008). The Grinder test measured FF ability via 6 tasks which included an equipment hoist, a hose-pull, a Keiser Sled, a stair-climb, an attic crawl, and a simulated civilian carry or drag. Both training groups experienced significant improvements in fitness from baseline to post-intervention, including 1-RM bench press, 1-RM squat, power output, and Grinder performance time. The individuals who participated in the UT experienced significantly greater improvements in Grinder performance when compared to the

traditional training group. Generally, UT elicited greater improvements on the administered test, including upper-body muscular strength, and lower-body muscular strength (Peterson et al., 2008). These results suggest that a more varied exercise program may be more effective in improving fitness and job performance compared to a more standard (i.e., traditional) training style. Our study utilized a similar all-male sample of recruit FFs and found similar improvements (~13%) in FF ability following a varied functional training program.

Limitations/Future Research

The largest limitation of the present study was the lack of a control or comparison group. The participants were simultaneously participating in a 7-week HIFT fitness intervention and the Basic Firefighter Academy at IFSI. Because of this, it is impossible to state whether the gains and improvements in fitness and FF ability were due to the HIFT, the FF training academy [which included manual labor and fire-ground training (live fires, equipment hoist and carry, ladder work, etc.)], or a combination of both. However, despite participating in 8+ hours of physically demanding fire-ground training 5 days·wk⁻¹ for 7 weeks, significant improvements were seen in various components of fitness. Additionally, despite self-reported fatigue and muscle soreness (anecdotal), significant changes in fitness were observed.

Future studies could observe changes in FF ability following a 7-week HIFT program compared to a control group. Researchers could utilize a no-exercise control group which would not participate in HIFT, but would participate in the Basic Firefighter Academy at IFSI. Alternatively, changes in fitness and FF ability can be observed in current career FFs who receive a 7-week HIFT program. Additionally, future research could utilize a cross-over design, where half the group engages in daily HIFT during the Academy for 3.5 weeks, and the other group receives a lecture-based curriculum emphasizing the important of physical fitness and

health for 3.5 weeks. The groups would then switch halfway through to see whether any observed changes are due to the HIFT or from training they are receiving on the fire-ground.

An additional limitation of the study was that exercise intensity was not systematically measured during the HIFT training. While recruits were instructed to work as hard and quickly as possible, we cannot be certain that the intensity at which the activities were performed was actually high intensity (>70% of estimated maximal heart rate). Future studies should utilize heart rate monitors to monitor heart rate and ensure the intensity can be classified as high intensity. Another possible solution, that perhaps is more cost effective than monitoring heart rate, is the use of self-reported rating of perceived exertion (RPE). High intensity interval training has been shown to be as, or more, effective in increasing overall fitness than traditional training programs, as well as being perceived as more enjoyable despite working at relatively high exercise intensities. Future research is warranted to further explore the positive benefits HIFT might have on both fitness and FF ability (Feito et al., 2018; Haddock et al., 2016; Heinrich et al., 2014). Additionally, we did not have a measure of muscular strength. Given that many of the tasks performed on the fire-ground (i.e., equipment carry, ladder raise, hose hoist, etc.) require muscular strength to perform optimally, future research should incorporate a measure of muscular strength in order to observe whether changes occur in muscular strength following a HIFT program.

Another potential limitation of the present study and current literature is the lack of female participants. Given that males make up over 95% of those in the fire service, it becomes challenging to find a large enough sample of female FFs to observe and include in such research. An additional limitation of the present study is that participants were required to engage in structured, daily physical activity for 7 weeks (60-min, 5 days·week⁻¹). As such, drop-out rates

were low and not an accurate depiction of what actually occurs once FFs graduate the Academy and are active duty fire service employees. Previous research has shown that adherence rates for active duty FFs are low and improvements that occur during the training academy are largely lost after 6 months on duty (Cornell et al., 2017; Gnacinski et al., 2016). Given this information, future research should also target career FFs who are currently not required to engage in regular physical activity or fitness programming.

Conclusions

While the present study has shed some light on which aspects of fitness are essential for FFs, additional research is needed to determine which aspects of fitness have the largest impact on FF ability. Understanding how and which components of fitness are correlated to better performance on fire-ground activities will allow researchers and exercise specialists to prescribe safe and relevant programming that not only improves physical fitness, but also creates more efficient and productive FFs.

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CHAPTER 5: THE RELATIONSHIP BETWEEN PHYSICAL FITNESS AND FIREFIGHTER ABILITY

Abstract

The physical demands of firefighting are obvious, and a high level of physical fitness is helpful to perform the job optimally. Despite this, the majority of firefighters and municipal departments fail to meet the National Fire Protection Association's recommended physical fitness levels and department standards. Given that the leading cause of on duty deaths is cardiac incidents due to stress or overexertion, exercise may be one the most effective strategies firefighters and first responders can use to prevent or attenuate multiple health risks as well as improve health and job performance. The purpose of this project was to investigate the relationship between multiple components of physical fitness and firefighter (FF) ability. Participants were male FF recruits ($N=54$; age= 26.8 ± 4.2 yrs) enrolled in a 7-week Basic Firefighter Academy training course during Spring and Fall of 2018. Firefighter ability was assessed via total completion time on the Academy Firefighter Challenge, a physical ability test consisting of several different tasks performed in sequence (Keiser Sled, SCBA maze, victim drag, hose charge, equipment-carry, and ladder set-up). Physical fitness was assessed via (1.5-mile run time, # of repetitions of sit-ups and push-ups, both done for 60 s, and YMCA bench press, vertical jump height, and flexibility). Both physical ability and physical fitness were assessed at Week 1 and Week 7 of the Academy. Physical fitness predicted significant variance in FF ability at Week 1 ($R^2=0.36$; $p< 0.01$) and Week 7 ($R^2=0.46$; $p< 0.01$), after accounting for age and BMI. Cardiovascular endurance accounted for 28.9% [$F(1, 50) = 22.83$] and 36.4% [$F(1, 50) = 28.70$] unique variance on FF ability at Week 1 and Week 7, respectively. At Week 1 and Week 7, muscular endurance accounted for an additional 11.0% [$F(1, 49) = 10.34$] and

10.2% [$F(1, 49) = 8.88$] unique variance in FF ability, respectively. Firefighting is a challenging occupation that is most effectively done by individuals who are in peak physical condition. Targeting FFs early in their careers and highlighting the importance of fitness is extremely vital to developing healthy, safe, and efficient FFs. Additionally, by better understanding the relationship between physical fitness and firefighting ability, exercise specialists, scientists, and physicians may be able to better prescribe exercise in this population.

Introduction

Firefighting involves various aspects of physical fitness, including cardiovascular endurance, muscular strength and endurance, power, agility, and flexibility. Despite the physical strain firefighting places on the men and women who choose this profession, the vast majority of career and volunteer firefighters (FFs) fail to maintain the needed levels of physical fitness to function safely and efficiently while on duty (Conrad, Balch, Reichelt, Muran, & Oh, 1994; Phillips et al., 2017; Poplin et al., 2016; Smith, 2011; Yang et al., 2013). There is a clear and apparent need for physical fitness and exercise guidelines and standards in the fire service, as the majority of FFs are not sufficiently fit to optimally perform their duties (Del Sal et al., 2009; Poplin et al., 2016; Soteriades et al., 2011). While they can perform the tasks necessary for the job, the additional strain placed on them due to their lack of fitness could lead to deleterious health outcomes over time.

Due to the mismatch of the physical demands of firefighting and the current physical state of most FFs, cardiac incidents and over-exertion are the leading causes of on-duty deaths. Cardiac incidents alone account for 40-50% of on-duty death among FFs (Fahy, 2006, 2012; Storer et al., 2014). While there are some non-modifiable risk factors that contribute to the likelihood of experiencing a cardiac incident (e.g., age, gender, family history, and

environmental work-related risks), there are also many modifiable risk factors that are often neglected in the fire service. Some of these modifiable risk factors include obesity, high blood pressure, smoking-status, poor nutrition, poor hydration, and lack of physical activity and physical fitness (Staley, Weiner, & Linnan, 2011; Storer et al., 2014). Previous research has highlighted the powerful effects physical activity and fitness can have on reducing obesity, high blood pressure, and other chronic conditions (Gibala, Little, Macdonald, & Hawley, 2012; Leischik et al., 2015). Improvements in physical activity and physical fitness have the potential to serve as buffers or preventative measures for reducing the likelihood of experiencing a cardiac incident.

Recent research has begun to examine the relationship between physical fitness and the likelihood of experiencing a cardiac incident among FFs. These findings have shown that poor physical health is often linked to a greater risk of experiencing a cardiac incident (Del Sal et al., 2009; Kales et al., 1999; Patterson, Smith, & Hostler, 2016; Scanlon & Ablah, 2008; Smith, 2011; Staley et al., 2011). In addition to preventing cardiac incidents in FFs, physical fitness has also been linked to the reduced likelihood of experiencing injury during routine fire-ground activities. Findings have shown that individuals who have higher BMIs and lower levels of physical fitness are more likely to experience injury while on duty and perform worse on work-related physical tasks (Butler et al., 2013; Del Sal et al., 2009; Dennison et al., 2012; Kesler et al., 2017; Salters-Pedneault et al., 2010; Seyedmehdi et al., 2016). Given that there is a clear need for adequate fitness levels to not only perform efficiently while on duty, but also to reduce the likelihood of sudden cardiac incidents, more research is warranted to determine the specific relationship between physical fitness and FF ability. This information would allow physicians, municipal departments, and exercise specialists to prescribe physical activity or exercise

programs more effectively in FF populations.

Due to the need for a better understanding of the relationship between physical fitness and FF ability, the aim of the present study was to examine this relationship. We hypothesized that cardiovascular endurance, muscular endurance, power, and flexibility would be related to FF ability, measured by performance time on the Academy Firefighter Challenge (AFC). We further hypothesized that increases in physical fitness over the course of a 7-week training program would be associated with greater FF ability (i.e., shorter completion time on the AFC).

Methods

Participants

The present study was approved by the University of Illinois Institutional Review Board. The participants were FF recruits ($N=54$, 100% male) enrolled in the Basic Firefighter Academy training course held at the University of Illinois Fire Service Institute (IFSI) in Champaign, Illinois. Academies are held biannually (Fall, Spring); data for this project were collected during the Spring 2018 and Fall 2018 Academies. Due to the low number of female FF recruits enrolled during those periods ($N=1$), females were excluded from the data analysis. See Table 5.1 for descriptive and fitness data.

Physical Fitness Testing

The data collection was supervised by IFSI instructors and the ExPPL research staff assisted. Rest time was given between physical fitness assessments on Day 1 and Day 2 of testing to reduce the chance of muscular fatigue.

