# An examination of the health and wellness of recruits and women in the U.S. fire service

by

Brittany Sara Hollerbach

A.A., Johnson County Community College, 2008
B.S., Kansas State University, 2015
M.S., Kansas State University, 2016

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Kinesiology
College of Human Ecology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2019

# Abstract

**Background:** Firefighting is a dangerous occupation, with high rates of line-of-duty injuries and fatalities as well as a high number of related psychological and physical health concerns. Poor health and low levels of firefighter (FF) fitness have significant economic costs for the individual, the fire department, and the public. Though FF fitness and injuries have been studied extensively among men in the fire service, research among recruits and women FFs is lacking. The purpose of this dissertation was to examine exercise training among recruits in the fire service as well as the perceptions, experiences, rates, types, and predictors of injuries among career women FFs.

**Methods:** This dissertation is composed of three different studies. The first was a pilot 10-week randomized trial of a novel exercise intervention, The First Twenty High-Performance Training Program (TF20), with fire academy recruits. Second, we qualitatively examined injury perceptions among women FFs via focus groups and key informant interviews. Last, a cross-sectional study used snowball sampling to solicit participation from women career FFs; participants completed an online survey regarding occupational injuries, which were compared to those of men in the fire service, with a specific focus on behavioral health predictors of injury.

**Results:** The pilot investigation was the first to examine TF20 among fire service recruits and found that recruits did not meet National Fire Protection Association (NFPA) physical fitness standards at baseline but did show improvements in body composition, muscular strength, agility, and aerobic capacity after the 10-week intervention. After examining fire recruits, interest in the lack of representation of women FFs arose, and the further investigations examined this "hidden population." First, after examining women FFs' perceptions and attitudes related to injury in the fire service, participants identified six key themes: the impact of working in a male-dominated field; harassment; the similar rates/types of injury among men FFs; inadequate training; ill-fitting

protective gear; and functional techniques/endurance related to injury in the fire service. This qualitative analysis led to a quantitative examination of injury among women FFs. Several behavioral health predictors including exercise habits, being a former or current smoker, depression, and job dissatisfaction were statistically significant predictors of injury.

**Conclusions:** Our data show that FFs, even new recruits, struggle with low levels of fitness. We also found that women experience similar rates and types of injury as their male counterparts, though their experiences with injury differ (e.g., they experience more chronic injuries, injuries related to discrimination and harassment, differing predictors of injury, and more missed days due to injury). Research among women FFs has shown that a lack of data negatively impacts recruitment and retention in the fire service. The combined information from these studies can help inform policy and training to address preliminary fitness training and injury prevention in the fire service to better protect all FFs.

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Major Professor
Katie M. Heinrich, Ph.D.

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# Dedication

I dedicate this work to my family; they are the strength and power behind what I do. I thank God for His continual strength and guidance in my life and my work. Gram, as is every great accomplishment in my life, this is for you.

# Chapter 1 - Introduction

## Overview

Firefighting is a dangerous and highly stressful occupation, with high rates of injuries and line-of-duty deaths (LODDs) (Fahy, LeBlanc, & Molis, 2018; Evarts & Molis, 2018; Poplin, Harris, Pollack, Peate, & Burgess, 2011). Of the approximately 1,160,450 firefighters (FFs) in the United States (U.S.) in 2017, the National Fire Protection Association (NFPA) estimated 58,835 FF injuries and 60 FF fatalities occurred in the line of duty (Evarts & Molis, 2018). Additionally, there were 7,345 documented exposures to infectious diseases and 44,530 exposures to hazardous conditions (Evarts & Molis, 2018).

Despite public perception of FFs as being muscular and "sexy," FFs also struggle with poor physical health (Jahnke, Poston, Haddock, & Jitnarin, 2013; Soteriades et al., 2005), high rates of overweight and obesity (Soteriades et al., 2005; Kales, Polyhronopoulos, Aldrich, Leitao, & Christiani, 1999; Poston et al., 2011), and low fitness levels (Poston et al., 2011; Tsismenakis et al., 2009). FFs tend to experience significant weight gain over the course of their careers and may gain anywhere from 29 to 85 pounds (i.e., 1.15 to 3.4 pounds/year) (Tsismenakis et al., 2009). As FFs' weight increases, their cardiorespiratory fitness plummets and their risk of cardiovascular disease (CVD) increases (Durand et al., 2011). Other diseases related to being overweight and obese include heart disease, stroke, type 2 diabetes, and certain types of cancers that are highly prevalent among the FF population (Poston et al., 2011; Centers for Disease Control and Prevention, 2015). In 2017, 29 FFs died while on duty due to cardiovascular events (Fahy et al., 2018). While there is a wealth of research that examines male FFs' physical health, there are limited data concerning the health of recruits and female FFs.