Day 1. The recruits were instructed to complete as many push-ups as possible in 60 s. Their partner kept track of the number of correctly completed repetitions and then recorded the score. A correct repetition required the recruit to bend their elbow and lower their entire body as

a single unit until their upper arms were at least parallel to the ground. They then returned to the starting position by raising their entire body until their arms were fully extended. The recruits were also instructed to complete as many sit-ups as possible in 60 s. They were instructed to assume the starting position by lying on their back with their knees bent at a 90-degree angle. Their feet were allowed to be together or up to 12 inches apart. No other method of bracing or holding the feet was authorized. The heel was the only part of their foot that had to stay in

Table 5.1
Participant Descriptive Statistics at Weeks 1 & 7

	Week 1	Week 7
Sample (N)	54	54
Age (years)	26.8 ± 4.2	--
Body Mass (kg)	89.51 ± 17.32	88.80 ± 16.15
Height (m)	1.78 ± 0.07	--
BMI (kg·m⁻²)	28.14 ± 4.50	27.37 ± 5.55
<i>Underweight (<18.5)</i>	--	
<i>Normal (18.5-24.9)</i>	22%	18.52%
<i>Overweight (25.0-29.9)</i>	50.0%	55.56%
<i>Obese (>30)</i>	27.8%	25.9%
Physical Fitness[†]	41.10 ± 5.03	44.36 ± 5.53
<i>Very poor*</i>	9.3%	5.6%
<i>Poor*</i>	55.6%	42.6%
<i>Fair*</i>	31.5%	31.5%
<i>Good*</i>	3.7%	14.8%
<i>Excellent*</i>	--	5.6%
<i>Superior*</i>	--	--

Note. [†]Estimated VO_{2max}; *ACSM Cardiorespiratory Fitness Classifications

contact with the ground. Their fingers had to be interlocked behind their head and the backs of their hands had to touch the ground on each repetition. On the command “Go”, they began raising their upper body forward to, or beyond, the vertical position (i.e., the base of their neck

was above the base of their spine). After they reached or surpassed the vertical position, they lowered their upper body until the bottom of their shoulder blades touched the ground. Their head, hands, arms, or elbows did not have to touch the ground. At the end of each repetition, a lab staff member stated and recorded the number of repetitions they correctly completed. Repetitions did not count if they failed to reach the vertical position, failed to keep their fingers interlocked behind their head, arched or bowed their back, raised their buttocks off the ground, or let their knees exceed a 90-degree angle. Another person held their ankles with the hands only. Finally, the recruits were instructed to complete a 1.5-mile course as quickly as possible, ideally by running; time to complete the 1.5 miles was recorded by research staff to the nearest second. The outdoor course was laid out on the grounds of the IFSI. Estimated aerobic capacity was determined using the formula: $(3.5 + (483 \cdot 1.5\text{-mi run time}^{-1}))$ (American College of Sport Medicine, 2000; Cooper, 1968).

Day 2. Weight (body mass, in kg) and height (without shoes, in cm) were recorded in on a Seca 284 digital scale. Body Mass Index (BMI) was calculated as body weight divided by height in meters squared ($\text{kg} \cdot \text{m}^2$; American College of Sport Medicine, 2000). The YMCA bench press protocol followed procedures of Golding et al. (1989). Participants were asked to complete as many repetitions as they were able to the beat of a metronome set to $60 \text{ b} \cdot \text{min}^{-1}$, with the press up or the return to the chest occurring with each click of the metronome, or until they reached a maximum of 60 repetitions. The total weight of the barbell was 80 lbs (36 kgs) for males. Hamstring and lower back (trunk) flexibility was assessed using a sit and reach box. The participants sat on the floor with legs stretched out, backs of the knees flat on the floor, and soles of the feet (without shoes) flat against the back of the sit-and-reach box. With hands placed one on top of the other, they were instructed to push a slide as far forward as possible in one smooth

motion. Distance reached was recorded to the nearest centimeter. Finally, for the vertical jump test, the participant stood near the Jump USA Vertec Vertical Jump System with one arm fully extended so research staff could record their standing height. The participant then jumped up and touch the highest possible vane of the Vertec System. The jump height was the difference between standing height and jumping height.

Day 3. Firefighter ability was assessed at Week1 and Week 7 via the Academy Firefighter Challenge (AFC). The AFC is a six-event physical performance test used to assess cardio-respiratory fitness and muscular endurance. This is an IFSI-specific test patterned after the Candidate Physical Ability Test (CPAT; International Association of Fire Chiefs), with the various tasks designed to mimic what a FF would encounter in everyday situations while on duty. The FFs wore full turnout gear during the AFC, including: helmet, bunker pants, bunker coat, boots, gloves, and self-contained breathing apparatus (SCBA; consists of facemask, regulator and hose, and air pack harness and air bottle) equipment. The AFC consisted of the following events: Keiser® Sled, Crawl, Victim Drag, Hose Advance, Equipment Carry, and Ladder Raise and Extension. A research staff member recorded the lap splits (time for each event) and overall time, while also directing the participant between stations.

Station 1: Forcible Entry. The forcible entry event required the use of a 10-pound (4.54 kg) sledgehammer to strike the measuring device (Keiser® Sled) until the sled was moved a distance of 5-feet. There was a 90-s time cap for this event; if the participant was unable to move the sled the required distance in 90 s they were instructed to stop and move on to the next station.

Station 2: The SCBA Crawl. The FFs entered the SCBA can, a sea-land container modified specifically for this task, and crawled through the course on hands and knees. The

SCBA crawl was a U-shaped maze that had low visibility and a floor that was uneven, resulting in variable ceiling heights. All obstacles (hoses, mattresses, etc.) were removed from the course.

Station 3: Victim Drag. Participants were required to carry or drag a 110-pound (49.90 kg) mannequin 100-ft to a pre-marked end point. They were allowed to grasp the mannequin in any manner they preferred.

Station 4: Hose Advance. This event required the FF to grasp a 100 ft (30 m) 1¾ inch (44-mm) charged hose and drag the hose 75 feet to a prepositioned cone. They were allowed to place the hose line over their shoulders or across their chest, as long as no more than 8-ft of the hose was placed over their body.

Station 5: Equipment Carry. The recruits picked up two saws (~15 lbs per saw), one in each hand, and carried them 50-ft to a designated turn-around point. They were permitted to place the saw(s) on the ground and adjust their grip as needed. Once they returned to the starting-line they placed each saw on the ground and moved on to the final station.

Station 6: Ladder Raise and Extension. The recruits approached a prepositioned fixed ladder (i.e., attached at the bottom) that was lying flat on the ground. They were instructed to raise the ladder as quickly as possible from the ground to a fixed vertical position (90 degrees) from its initial position.

Statistical Analysis

Descriptive statistics were calculated for each of the variables under consideration. Statistical analyses were conducted using SPSS 24.0 for Windows (SPSS, Chicago, IL). A significance level of $\alpha \leq 0.05$ was chosen to denote statistical significance. Bivariate correlations were used to determine the magnitude and direction of the relationship between various aspects of fitness (cardiovascular endurance, muscular endurance, flexibility, and lower

body power) and firefighting ability (Keiser sled, SCBA crawl, victim drag, hose advance, equipment carry, ladder raise, and total completion time) at Week 1 and Week 7 (see Tables 5.2 & 5.3). Assuming a significant correlation between a measure of fitness and total completion time on the FF challenge, a hierarchal regression was conducted.

Results

Bivariate correlations (Tables 5.2 & 5.3) revealed significant relationships between cardiovascular endurance ($r = -0.59, p \leq 0.01$), bench press ($r = -0.44, p \leq 0.01$), push-ups ($r = -0.34, p \leq 0.05$), sit-ups ($r = -0.32, p \leq 0.05$) and total FF ability (total completion time) at Week 1. At Week 7, significant relationships were revealed between cardiovascular endurance ($r = -0.58, p \leq 0.01$), bench press ($r = -0.40, p \leq 0.01$), sit-ups ($r = -0.29, p \leq 0.05$) and total FF ability (total completion time). Lower body power (vertical jump) and flexibility (sit and search) were not significantly related to overall FF ability.

Hierarchal linear regressions (Tables 5.4 & 5.5) were conducted to determine the unique variance accounted for by each variable at Week 1 and Week 7. At Week 1, after accounting for age and BMI (7.9% variance, $p \geq 0.05$), fitness (cardiovascular endurance, muscular endurance) predicted an additional 36.1% variance in FF ability, with cardiovascular endurance accounting for 28.9% [$F\Delta = (1, 50) = 22.83; p \leq 0.001$] unique variance and muscular endurance (bench press) accounting for an additional 11.0% [$F\Delta = (1, 49) = 10.34; p \leq 0.01$] unique variance. At Week 7, after accounting for age and BMI (<1% variance, $p > 0.05$), fitness (cardiovascular endurance, muscular endurance) predicted an additional 46.1% variance in FF ability, with cardiovascular endurance accounting for 36.4% [$F\Delta = (1, 50) = 28.70; p < 0.001$] unique variance and muscular endurance accounting for an additional 9.7% [$F\Delta = (1, 49) = 8.88; p < 0.01$] unique variance. Push-ups and sit-ups did not account for any additional variance at Weeks 1 or 7.

Table 5.2

Correlations between Fitness and FF Ability at Week 1

Variable(s)	<i>Keiser Sled (s)</i>	<i>SCBA Crawl (s)</i>	<i>Victim Drag (s)</i>	<i>Hose Advance (s)</i>	<i>Equipment Carry (s)</i>	<i>Ladder Raise (s)</i>	<i>Total Challenge Completion Time (s)</i>
<i>Age (yrs)</i>	.003	.384**	.021	-.037	-.059	-.051	.207
<i>BMI</i>	-.025	.394**	.090	.040	.010	-.066	.216
<i>Estimated VO_{2Max} (ml·kg⁻¹·min⁻¹)</i>	-.226	-.586**	-.542**	-.403**	-.432**	-.064	-.587**
<i>Push-ups (reps)</i>	-.252	-.316*	-.266	-.262	-.099	-.237	-.344*
<i>Sit-ups (reps)</i>	-.105	-.280*	-.101	-.039	-.308*	-.115	-.320*
<i>Bench Press (reps)</i>	-.370**	-.287*	-.462**	-.349**	-.338**	-.314*	-.442**
<i>Sit and Reach (cm)</i>	-.180	-.200	-.046	-.070	.046	-.089	-.134
<i>Vertical Jump (in)</i>	-.253	-.179	-.284*	-.210	-.261	-.237	-.253

Note. * $p \leq 0.05$ level (2-tailed); ** $p \leq 0.01$ level (2-tailed)

Table 5.3
Correlations between Fitness and FF Ability at Week 7

Variable(s)	<i>Keiser Sled (s)</i>	<i>SCBA Crawl (s)</i>	<i>Victim Drag (s)</i>	<i>Hose Advance (s)</i>	<i>Equipment Carry (s)</i>	<i>Ladder Raise (s)</i>	<i>Total Challenge Completion Time (s)</i>
<i>Age (yrs)</i>	-.145	.068	-.057	.025	.062	-.038	-.013
<i>BMI</i>	-.138	.201	.021	-.228	.039	-.123	.045
<i>Estimated VO_{2Max} (ml·kg⁻¹·min⁻¹)</i>	-.255	-.573**	-.600**	-.182	-.548**	-.221	-.578**
<i>Push-ups (reps)</i>	-.171	-.218	-.278*	-.021	-.263	-.094	-.229
<i>Sit-ups (reps)</i>	-.149	-.245	-.168	-.062	-.274*	-.197	-.289*
<i>Bench Press (reps)</i>	-.375**	-.165	-.482**	-.475**	-.391**	-.414*	-.402**
<i>Sit and Reach (cm)</i>	-.010	-.153	.033	.206	.029	.217	.025
<i>Vertical Jump (in)</i>	-.186	-.034	-.287*	-.107	-.182	-.170	-.141