## FF Recruits

Often, the term *FF recruit,* or *rookie,* refers to a member of a class of new hires at a fire department who attend the department's fire academy for formal training before beginning work as an FF (Cornell et al., 2016; Gnacinski et al., 2016; Roberts et al., 2002). Limited research examining professional FF recruits has shown that even those with fire service experience tend not to be as physically fit as is recommended when they begin their fire academy training (Cornell et al., 2016; Roberts et al., 2002).

Roberts et al. (2002) examined newly hired FF recruits before and after a 16-week exercise training program. The periodized (progressive movement through different aspects of training) program consisted of cardiovascular training, muscular strength/endurance training, job-specific activities, core work, cooldown exercises, and stretching. Overall, researchers found that, on average, prior to the training, recruits were clinically overweight according to body mass index ([BMI]; average BMI $\geq$ 25) and had low levels of aerobic fitness (Roberts et al., 2002). After training, the recruits significantly increased their aerobic capacity, muscular endurance, and flexibility. Although this was a beneficial investigation, the study participants already had some fire service training and were participating in an arduous fire academy (five days/week) that included climbing ladders, lifting and carrying fire hoses, traversing up and down stairs in FF personal protective equipment (PPE), and more, which limits the ability to attribute the physical fitness improvements to the training alone.

Cornell et al. (2017) examined 78 male FF recruits recently hired at fire departments in a midwestern state. On average, participants were overweight (BMI 25.0–29.9) and had estimated maximal oxygen uptake ($VO_2$ max) values below the level suggested by the NFPA (42.0 ml/kg/min; NFPA 1582) (NFPA, 2013, p. 95). Gnacinski et al. (2016) examined 42 FF recruits

employed in metropolitan areas of a midwestern state. Prior to the study, the participants had already passed physical and psychological screenings, as required by their respective departments. The researchers examined recruits as they progressed through a 16-week FF training academy. Recruits had statistically significant improvements in estimated $VO_{2max}$ and heart rate recovery within the first 8 weeks of training, but no significant changes were observed during the last 8 weeks of training. Further investigation is therefore necessary to examine fitness programs to improve FF recruit fitness and attenuate fitness decrements that occur during an FF's career.

While some studies examined FFs in recruit academies, these studies focused on FFs that were already hired at fire departments. Regardless of their experience in the fire service, even fire service recruits hired by fire departments did not possess the levels of fitness deemed necessary for fireground operations. Further investigation is necessary to examine fire recruits who have little or no experience in the fire service and the fitness interventions necessary to improve the health, wellness, and physical performance of FFs. Our examination of FF recruits is among the first research examining this subset of the FF population, and we examined "true recruits," meaning the recruits in our study had little to no background in the fire service, were not professional FFs, and had not yet been hired by any fire department. The benefit of studying true recruits is the ability to examine those with little to no fire service training as they progress through a physically demanding fire academy, and to examine the potential benefits of a training program tailored specifically to FFs.

## Women FFs

Women represent an incredibly small proportion of the fire service, even lower than that of the U.S. Marine Corps, in which all members are expected to be combat ready (Women in Military Service for America Memorial Foundation, 2010). According to the NFPA, women

represent approximately 8.9% of volunteer and 3.7% of career FFs (Haynes & Stein, 2017). Despite representing a small percentage, more than 85,100 women are on the front lines of the fire service, protecting communities across the U.S. (Haynes & Stein, 2017); however, they often are overlooked in studies and excluded from statistical analyses due to their small sample size (Jahnke et al., 2012; Hollerbach et al., 2017).