Note. * $p \leq 0.05$ level (2-tailed); ** $p \leq 0.01$ level (2-tailed)

Table 5.4
Week 1 Hierarchal Regression

<i>Model</i>	<i>R²</i>	<i>Adjusted R²</i>	<i>ΔR²</i>	<i>ΔF</i>	<i>p-value</i>
<i>Level 1: Age, BMI</i>	0.08	.04	0.08	2.17	≥ 0.05
<i>Level 2: Cardiovascular Endurance</i>	0.37	0.33	0.29	22.83	≤ 0.001
<i>Level 3: Muscular Endurance (Bench Press)</i>	0.48	0.44	0.11	10.34	≤ 0.01
<i>Level 4: Muscular Endurance (Sit-ups & Push-ups)</i>	0.48	0.42	0.004	0.18	≥ 0.05

Level 1: Predictors: BMI, Age

Level 2: Predictors: BMI, Age, Est-VO_{2max}

Level 3: Predictors: BMI, Age, Est-VO_{2max}, Bench press

Level 4: Predictors: BMI, Age, Est-VO_{2max}, Bench press, push-ups, sit-ups

Table 5.5
Week 7 Hierarchal Regression

<i>Model</i>	<i>R²</i>	<i>Adjusted R²</i>	<i>ΔR²</i>	<i>ΔF</i>	<i>p-value</i>
<i>Level 1: Age and BMI</i>	0.003	-0.04	0.003	0.065	≥ 0.05
<i>Level 2: Cardiovascular Endurance</i>	0.37	0.33	0.37	28.70	≤ 0.001
<i>Level 3: Muscular Endurance (Bench Press)</i>	0.46	0.42	0.097	8.88	≤ 0.01
<i>Level 4: Muscular Endurance (Sit-ups & Push-ups)</i>	0.47	0.40	0.005	0.23	≥ 0.05

Level 1: Predictors: BMI, Age

Level 2: Predictors: BMI, Age, Est-VO_{2max}

Level 3: Predictors: BMI, Age, Est-VO_{2max}, Bench press

Level 4: Predictors: BMI, Age, Est-VO_{2max}, Bench press, push-ups, sit-ups

An additional hierarchal regression (Table 5.6) was conducted to determine if ΔFF ability and Δfitness predicted unique variance in FF ability at Week 7. At Week 7, after accounting for age and BMI (<1% variance, $p > 0.05$), ΔFF ability and Δfitness accounted for 7.4% unique variance, albeit not significantly ($p = 0.16$). Fitness (cardiovascular endurance and muscular endurance) predicted an additional 45.1% variance in FF ability, with cardiovascular endurance accounting for 37.0% [$F\Delta = (1, 47) = 31.32; p < 0.001$] unique variance and muscular endurance (bench press) accounting for an additional 8.1% [$F\Delta = (1, 46) = 8.88; p < 0.01$] unique variance. Push-ups and sit-ups did not account for any additional significant variance.

Table 5.6

Week 7 Δ Fitness and Δ FF Ability Hierarchical Regression

<i>Model</i>	<i>R²</i>	<i>Adjusted R²</i>	<i>ΔR^2</i>	<i>ΔF</i>	<i>p-value</i>
<i>Level 1: Age and BMI</i>	0.002	-0.04	0.002	0.04	≥ 0.05
<i>Level2: ΔFitness and ΔFF Ability</i>	0.08	-0.002	.074	1.92	≥ 0.05
<i>Level 3: Cardiovascular Endurance</i>	0.45	0.39	0.37	31.32	≤ 0.001
<i>Level 4: Muscular Endurance (Bench Press)</i>	0.53	0.47	0.08	7.88	≤ 0.01
<i>Level 5: Muscular Endurance (Sit-ups & Push-ups)</i>	0.53	0.44	0.001	0.04	≥ 0.05

Level 1: Predictors: BMI, Age

Level 2: Predictors: Δ Fitness and Δ FF Ability

Level 2: Predictors: BMI, Age, Δ Fitness and Δ FF Ability, Est-VO_{2max}

Level 3: Predictors: BMI, Age, Δ Fitness and Δ FF Ability, Est-VO_{2max}, Bench press

Level 4: Predictors: BMI, Age, Δ Fitness and Δ FF Ability, Est-VO_{2max}, Bench press, push-ups, sit-ups

Discussion

The present study sought to determine to the extent to which ability to perform during a physical ability challenge test (i.e., Academy Firefighter Challenge, AFC) was influenced by various components of physical fitness. We hypothesized that FF recruits who possessed greater levels of physical fitness would perform better on the AFC. We also sought to explore the extent to which each component of fitness predicted performance on the AFC and determine if Δ fitness and Δ FF ability predicted Week 7 AFC performance. Our results revealed that better physical fitness was associated with better performance on the AFC. Specifically, at Week 1 cardiovascular endurance (i.e., estimated aerobic capacity based on 1.5 mi run time) and muscular endurance (i.e., bench press repetitions, push-ups, and sit-ups) were significantly correlated with FF ability assessed via the AFC. Nearly identical patterns emerged at Week 7.

Additionally, our results revealed that these components of fitness accounted for 36.1% and 46.1% total variance in FF ability at Week 1 and Week 7, respectively. Specifically, cardiovascular endurance accounted for the majority of this variance (~23%, ~36%) and muscular endurance accounted for the remainder of the explained variance (~10%) at Week 1 and Week 7, respectively. Contrary to our hypothesis, lower body power and flexibility were not significantly associated with better performance on the AFC. Additionally, we found that Δ FF ability and Δ fitness accounted for a small amount of unique variance on Week 7 FF ability, but not significantly. These findings support previous research that highlights the importance of physical fitness on the ability to perform firefighting tasks efficiently, as indexed by faster completion of the various tasks of the AFC in those with greater aerobic capacity and muscular endurance.

Firefighting is one of the most physically demanding professions an individual can undertake. When engaged in fire-ground activities, while wearing heavy and cumbersome personal protective equipment, a significant burden can be placed on the cardiovascular system (Abel, Mortara, & Pettitt, 2011; Kales et al., 1999; Lindberg, Oksa, Gavhed, & Malm, 2013; Smith, 2011; Staley et al., 2011). In addition to cardiovascular strain, fire-ground activities (e.g., forcible entry, hose hoist, search/rescue, ceiling overhaul) can require varying degrees of muscular endurance, strength and power. It is clear that firefighting requires at least a satisfactory level of overall fitness, rather than relying primarily on only one component (e.g., aerobic capacity). This is one of the first studies to explore which components of physical fitness (i.e., cardiovascular endurance, muscular endurance, flexibility, and power) are linked to better performance outcomes on firefighting tasks assessed via the AFC.

Cardiovascular endurance (estimated VO_{2max}) and muscular endurance (bench press repetitions) were significantly related to overall AFC completion time, as well as many of the specific skills assessed (i.e., Keiser[®] sled, SCBA crawl, victim drag, hose advance, equipment carry, and ladder raise). These findings support the idea that sufficient fitness is needed to efficiently perform firefighting specific tasks (Kesler et al., 2017; Poston, Haddock, Jahnke, & Jitnarin, 2011; Smith, 2011; Staley et al., 2011). These findings also provide new and relevant evidence that highlight which specific aspects of fitness are needed for overall FF ability, as well as for the varied, specific tasks performed on the fire ground.

Recently, research found that FFs who possessed lower levels of fitness were less likely to be able to complete two successive bouts of simulated firefighting work cycles (Kesler et al., 2017). Participants were 30 FFs (29 males, 1 female; average age= 30.4 ± 1.5 yrs; BMI= 27.4 ± 0.7 kg/m²; average VO_{2max} = 43.7 ± 1.3 ml·kg⁻¹·min⁻¹). The participants engaged in 3 conditions: (1) one bout of FF tasks in an environmental chamber; (2) two bouts of FF tasks with rest outside the chamber; and (3) back-to-back bouts in the environmental chamber. Eleven of the 30 subjects failed to complete at least one of the two-bout activities because they felt too tired, too hot, too nauseous, or felt unsafe. These participants had lower levels of fitness, were heavier, and had higher BMIs than the 19 participants who successfully completed all work cycles (Kesler et al., 2017). Our results support these findings and found that individuals who were more physically fit had better performance outcomes on the AFC. Specifically, Kesler et al. found that greater aerobic capacity was associated with more successful performance on simulated FF tasks and our results revealed greater aerobic capacity was associated with faster completion time on the AFC at Weeks 1 and 7. Our findings expand upon this research as we found that greater muscular endurance was also significantly associated with faster completion

time on the AFC. Combined, these findings suggest that individuals who are more physically fit are more capable of performing firefighting tasks when compared to their less fit-peers.

Our AFC was designed to be model the Candidate Physical Ability Test (CPAT), a well-established and verified means of assessing FF ability. The CPAT test includes a stair mill climb, ladder raise and extension, forcible entry, search, rescue, and ceiling breach and pull. Sheaff et al. (2010) examined the relationship between fitness and performance on the CPAT in 33 career and volunteer FFs. Their aerobic capacity (absolute VO_2), anaerobic fitness (Wingate anaerobic cycling test), and FF ability (CPAT) were assessed, with the results indicating that anaerobic and cardiovascular fitness were the best predictors of overall CPAT performance. Additionally, 57 (23 females) FFs attempted the CPAT and only 91% of males and 15% of females were able to successfully complete the CPAT under the criterion time (10 min 20 sec; Williams-Bell, Villar, Sharratt, & Hughson, 2009). It was shown that relative VO_2 , body mass, and handgrip strength accounted for 67% of variance on CPAT performance. Both of these studies indicate that fitness is correlated to better performance on FF tasks, with cardiovascular endurance being a strong indicator of performance (Sheaff et al., 2010; Williams-Bell et al., 2009). Similar to these studies, our results revealed that fitness accounted for significant variance on AFC performance. Specifically, cardiovascular endurance was significantly correlated to better performance on the AFC and accounted for a larger amount of significant variance (~23-36%) on AFC performance than muscular endurance (~10%). Taken together, these previous and present findings suggest that greater cardiovascular endurance is strongly associated with performance on FF-specific tasks. Given the strong association between fitness and FF performance, municipal departments should focus on increasing the current physical fitness levels of FFs to improve job performance.

Additionally, a recent study looked at the association between muscular endurance (push-up capacity) and the likelihood of future cardiovascular events in 1,104 male FFs (39.6±9.2 yrs, BMI= 28.7±4.3; Yang et al., 2019). Thirty-seven cardiac incidents occurred during the 10-year follow up. Significant negative associations were found between push-up capacity and the cardiac incidents. The FFs who were able to perform ≥ 40 push-ups were at a significantly lower risk of experiencing a cardiac incident compared to their less fit counterparts (Yang et al., 2019). While the present study did not assess cardiac risk, the findings showed that physical fitness accounted for 36-48% of the time it took to complete the simulated FF skills and drills encapsulated in the AFC. After accounting for cardiovascular endurance, muscular endurance (assessed via bench press) still accounted for significant variance on FF ability. Our findings suggest that upper body muscular endurance is associated with better performance on FF tasks. These findings highlight the need for adequate levels of multiple components of physical fitness in FFs in order to potentially increase the ability to perform fire-ground tasks. An additional benefit of such increased fitness would be the reduced likelihood of line of duty deaths due to cardiac incidents caused by overexertion as seen in the findings of Yang et al. Adequate fitness levels are needed to perform FF specific tasks. Fitness may also act as buffer against, or a preventative measure for reducing, the risk of experiencing a sudden cardiac event during fire-ground activities.

Lastly, we examined whether a change in FF ability or the change in fitness was associated with FF ability at Week 7. Neither the amount of improvement in fitness nor the amount of overall change in performance predicted any significant variance in performance on the AFC at Week 7. It is plausible that these variables did not predict significant variance due to how FF ability was assessed (i.e., completion time on the AFC). At Week 1 the recruits were

novice and were not given the opportunity to practice the skills that are associated with the AFC. By Week 7 they were familiar with the skills and had already had the opportunity to complete the course, which familiarized them with the tasks and how the AFC was set-up. It is plausible that because of this, the amount of change in FF ability and fitness was not predictive of Week 7 AFC performance. Perhaps examining changes in fitness in established career FFs and its relationship to performance on FF performance would reveal greater variance given that career FFs are already familiar with the tasks associated with FF.

Despite not seeing a relationship between changes in FF ability or fitness and performance on the AFC at Week 7, given what we know from previous findings (i.e., better physical fitness is associated with performance on simulated fire-ground tasks), improving physical fitness is important for individuals who lack adequate levels of physical fitness (Dennison et al., 2012; Kesler et al., 2017). For example, Dennison et al. examined performance on a simulated fire-ground test (SFGT) in 12 trained (VO_2 peak = 45.6 ± 3.3 ml·kg⁻¹·min⁻¹) and 37 untrained FFs (VO_2 peak = 40.2 ± 5.2 ml·kg⁻¹·min⁻¹) FFs. They found that 81% of the trained FFs had faster completion times on the SFGT compared to the untrained FFs. Further, when the trained FFs performed the SFGT immediately following an exercise session, 70% of the trained FFs completed the SFGT faster than the untrained FFs (Dennison et al., 2012). These findings suggest that not only is physical fitness associated better performance on fire-ground tasks, but it may also act as a buffer against fatigue and improve recovery time following physically demanding tasks.

While change in FF ability and change in fitness did not predict performance on the Academy Firefighter Challenge at Week 7, fitness at Week 1 was significantly related to performance on the Academy Firefighter Challenge. Specifically, Week 1 cardiovascular

endurance (i.e., estimated VO_{2max}) and muscular endurance (YMCA Bench Press score) was moderately associated with AFC (i.e., completion time) at Week 7. This suggests that FFs who possess higher baseline levels of physical fitness are more likely to perform better on fire-ground activities currently as well as in the future. While significant improvements in physical fitness were seen during the Academy, the baseline levels of fitness were more predictive of Week 7 FF ability. This highlights the need for adequate levels of fitness entering the fire service and also the importance of maintaining sufficient levels of fitness during their careers.

Previous work has highlighted the importance of cardiovascular fitness and its association with reduced risks of experiencing a cardiac incident in FFs. Specifically, FFs who possess higher levels of physical fitness are less likely to experience a sudden cardiac incident while on-duty (Poplin et al., 2016; Smith, 2011; Yang et al., 2013, Yang et al., 2019). While our study did not assess cardiac incidents, given what we know about the relationships between physical fitness and FF ability and physical fitness and risk of experiencing a cardiac incident, there may potentially be a link between FF ability and risk of experiencing a cardiac incident, with physical fitness potentially acting as a moderator.

Limitations/Future Research

The largest limitation of the present study was the lack of control or comparison group. Participants simultaneously participated in a 7-week HIFT program while also being enrolled in a Basic Firefighter Academy. The lack of control makes it difficult to determine if the changes in fitness and FF ability that occurred from Week 1 to Week 7 were due the HIFT program, were a result of the training tasks the FFs engaged in on the fire-ground as part of the Academy, or some combination of both. This may also be a potential explanation for why changes in FF ability and fitness did not predict significant variance on overall AFC performance at Week 7.

The recruits were practicing the skills and drills seen during AFC on a regular basis during their time in the Academy, and this may explain why the degree of improvement in fitness did not predict Week 7 AFC completion time.

Due to the well-known positive benefits of physical activity and exercise, to some extent it may be unethical to deny a fitness intervention to recruit FFs. Researchers could use a split-group design during the Academy where half the group participates in HIFT and the other half receives an educational wellness program for the first 3-4 weeks; the groups would then switch. Another potential solution for this problem is to assess the relationship between physical fitness and FF ability in career FFs not going through Academy. Researchers could observe whether changes in fitness during an exercise program are associated with FF performance in current career FFs. Additionally, we did not have a measure of muscular strength. Given that many of the tasks performed on the fire-ground (e.g., equipment carry, ladder raise, hose hoist, etc.) require a degree of muscular strength to perform, future research should incorporate a measure of muscular strength in order to further understand the extent to which this aspect of fitness is associated with performance on the fire-ground.

Another potential limitation of the present study is that we did not control for nutrition, hydration status, and past work experience (e.g., manual labor, military experience, construction etc.). All three of these factors (i.e., nutrition, hydration, experience) may account for variance in FF ability and could allow researchers to better understand what contributes to enhanced FF ability. Poor nutrition and hydration have been linked to poor physical health and are often associated with decrements in physical performance (Boyd, Rogers, Docherty, & Petersen, 2015; Goheer, Bailey, Gittelsohn, & Pollack, 2014; Moe et al., 2002). Additionally, individuals who have experience in professions that require manual labor or who engage in physically demanding

tasks (e.g., chopping, hammer or axe swinging, equipment carry, push and pull movements, etc.) may be more inclined to perform better on fire ground activities due to the similarities in required tasks.

An additional limitation of this study was the lack of females in our sample. Given that only $\leq 5\%$ of the fire service is made up of females it is often challenging to get a large enough female cohort to study in regard to fire service research. Additionally, our sample was a relatively young (26.8 ± 4.2 yrs) and unfit sample. Nearly 78% of our sample was considered overweight or obese based on BMI, and $\sim 65\%$ were classified as having “poor” or “very poor” aerobic fitness as determined the American College of Sport Medicine Cardiorespiratory Fitness Classifications. Perhaps examining a more varied sample would shed more light onto the relationship between physical fitness and FF ability.

Studying recruit FFs and examining the relationship between physical fitness and FF ability is important and allows novice FFs to better understand the importance of physical fitness as they embark on their fire service careers. However, future research should examine the relationship between fitness and FF ability in a more unique FF sample (i.e., non-recruit FFs). Previous research has suggested that as FFs age they are at an increased risk of experiencing a sudden cardiac incident (Staley et al., 2011; Walker, Driller, Argus, Cooke, & Rattray, 2014; Yang et al., 2013). Thus, examining the relationship between fitness and FF ability in older career FFs is potentially equally as important as studying this relationship in young and relatively healthy recruit FFs. Additionally, future research should examine whether performance on simulated fire-ground tasks is associated with risk of experiencing a sudden a cardiac incident. It is known that physical fitness is associated with better performance on simulated fire-ground activities, and poor physical fitness is associated with an increased risk of experiencing a sudden

cardiac incident. There may also be a relationship between fire-ground performance and risk of experiencing a sudden cardiac incident.

While the present study assessed FF ability via performance time on the AFC, we did not assess the technique and form executed during the AFC. Proper technique and form during fire-ground activities is important for safe firefighting and can reduce the risk of experiencing injury during demanding tasks. Examining whether physical fitness is associated with proper form and technique during simulated fire-ground activities would be a potentially interesting venue of research. Such research can shed light on the impact physical fitness has on efficiency and safety during FF specific tasks.

Conclusions

The present study provides evidence that multiple components of physical fitness are associated with better (i.e., faster) performance on simulated fire ground activities. The findings suggest that cardiovascular endurance and muscular endurance are the most important components for completing such tasks quickly. This information could be used by municipal departments, physicians, researchers, and exercise specialists to develop physical fitness standards and codes of conduct in the fire service. Additionally, this information could be used to better prescribe exercise to FFs. By prescribing safe, effective, and relevant exercise, municipal departments can create healthier, safer, and more efficient FFs.

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CHAPTER 6: PERSONALITY, FITNESS, AND FIREFIGHTER ABILITY

Abstract

Currently, many firefighters fail to maintain adequate levels of physical fitness, which often leads to unsafe and inefficient firefighting. Understanding what contributes to exercise behaviors and patterns could be beneficial in identifying which individuals are more or less likely to engage in physical activity or exercise behavior. The purpose of this project was to examine the relationship between selected personality variables (i.e., exercise intensity preference and tolerance, extraversion), physical fitness (cardiovascular and muscular endurance), and firefighter ability. Male recruit firefighters ($N= 45$, age= 26.4 ± 4.2 yrs, weight= 88.41 ± 17.18 kg, estimated $VO_{2max}= 41.30\pm 5.33$ ml·kg⁻¹·min⁻¹) were enrolled in a Basic Firefighter Academy training course in the Midwest. Physical fitness (cardiovascular and muscular endurance) and firefighter ability (a series of firefighter specific tasks) were assessed at Week 1 and Week 7 of the Academy. Measures of individual differences (exercise intensity preference, exercise intensity tolerance, extraversion) were collected during Week 1 of the Academy. Personality, specifically Intensity Preference, was significantly and directly related to physical fitness and physical fitness was significantly and directly related to firefighter ability. Preference predicted significant variance in firefighter ability; however, physical fitness mediated the relationship in this sample. The present study suggests that firefighters' exercise intensity preference influences ability to complete a physical performance test, but this relationship is mediated by level of physical fitness. Higher levels of exercise intensity preference are associated with higher levels of physical fitness, which is associated with better (i.e., faster) performance on firefighter specific tasks.

Introduction

Firefighters (FFs) are required to engage in physically demanding tasks on a regular basis. These tasks require a battery of physical skills and having adequate levels of physical fitness facilitates better performance on fire-ground activities (Dennison et al., 2012; Kesler et al., 2017; Sheaff et al., 2010; Williams-Bell et al., 2008). Despite the demands of firefighting, the men and women who choose this as their profession often fail to maintain sufficient levels of physical fitness and lead relatively inactive lives (Abel et al., 2011, 2015; Beach, Frost, McGill, & Callaghan, 2014; Lindberg et al., 2013; Scanlon & Ablah, 2008; Smith, 2011). Previous findings suggest that greater levels of physical fitness are associated with better performance on simulated fire-ground tasks (Dennison et al., 2012; Kesler et al., 2017; Williams-Bell et al., 2009). Nearly 75% of FFs are classified as overweight or obese, and this often leads to on-duty injuries and shortened careers (Anderson et al., 2016; Poston, Jitnarin, et al., 2011; Wilkinson et al., 2014). Furthermore, FFs who have poor physical health are more likely to experience injury and file worker's compensation claims compared to their more fit peers (Anderson et al., 2016; Kales et al., 1999). Firefighters who possess higher levels of physical fitness are often more physically capable of performing routine fire-ground activities (Butler et al., 2013; Dennison et al., 2012; Kesler et al., 2017; Pawlak et al., 2015).

The National Fire Protection Association (NFPA) has recognized the importance of physical fitness and has stated that "implementing a fitness program will promote the member's ability to perform occupational activities with vigor and to demonstrate the traits and capacities normally associated with a low risk of development of injury, morbidity, and mortality" (NFPA 1583). The NFPA has reported that only 30% of fire departments met have successfully implemented programs that meet the outlined requirements in NFPA 1582 and NFPA 1853.

Despite the NFPA suggestions of using fitness as means of improving job performance, it is alarming that there is a current mismatch in the demands of firefighting and current physical fitness levels in the fire service. Perhaps a better understanding of the antecedents of physical activity and exercise behavior can shed light as to why individuals remain inactive despite the well-known benefits of regular exercise. Understanding why an individual is more or less inclined to engage in a regular exercise regimen is perhaps as important as the activity itself. Exploring what influences physical activity and exercise behavior in first responders may help in creating strategies and programs that could lead to involvement in regular exercise and the resultant increases in physical fitness that accrue from such activity.

There is very limited research that has examined the relationship between psychological factors (e.g., personality), physical activity, and physical fitness within a FF sample. Personality may be a useful tool when prescribing exercise to this population. Being able to predict an individual's likelihood to engage in and enjoy physical activity or exercise could prove beneficial for several reasons, including better prescription of exercise, increases in exercise adherence, increases in positive affective responses, and increased enjoyment before, during, and after exercise as well (Ekkekakis et al., 2005; Ekkekakis, Parfitt, & Petruzzello, 2011; Ekkekakis, Thome, Petruzzello, & Hall, 2008). While prescribing exercise and achieving adherence is challenging in all populations, it is particularly important in FFs as better levels of fitness are beneficial in performing the work they do.

Preference for and tolerance of exercise intensity has previously been used to predict exercise behavior (Hall, Petruzzello, Ekkekakis, Miller, & Bixby, 2014). Exercise intensity preference has been defined as an individual's predisposition to select a particular exercise intensity when given the opportunity. Exercise intensity tolerance has been defined as a trait that

influences the decision to continue exercising at levels of intensity associated with discomfort or displeasure (Ekkekakis et al., 2005). Knowing and understanding what type and intensity of exercise an individual prefers and can tolerate has been shown to be beneficial in increasing positive affective responses to exercise, that is in maximizing the pleasantness or minimizing the unpleasantness of the exercise experience (Ekkekakis et al., 2005). These relatively more pleasant affective experiences have been shown to lead to increased adherence rates (e.g., Rhodes & Kates, 2015; Williams et al., 2008). Being able to increase exercise adherence rates can lead to more fit and healthier FFs. Increases in physical fitness may potentially lead to reductions in injuries and on-duty deaths as well. Thus, exploring the extent to which personality factors are associated with physical activity behavior may prove beneficial in predicting physical activity patterns and fitness in FFs.

In addition to exercise intensity preference and tolerance, other aspects of an individual's personality may provide insight into their exercise habits. Extraversion has consistently been shown to be associated with physical activity habits (De Moor et al., 2006; Ingledew et al., 2004; Salters-Pedneault et al., 2010; Szabo, 1992). Individuals with higher levels of extraversion tend to engage in higher levels of exercise and physical activity (i.e., greater intensity, duration, frequency) when compared to those with lower levels of extraversion. Significantly higher levels of extraversion have been shown in FFs in comparison to non-rescue workers (Meadows, Shreffler, Mullins-Sweat, 2011; Wagner, Fraess-Phillips, & Mikkelson, 2016; Wagner, Martin, & McFee, 2009). Despite these higher levels of extraversion, FFs tend to lead inactive lifestyles (Poston et al., 2011). One possible explanation as to why we see high levels of extraversion yet low levels of activity in FFs is that, given the unpredictable nature of their occupation, FFs may seek sensation or simulation more than less extraverted individuals (Salters-Pedneault et al.,

2010). Extraversion is a personality trait that is made up several facets, two of which are activity level and excitement seeking. Thus, if an individual scores high on excitement seeking, they may score high on extraversion but report low levels of activity. Minimal research has explored the role personality plays in fitness in FFs. By examining the relationship of individual differences and fitness, the present study has the potential to establish or highlight specific individual differences that can foster fit, healthier FFs.

Given that fitness has shown to be associated with FF ability and that personality has been associated with physical activity and fitness, there may also be an association between personality and FF ability. The present study is one of the first to explore what impact personality factors may have on physical fitness and FF ability. The aim of the present study was to examine the extent to which personality traits, specifically exercise intensity preference and tolerance along with extraversion influence physical fitness and FF ability. Specifically, it was hypothesized that individuals who possess higher levels of preference for and tolerance of exercise intensity would have greater levels of physical fitness and better ability to complete FF-specific tasks. Additionally, it was hypothesized that individuals with higher levels of extraversion would also be more physically fit and demonstrate better FF ability compared to those with less extraversion.

Methods

Participants

The present study was approved by the university Institutional Review Board. Participants were FF recruits enrolled in a Basic Firefighter Academy in the Midwest. Data were collected in Spring and Fall of 2018 during a 7-week Academy from newly hired male FFs ($N=45$). The recruits were given a brief overview of the research study and any potential benefits

and risks associated with their participation in the study were described. They then read and signed an informed consent document approved by the institutional review board. See Table 6.1 for descriptive data.

Table 6.1

Participant Descriptive Data

	Week 1	Week 7
Age (yrs)	26.4 ± 4.2	--
Body Mass (Kg)	88.41 ± 17.18	87.43±15.86
Height (cm)	177.67 ± 7.19	--
BMI	27.92 ± 4.62	27.64±5.15
Estimated VO_{2max} (ml·kg⁻¹·min⁻¹)	41.30 ± 5.33	44.36±5.97
<i>Very Poor*</i>	9%	7%
<i>Poor*</i>	53%	40%
<i>Fair*</i>	31%	29%
<i>Good*</i>	7%	20%
<i>Excellent*</i>	--	4%

Note. †Estimated VO_{2max}; *ACSM Cardiorespiratory Fitness Classifications

Measures

Measures of physical fitness and FF ability were taken at Week 1 and Week 7 of the 7-week training course. These measures were assessed over the course of 3 days each week.

Personality measures were obtained only during Week 1 of the Academy. All measures are described in detail below.

Physical Fitness Measures

Day 1. The recruits completed two muscular endurance tests (60-seconds of sit-ups and

60-seconds of push-ups), with the number of completed repetitions used as the dependent measure. The recruits also completed a measure of cardiovascular endurance. This was a timed outdoor run on a course designed to be 1.5 miles in length. Estimated aerobic capacity was determined using the formula: $(3.5 + (483 \cdot 1.5\text{-mi run time}^{-1}))$; American College of Sport Medicine, 2000; Cooper, 1968). Adequate rest time was given between tests to avoid muscular fatigue.

Day 2. Weight (body mass, in kg) and height (in cm, both without shoes) were recorded using a Seca 284 digital scale. Body Mass Index was calculated using the formula ($\text{kg} \cdot \text{m}^{-2}$; American College of Sport Medicine, 2000). The YMCA bench press (using 80 lbs of weight, including the weight of the barbell) protocol was followed (Golding et al., 1989). Hamstring and lower back (trunk) flexibility was assessed using a sit and reach box. The participants were all assessed on lower body power via vertical jump using the Jump USA Vertec Vertical Jump System.

Day 3. Firefighter ability was assessed at Week 1 and Week 7 via the Academy Firefighter Challenge (AFC). The AFC is a six-event physical performance test used to assess cardiorespiratory fitness and muscular endurance. The AFC consisted of the following events: Keiser® Sled, Crawl, Victim Drag, Hose Advance, Equipment Carry, and Ladder Raise and extension. An ExPPL research staff member recorded the time to complete each event and the overall time, while also directing the FF between stations. During the AFC, the FFs wore full turnout gear including: helmet, bunker pants, bunker coat, boots, gloves, and SCBA equipment.

Individual Difference Questionnaires

During the session on Day 1, the participants were given a battery of questionnaires assessing individual difference measures and were instructed to return the packet the following

day.

International Personality Item Pool (IPIP). This is a 50-item questionnaire which uses a 5-point Likert scale (1 = very inaccurate; 2 = moderately inaccurate, 3 = neither inaccurate nor accurate; 4 = moderately accurate, 5 = very accurate) to assess individual differences (Goldberg et al., 2006). Specifically, each of the Big 5 personality factors (Extraversion, Emotional Stability, Conscientiousness, Agreeableness, and Intellect/Imagination) were assessed with the IPIP, each being derived from 10 of the 50 items.

Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q). The PRETIE-Q (Ekkekakis et al., 2005) is a 16-item questionnaire designed to discern an individual's preference for (8 items) and tolerance of (8 items) exercise intensity. Participants responded, using a 5-point Likert scale ranging from 1 (I totally disagree) to 5 (I totally agree), to items designed to reflect preference for high and low intensity exercise and tolerance of high and low intensity exercise.

Statistical Analysis

Personality constructs (extraversion, Intensity-Preference, Intensity-Tolerance) were derived from the individual questionnaire items. Pearson's r was used to examine bivariate relationships between the various components of fitness, personality, and FF ability. Additionally, a multiple linear regression was used to account for variability in FF ability from fitness. Separate linear regressions were used to test a mediation analysis. A mediation analysis was deemed appropriate to use because the following four requirements were met, suggesting a mediation occurred (Tyron, 2018). First, the predictor (personality) must be associated with the outcome (FF ability; path c). Second, the predictor must be associated with the hypothesized mediating variable (fitness; path a). Third, the hypothesized mediator must be associated with

the outcome variable (path b). Lastly, the proposed predictor must have substantially diminished effects on the outcome variable (path c') following the inclusion of a mediating variable into the model. In meeting the above outlined requirements, a mediation model was used to determine the effect of the mediator. Statistical analyses were conducted using SPSS 24.0 for Windows (SPSS, Chicago, IL). A significance level of $\alpha < 0.05$ was chosen to denote statistical significance.

Results

Personality, Fitness and Firefighter Ability

Exercise-intensity Preference was the only personality factor related to fitness (cardiovascular and muscular endurance) and FF ability at both baseline (Week 1) and post testing (Week 7; See Table 6.2 for all correlation analyses). Exercise-intensity Preference was significantly related to cardiovascular endurance at Week 1 ($r=.344$) and Week 7 ($r=.316$). Additionally, Preference was significantly related to muscular endurance ($r=.327$; $r=.304$) at both time points as well. Lastly, Preference was significantly related to FF ability at Week 1 ($r=-.296$) and Week 7 ($r=-.330$). Simple linear regressions revealed exercise-intensity preference predicted significant variance at Week 1 and Week 7 in cardiovascular endurance ($F\Delta (43, 1)= 5.78, \beta= .344$; $F\Delta (43, 1)= 4.75, \beta= .316$), muscular endurance ($F\Delta (43, 1)= 5.16, \beta= .327$; $F\Delta (43, 1)= 4.37, \beta= .304$) and FF ability ($F\Delta (43, 1)= 4.14, \beta= -.296$; $F\Delta (43, 1)= 5.25, \beta= -.330$), respectively. See Table 6.2 below for details.

Table 6.2

Correlations Between Personality, Physical Fitness, and Firefighter Ability

	<i>Mean±SD</i>	<i>Alpha Based on Standardi zed items</i>	E	Pref	Tol	CV Endurance Pre	Muscular Endurance Pre	Firefighter Ability Pre	CV Endurance Post	Muscular Endurance Post	Firefighter Ability Post
E	50.44±5.72	.669	1	-.038	.334*	.139	-.296	-.186	.096	-.354*	-.184
Pref	26.56±6.23	.895		1	.541**	.344*	.327*	-.296*	.316*	.304*	-.330*
Tol	27.44±5.43	.827			1	.233	.118	-.176	.227	.048	-.135
CV Endurance Pre	41.30±5.33					1	.267	-.646**	.891**	.198	-.604**
Muscular Endurance Pre	28.24±11.99						1	-.437**	.200	.858**	-.434**
Firefighter Ability Pre	247.74±41.67							1	-.656**	-.388**	.881**
CV Endurance Post	44.36±5.97								1	.149	-.651**
Muscular Endurance Post	33.53±11.95									1	-.365*
Firefighter Ability Post	217.27±40.17										1

Note. * $p \leq 0.05$ level (2-tailed); ** $p \leq 0.01$ level (2-tailed). E= Extraversion, Pref= Preference, Tol= Tolerance, CV= Cardiovascular

Mediation Model

Week 1 (See Figure 6.1).

Separate simple linear regressions revealed significant associations for exercise intensity preference and fitness (cardiovascular and muscular endurance) (**path a**, $R^2 = .112$, $R^2 = .107$), fitness (cardiovascular and muscular endurance) and FF ability (**path b**, $R^2 = .417$, $R^2 = .191$), and exercise intensity preference and FF ability (**path c**, $R^2 = .088$), meeting the mediating relationship requirements. When cardiovascular endurance and muscular endurance were separately applied as mediating variables, the impact of the association between preference and FF ability (**path c'**) was reduced (beta weight decline of 21.2% and 12.5%, respectively) and was no longer a significant factor ($p = .505$, $p = .242$).

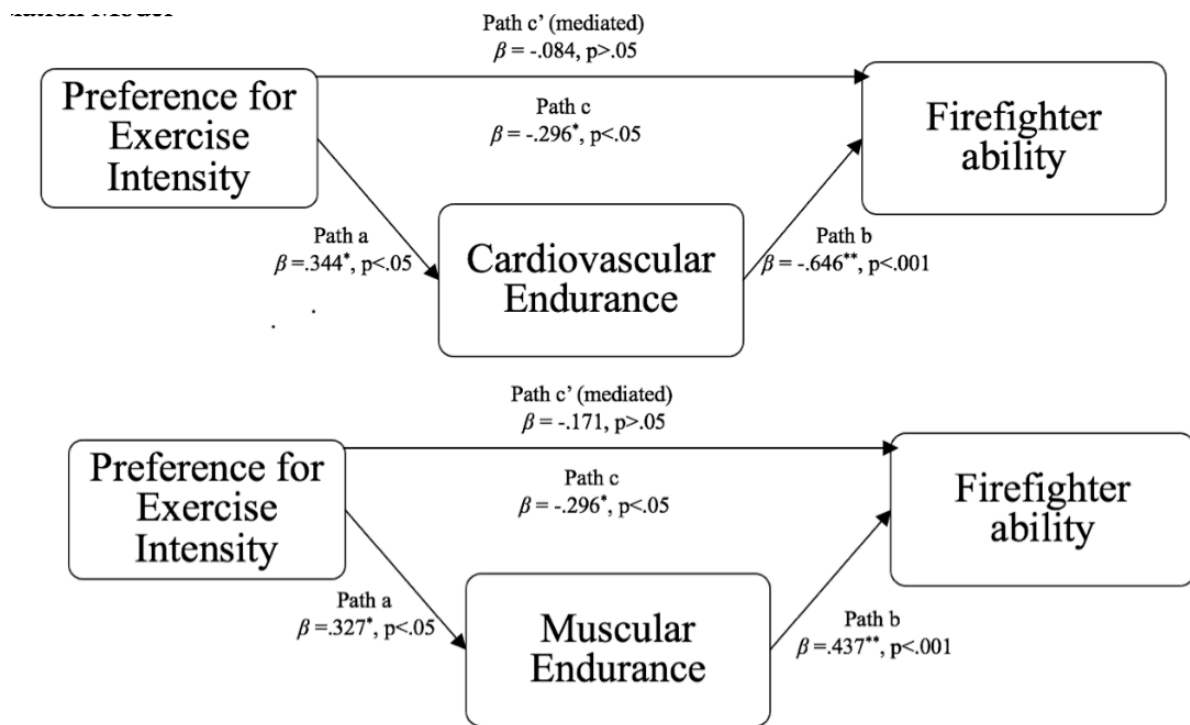


Figure 6.1. The relationship between personality, physical fitness (cardiovascular and muscular), and FF ability at Week 1

Week 7 (See Figure 6.2).

Separate simple linear regressions revealed significant associations for exercise intensity preference and fitness (cardiovascular and muscular) (**path a**, $R^2 = .100$, $R^2 = .092$), fitness (cardiovascular and muscular) and FF ability (**path b**, $R^2 = .423$, $R^2 = .133$), and preference and FF ability (**path c**, $R^2 = .109$), meeting the mediating relationship requirements. When fitness (cardiovascular and muscular endurance) were separately applied as mediating variables, the impact of association between preference and FF ability (**path c'**) was reduced (beta weight decline of 19.2% and 8.9%, respectively) and was no longer a significant factor ($p = .262$, $p = .106$).

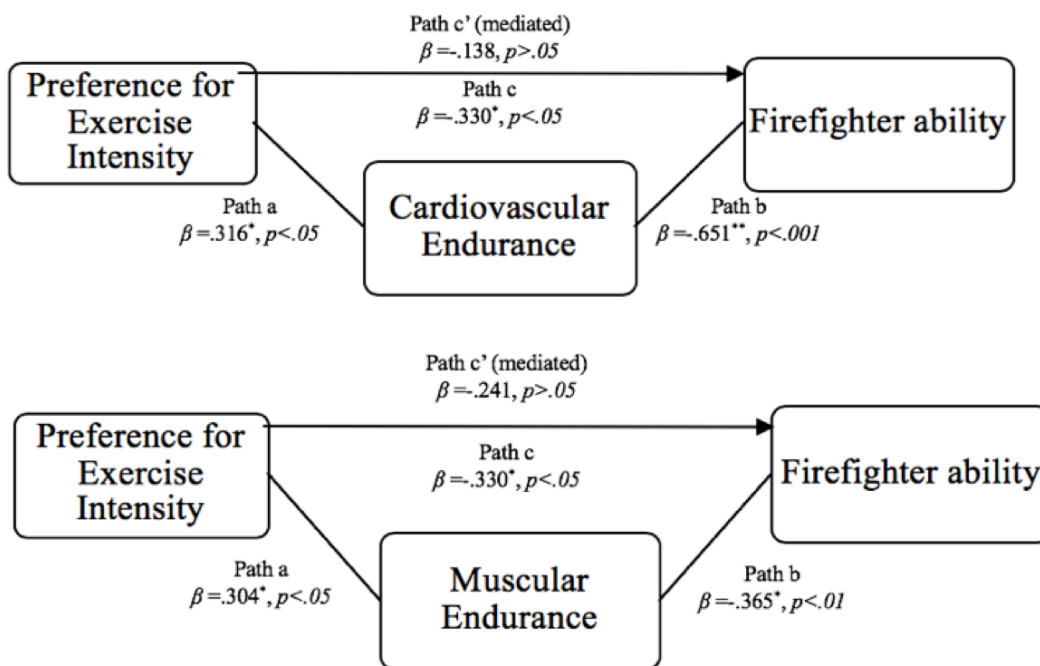


Figure 6.2. The relationship between personality, physical fitness (cardiovascular and muscular), and firefighter ability at Week 7.

Discussion

The purpose of this study was to explore relationships between personality and physical fitness, and personality and firefighting ability in FF recruits. Our hypothesis, which predicted that preference for exercise intensity would be related to both physical fitness and FF ability, was supported with our findings. Exercise intensity preference was directly related to physical fitness and physical fitness was directly related to FF ability. Additionally, preference was indirectly related to FF ability. Using a mediation model, our findings suggest physical fitness acts as a mediator between exercise-intensity preference and FF ability. Contrary to our hypotheses, exercise intensity tolerance and extraversion were not related to either physical fitness or FF ability. Firefighting is a challenging occupation for which high levels of physical fitness are likely to be advantageous. Being able to screen individuals to better understand if or why they choose to engage in or avoid physical activity could potentially allow municipal departments to better prescribe and provide exercise initiatives to FFs.

Physical Fitness and Personality

Our findings support previous research which has shown exercise intensity preference to be a predictor of physical fitness. Hall et al. (2014) had 516 (women $n=327$, men $n=189$) college aged participants take part in a battery of physical fitness testing (handgrip strength, push-ups, sit-ups, estimated VO_{2max} , sit-and-reach, body fat, and self-reported physical activity. After controlling for age and BMI, exercise intensity preference exhibited significant correlations with almost all fitness variables, body composition, and physical activity. These findings suggest that individuals who preferred higher intensity exercise were more physically fit and engaged in more physical activity compared to their lower preference peers (Hall et al., 2014). Furthermore, 42 male FF recruits had their physical fitness assessed during the first and last week of a 6-week

basic FF academy. Results revealed that exercise intensity preference was significantly related to muscular endurance (# of sit-ups completed in 60 s) and cardiovascular endurance (1.5-mile run time) during the first week, but not during the last week (Hall et al., 2014). Our findings further support this, showing that exercise intensity preference is related to greater physical fitness. Using preference as a screening tool may help identify individuals who are less likely to engage in physical activity and also to possess lower levels of physical fitness.

Currently, nearly 75% of FFs are classified as overweight or obese (Kuehl et al., 2012). Additionally, despite the physical nature of most fire-ground activities, there is a mismatch in the demands of such tasks and fitness levels in FFs (Butler et al., 2013; Kales et al., 2003; Kesler et al., 2017; Patterson et al., 2016; Smith, 2011). Given that poor physical fitness is associated with increased risk of injury and cardiac incident, along with lower levels of worksite productivity, it is essential to increase fitness levels in FFs (Dennison et al., 2012; Wilkinson et al., 2014). Fitness testing and screening can often be time consuming and not cost effective. One potential solution to this problem is using personality, specifically exercise intensity preference, to identify those individuals who are more or less likely to engage in physical activity and who possess less than adequate levels of physical fitness. Preference has been linked to greater fitness levels and higher levels of self-reported physical fitness, thus could be a useful tool for screening FFs (Hall et al., 2014).

Personality, Fitness, and Firefighter Ability

The present study was one of the first studies to examine the relationship between personality and FF ability. Our findings suggested personality directly impacts fitness, fitness directly impacts FF ability, and personality indirectly impacts FF ability with physical fitness acting as a mediator in this relationship. Previous findings have found that greater levels of

physical fitness are correlated with better performance on FF-specific tasks. In one such study, 30 FFs were asked to complete two cycles of simulated firefighting drills in an environmental chamber while wearing full turn-out gear (Kesler et al., 2017). Thirty-seven percent of the sample was unable to successfully complete both work cycles. The individuals who were unsuccessful had a higher BMI and lower aerobic capacity compared to the FFs who completed both bouts of work. Such findings, in addition to the present findings, suggest that there is a direct relationship between physical fitness and FF ability.

In another study, 12 trained FFs ($BMI = 27.7 \pm 3.3 \text{ kg} \cdot \text{m}^{-2}$, $VO_{2\text{Peak}} = 45.6 \pm 3.3 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) and 37 untrained FFs ($BMI = 31.3 \pm 5.2 \text{ kg} \cdot \text{m}^{-2}$, $VO_{2\text{Peak}} = 40.2 \pm 5.2 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) completed a simulated fire ground test (SFGT; Dennison et al., 2012). The trained FFs had significantly faster completion times on the SFGT when compared to the untrained group. Furthermore, the trained FFs underwent a single exercise session that consisted of circuit training and were then asked to complete the same SFGT while fatigued. The fatigued yet trained FF still had significantly faster completion times when compared to the untrained FF (Dennison et al., 2012). These findings suggest that physical fitness not only has a direct relationship with FF ability, but likely also acts to attenuate the effect of fatigue on FFs.

Our findings and the work of others shows the direct relationships between personality and physical fitness, as well as fitness and FF ability. The present study found that prior to accounting for physical fitness, exercise intensity preference and FF ability were significantly related at both Week 1 and Week 7 of the FF training course (see Figures 6.1 & 6.2). However, once physical fitness was accounted for as a mediator, the relationship no longer remained significant. This indicates that the effect of personality on FF ability is indirect, being mediated

by physical fitness. This research is novel and allows researchers to begin to better understand what contributes to FF ability beyond physical fitness and skills.

Limitations/Future Research

Our study utilized an all-male sample due to the low number ($n=1$) of females enrolled in the fire academies during the data collection periods. This limitation is common in FF research due to the low number of female FFs that serve as career FFs (~3-5%). Additionally, our sample was relatively young (~26 years of age) and were just starting their careers. Further, based on BMI ~75% of our sample was either overweight or obese and >50% of our sample was classified as either poor or very poor in terms of their aerobic fitness (based on ACSM's aerobic fitness classification). There was relatively little variance in fitness levels, with relatively few individuals having or achieving "good" fitness levels at baseline or at the end of the 7-week training program, respectively. It is possible that in a more varied population of FFs we would see a larger impact of personality on FF ability.

Our study was one of the first to examine the relationship between personality, physical fitness, and FF ability. Previous studies have established that physical fitness influences FF ability (Abel et al., 2011; Dennison et al., 2012; Kesler et al., 2017). Additionally, personality has repeatedly been shown to be related to physical fitness and physical activity (Hall et al., 2014; Hayes & Joseph, 2003; Ingledeew et al., 2004; Szabo, 1992). Lastly, the personality profile of first responders has been explored, but little to no research has been done to establish the impact personality has on FF ability (Wagner et al., 2009). Future research should continue to expand upon on these findings to help FFs, municipal departments, and scholars to better understand what influences both fitness and FF ability.

Conclusions

Better understanding the influence of personality on both fitness and FF ability could prove beneficial and is worthy of further exploration. Using personality as a screening tool could prove beneficial in predicting how individuals would respond to physically demanding work conditions. First responders are called on to act as servants to society and are responsible for the safety of many. They are sometimes required to perform feats of strength, power, and endurance. Unfortunately, first responders often fail to maintain adequate physical. The current findings are novel and noteworthy considering the physically demanding tasks first responders face on a regular basis and personality could possibly help predict who may or may not respond positively to these demanding situations.

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CHAPTER 7: GENERAL DISCUSSION

The purpose of this project was to examine the effectiveness of a 7-week Basic Firefighter Academy course, which included a high-intensity functional training (HIFT) program, on both physical fitness and the ability of firefighters to quickly complete a series of simulated fire-ground tasks. This was done by assessing fitness at baseline (Week 1), mid-Academy (Week 4), and post (Week 7) along with firefighter ability at Weeks 1 and 7. In addition to exploring the effects of a HIFT program, the present study explored the relationships between: (1) physical fitness and firefighter ability; (2) individual differences (exercise intensity preference and tolerance, extraversion) and physical fitness; and (3) individual differences and firefighter ability. The present study showed that the HIFT program was effective in improving various components of fitness and that firefighter ability also improved at the end of the 7-week Academy training program in recruit firefighters. Additionally, the results from this project help identify the role fitness (cardiovascular and muscular endurance) plays on firefighting capabilities and what impact individual differences (preference) had fitness and firefighting capabilities.

The present project found improvements in multiple components of physical fitness following a 7-week HIFT program. The ability of the recruit firefighters to successfully complete a series of simulated fire-ground tasks (referred to as the Academy Firefighter Challenge, AFC) was improved as indexed by their faster completion times for the AFC at Week 7 (see Chapter 4, Table 4.2). Specifically, we found that cardiovascular endurance (assessed via 1.5-mile run time) was significantly improved from Week 1 to Week 4 and again from Week 4 to Week 7 (and thus also from Week 1 to Week 7). Similarly, muscular endurance (assessed via the number of push-ups completed in 60 s and the number of sit-ups completed in 60 s) improved from Week 1 to

Week 4 and Week 4 to Week 7 (and thus also from Week 1 to Week 7). There were also significant reductions in weight (body mass) and BMI along with increases in flexibility, and bench press scores from baseline to post testing. Following the Academy course and the 7-week HIFT program, there was also a 13.3% improvement in overall firefighter ability (i.e., shorter time to complete the AFC). These results support previous findings that HIFT is a safe and effective means of improving general fitness (Feito et al., 2018; Heinrich et al., 2018; Poston, Haddock, et al., 2017). While previous work has focused on military populations, our findings are some of the first that have used HIFT with firefighters. Our findings suggest that using HIFT with firefighters is worthwhile and may help address the problem of inactivity and poor physical health that is common among firefighters.

We also hypothesized that greater levels of physical fitness would be associated with faster performance on the AFC. We found that better physical fitness was associated with overall firefighter ability (i.e., faster AFC total time, assessed via a 6 simulated fire-ground tasks). Specifically, cardiovascular endurance and muscular endurance accounted for significant unique variance in firefighter ability at both Week 1 and Week 7 of the Academy. After accounting for age and BMI, fitness accounted for ~40-50% the variance in AFC total time. Our findings expand on previous work which has shown that more fit individuals are capable of performing simulated firefighter tasks faster or are able to repeat these tasks in succession (Dennison et al., 2012; Kesler et al., 2017; Pawlak et al., 2015). Our findings are unique in that they identify which specific components of physical fitness are related to overall firefighter ability, as well as time to complete each task that comprised the AFC. Additionally, our findings identify the amount of unique variance each fitness variable accounted for in relation to firefighter ability,

allowing the identification of the more important components of fitness with respect to firefighting.

Lastly, we hypothesized that aspects of personality, as a marker of individual differences, would be related to higher levels of physical fitness and firefighter ability. Specifically, we proposed that higher levels of exercise intensity preference, exercise intensity tolerance, and extraversion would be seen in those firefighters with greater levels of fitness and would also be associated with faster completion times on the AFC. Our hypothesis was only partially supported: only exercise intensity preference was significantly related to physical fitness and firefighter ability. When examining the relationship between intensity preference and firefighter ability, we discovered that physical fitness acted as a mediator of this relationship. Preference was significantly correlated with better physical fitness and physical fitness was significantly correlated with firefighter ability. These findings support previous work that has found exercise intensity preference to be a predictor of physical fitness and physical activity patterns (Ekkekakis, Thome, et al., 2008; Hall et al., 2014). The significant relationship between preference and firefighter ability was attenuated and no longer significant after accounting for physical fitness. These results suggest that the influence of preference on firefighter ability (i.e., time to complete AFC) is mediated by fitness, that is, it has an indirect influence through the direct effect preference has on fitness.

By better understanding physical fitness and exercise behaviors in firefighters, we can potentially reduce the risk of experiencing injury and cardiac incidents while on-duty, the most prominent health issues firefighters face (Li, Lipsey, Leach, & Nelson, 2017; Patterson et al., 2016; Smith, 2011). The present findings provide information that highlights which components of fitness, specifically cardiovascular and muscular endurance, are associated with better

firefighter performance. Additionally, it shows the effectiveness that HIFT has on improving both fitness and potentially firefighter ability. Given that the recruits were simultaneously participating in the 7-week HIFT program and Basic Firefighter Academy, it is plausible that the improvements in firefighter ability can be attributed to a combination of the HIFT and the Academy. HIFT was an effective means of improving both cardiovascular and muscular fitness, indicating that HIFT may be a safe and effective form of programming to use among firefighters when trying to improve fitness and job performance.

Additionally, we found that exercise intensity preference was related to both fitness and firefighter ability. Using preference (an individual difference measure) may be a beneficial screening tool to identify which individuals are more or less likely to possess high levels of physical fitness and/or engage in exercise behaviors that could lead to such levels of fitness. Physical fitness testing or screening can be time-consuming and costly. Incorporating personality assessments into such testing or screenings may prove to be beneficial and cost-effective in determining which firefighter's may or may not be successful when faced with physically demanding tasks.

Future research should expand on these findings and explore what additional factors contribute to firefighter performance. Researchers can use HIFT programming in a sample of career firefighters to determine the extent to which HIFT can improve fitness and firefighter ability in firefighters who already possess the skills and knowledge of firefighting tasks. Additionally, future studies should explore the extent to which nutrition, sleep, and past careers (e.g., military duty) have on firefighter ability. Given that cardiac incidents are the leading cause of on-duty deaths among firefighter, more fitness initiatives need to be implemented and physical

fitness standards need to be put in place to ensure that all firefighters are held accountable and are held to a standard that will ensure adequate fitness levels.

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APPENDIX A: PT DESCRIPTIONS AND EQUIPMENT

Academy Physical Fitness Test

Push-ups in 1 minute

Sit-ups in 1 minute

1.5-mile run

Supplies:

Stopwatch

Cone to mark finish

PT Scorecards

Swept pad

Research Data Collection

Body Measurements (hip and waist circumference)

Sit & Reach

Muscle Endurance (bench press)

Vertical Jump

Supplies:

Cones

Bench Press Bench and Weights

Metronome

Body Tape Measures

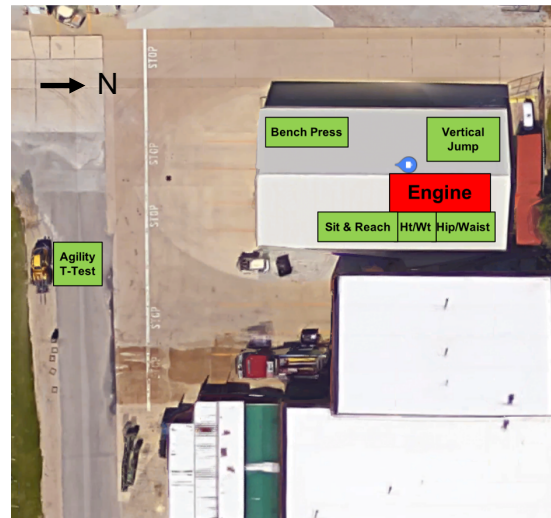
Scale

Sit & Reach

Privacy Curtains

Vertical Jump Stand

Swept pad and 1173



Team Challenge – Circle Drive

Companies start at pavilion north of Taxpayer. Each company has one section of hose looped through pavilion for Battle Hose. First person does prescribed reps of battle hose, then runs east on Circle Drive to Air squat station, then continues to Triceps Dip Station, and returns to pavilion. Second person can start when Person #1 finishes Battle Hose. Once entire company has assembled back at Pavilion, company performs 20 push-ups together (Week 1) or does over/under pushups (week 2). For over/under pushups, companies begin in the high plank position. Person #1 army crawls under the rest of the company and assumes plank position at the other end. Person #1 shouts “GO”, and entire company does 1 push-up. Once all members have completed the Unders, the company begins the Overs. All members hold the low pushup position and Person #1 runs over the rest of the company. Person #1 shouts go, and the company does 1

push-up. Once all have completed the Under, the Challenge is complete.

Supplies:

- 4 x Hose (1 ¾ or 2 ½, see schedule)
- 2 x Large Tractor Tires (placed near South Circle Drive)
- Cones (placed at Air squat station, behind LRRC)

The Academy Firefighter Challenge

The Kiser Sled

This event requires the candidate drive the sled 5 feet. Only the orange sledge specific to the test should be used. **This event is capped at 1 minute and 30 seconds.**

The Crawl

This event requires the candidate to crawl through the SCBA maze with **all** obstacles removed. The candidate must stay on hands and knees throughout the task.

The Victim Drag

This event requires the candidate to drag a victim/dummy weighing approximately 110 pounds and drag it 100 feet, using webbing secured around the victim’s shoulders and long enough to loop around the firefighter’s shoulder. The firefighter should be facing forward when dragging the victim.

The Hose Advance

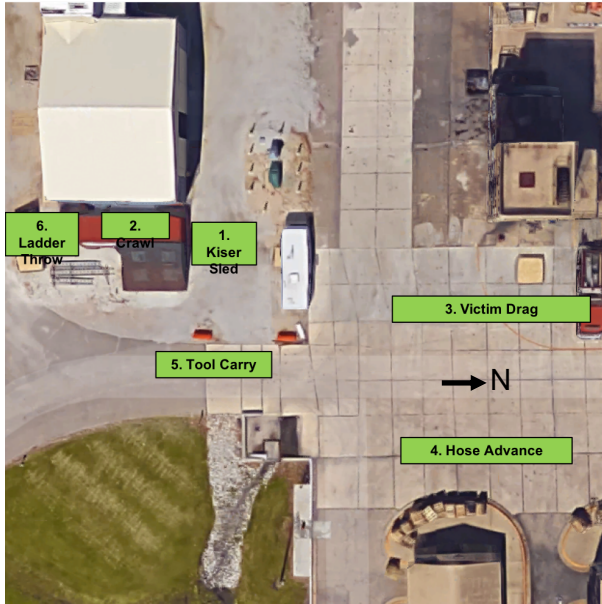
This event requires the candidate to grasp the end of a charged 1 ¾” hoseline and drag it 75 feet. Hoseline is charged with hydrant pressure from hydrant south of Single Family.

The Equipment Carry

This event requires the candidate to pick up two saws (one K12/circular saw and one chain saw), walk 50 feet, circle a cone, and return to the starting point. The candidate then **gently** sets the saws on the ground.

The Ladder Raise

This event requires the candidate to throw a 35-foot extension ladder fixed against the side of a building. The ladder is anchored at the bottom rung and allowed to pivot. The candidate is required to raise the ladder from the ground to the vertical position. The ladder is not extended after it is thrown.



Timing:

One staff member will keep the firefighters lap splits and overall time, while directing him/her between stations. Each station will have one staff member dedicated to supervising and resetting that station. At the completion of the station, the station staff will reset the station and advise the next incoming candidate if needed. At the end of the AFC the escort staff member will record the split and overall completion times.

Supplies:

Kiser sled (Sled, Frame and Sledge)
1 x 110lb Rescue Randy dummy with webbing
2 x 50ft 1 ¾" Hose Sections
1 x 2 ½" to 1 ¾" reducer
1 x Hydrant Wrench
1 x K12 (or similar) circular saw
1 x chain saw
1 x 35ft 2 section fixed extension ladder
Cones and/or Chalk

4 Stations

All companies should have bunker coats and gloves (work or firefighting). Companies split into 4 stations. Companies rotate based on the Litter Carry group.

Stair Run

Firefighter sprints up TRT prop, hitting every step. Run around the anchor at the top. Each firefighter waits for the previous firefighter to finish the first flight before starting. Firefighters jog back down slowly and controlled, loop around the manhole cover and repeat. Companies go in reverse order second time. Typically do 3-4 rounds.

2 ½" Hose Drag

Firefighters partner up and lay out hose north of Taxpayer. Partner #1 drags hose across grass with Partner #2 jogging behind. Partners then switch positions. Typically do 4 rounds, rest, then 3-4 more rounds.

Litter Carry

Backboards or litters are loaded with 2 sections of 1 ¾" hose. Groups of 3-4 firefighters carry the litter around circle drive, stopping half way to switch sides.

Bear Crawl/Plank

Firefighters partner up. One partner bear crawls down to the cone, turns around and crawls back. The other partner holds the plank position. After partner #1 returns, they switch positions.

Supplies:

11 x 2 ½" Hose

3 x Backboards or Litters

Standard Circuits

The drill cards are split into 3 categories: Core, Lower Body, Upper Body. The cards are spread in a circle, rotating between the categories. Groups switch sides (for some drills) at 30 seconds and switch drills at 1 minute. For round two, the time is increased to 45sec/90sec.

Supplies:

4 x 2 ½" Hose

4 x 1 ¾" Hose

Ability Group Run

Companies are split into 3 ability groups based on 1.5 mile run times. Groups run together for the prescribed run time. Course can be around circle drive, or go off campus. When running off-campus, the front of the pack should carry hand lights.

Supplies:

6 x Hand Lights (if going off campus)

Partner Circuits

Companies split into 4 groups. Each group performs one of the stations. Partner #1 completes the prescribed number of repetitions while the second partner performs the second task. When partner #1 completes the task, the firefighters switch positions. After completing each drill twice, all companies rotate between stations.

Supplies (Week 2 & 3):

12 x Wall Balls

3 x Small Tractor Tire with Pull Handle

6 x Straw Bales

Supplies (Week 5 Tues):

6 x 1 ¾" Hose

12 x 2 ½" Hose

6 x Straw Bales
2 x Large Tractor Tire

Supplies (Week 5 Thurs):

6 x 12lb Sledge
2 x Large Tractor Tire
6 x High Rise Bundle (1 ¾" Hose)
6 x Surge Pipe

Supplies (Week 6):

6 x 1 ¾" Hose
6 x Jump Ropes
6 x Surge Pipe
6 x 2 ½" Hose
6 x Straw Bales

Battle Hose Stations

Each company has a section of hose at the corner of the pavilion north of the Taxpayer. Person #1 complete the prescribed Battle Hose movement for 30 seconds. Every other person rests or performs the alternate exercise (i.e. Person #2 rests, Person #3 does Air Squats, #4 rests, etc.). Person #1 the goes to the end of the line. When all members have completed the first movement, all groups move to the next set of exercises.

Supplies:

4 x 2 ½" Hose

Team Challenge – Victim Rescue

Companies start at pavilion north of Taxpayer. Each member of the company must move the victim from one end to the other in the grass. The company must then load the victim into the litter and make 2 laps around the circle drive. Teams must then complete 10 burpees per person, with only one person performing them at a time.

Supplies:

4 x 110lb Rescue Randy
4 x Litter or Backboard

Team Challenge – Power

Companies start on the pad South of the Tower. Each member of the company must drive the tire from one cone to the other, then run to the grass pad North of the Taxpayer. Then the firefighter must move the victim from one end to the other in the grass. The firefighter then completes a lap around Circle Drive back to the Streetscape where the Battle Hose is completed. Then the

firefighter completes Surge Front Squats. The second person can start as soon as the Tire Drive is complete.

Supplies:

- 4 x Small Tires
- 4 x 12lb Sledges
- 4 x 110lb Rescue Randy
- 4 x 2 ½” Hose
- 4 x Surge Pipes

4 Corners

Cones are set up in a large square, with each company stationed at a corner. One at a time the companies move along one side of the square using the prescribed movement. All others in the company perform the alternate exercise while waiting. For the High Plank Hose Drag, companies spread out between the cones in the High Plank position and must drag a 50’ section of 2 ½” hose from one cone to the other, passing it between members. For the Boat Medicine Ball Handoff, companies spread out holding the boat position and pass a weighted ball down the line.

Supplies (Week 4 Tues):

- 6 x Jump Rope
- Cones

Supplies (Week 5 Thurs):

- 1 x 2 ½” Hose
- 1 x Wall Ball
- Speed Hurdles
- Cones

Drills for Inside

- Standard Circuits
- 4 Corners
- Partner Circuits (Tuesday, Week 6)
- Tool Lifts
- Each company must complete (per person): 20 pushups, 10 burpees, 10 Surge squats

Stadium Stair Run

- Held at the University of Illinois Memorial Stadium
- Each recruit will run the steps of the lower level of Memorial Stadium
- Each recruit carries 1 piece of fire equipment while completing the stadium run

Stadium Challenge

Held at the University of Illinois Memorial Stadium

Each company will move their assigned each up and down each column of stairs on the lower level of memorial stadium

Recovery and Motivation

Guest speaker will be brought in and speak to the Academy class in place of fitness/PT.