While all FFs face environmental and occupational stressors, women in the fire service face additional barriers adversely affecting their health and wellness (Hollerbach et al., 2017; Jahnke et al., 2012; Jahnke et al., 2019). These barriers include harassment, inadequate training, ill-fitting gear, and a lack of resources, including insufficient support and policies specific to women (Hollerbach et al., 2017; Hulett et al., 2008; Jahnke et al., 2019). This can lead to unhealthy coping mechanisms including substance use and abuse, poor mental health, and an increased injury risk (Haddock et al., 2017; Jahnke et al., 2019). Additionally, the culture of the fire service has been traditionally unaccepting of women (Hollerbach et al., 2017; Hulett et al., 2008; Horvath, 2013). A combination of these factors likely contributes to the low rates of recruitment and retention of women in the fire service (Horvath, 2013). Our research begins to bridge the gap in research examining women FFs.

## Purpose of Dissertation

Despite a wealth of research examining male FFs over the last decade, there is limited scientific literature examining the health of recruits and women in the fire service. This lack of information negatively impacts the fire service by effectively limiting the evidence base for developing and informing standard operating procedures and guidelines. Further, a lack of data specifically related to women and recruits may negatively affect recruitment and retention processes, effectively lowering the recruitment pool of qualified candidates and forcing women

out of the fire service prior to retirement (Horvath, 2013). The purpose of this dissertation was to examine these FF population subsets (i.e., recruits and women) with regard to physical fitness (weight, cardiovascular health, aerobic capacity, strength, and occupational performance) and injury (perceptions, experiences, frequency, types, and predictors). The next three chapters in this dissertation represent three separate studies conducted to achieve this aim.

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# Chapter 2 - Examining a Novel Firefighter Exercise Training Program on Simulated Fireground Test Performance, Cardiorespiratory Endurance, and Strength: A Pilot Investigation

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## Background

Firefighting is a strenuous and physically demanding occupation [1]. FFs work in dangerous and complex environments, which increases their risk for injuries and fatalities [2]. In addition to the dangerous nature of the job, FFs struggle with poor health and low levels of physical fitness, including very high (>80%) rates of overweight and obesity (BMI ≥25.0 kg/m$^2$), likely related to the culture of the fire service [3]. Many FFs experience significant weight gain over the course of an approximately 25-year career, with a range of between 29 and 85 pounds gained (i.e., 1.15 to 3.4 pounds/year) [3]. As weight increases, cardiorespiratory fitness plummets and the risk of CVD increases [4]. Comorbidities related to overweight and obesity include heart disease, stroke, type 2 diabetes, and certain types of cancer that are highly prevalent among the FF population [3, 5].

It is well documented that physical fitness is related to job performance, including the performance of simulated firefighting tasks that are relevant to actual job tasks (e.g., pulling a hose, carrying a ladder, or rescuing a victim) [3]. Firefighting presents a unique challenge for physical fitness training because it requires the concurrent improvement of multiple fitness domains [6]. Firefighting requires optimal levels of power, strength, muscular endurance, and

anaerobic/aerobic endurance [6, 7]. Inadequate fitness levels may reduce occupational performance and increase the risk of overexertion injuries for FFs [7]. In contrast, increased physical fitness is related to lower levels of injury/illness, reduced absenteeism, increased productivity, and increased work capacity for FFs [6].

Limited resources exist for fire departments that are tailored to the culture and work requirements of these tactical athletes [6]. There has been increasing interest in high-intensity functional training (HIFT) programs among tactical populations, yet key research data are lacking for the FF population [6, 8]. The NFPA has several standards that focus on the health risks of FFs (e.g., NFPA 1500, NFPA 1582, and NFPA 1583) [9–12]. While these guidelines exist, there are no nationally enforced fitness or physical activity requirements for FFs, which leads to inconsistent fitness training within and between fire departments, substandard fitness levels, and greater risks for obesity, injury, and cardiovascular-related events [9]. For example, only 38.7% of career FFs and 23.6% of volunteer FFs meet the fitness threshold suggested by NFPA 1582 as a minimal return-to-work fitness level after a cardiac event, which includes a $VO_{2max}$ of at least 42 ml/kg/min [9, 11].

The NFPA recommends that FFs be allowed to exercise while on duty to maintain adequate fitness levels [12]. While Poplin et al. [13] found that on-duty physical exercise was responsible for one-third of all FF injuries (32.9%), most injuries tended to be minor strains/sprains. It is still recommended that FFs be encouraged to exercise while on duty, as the fitness benefits outweigh the minor injury risks. Studies have shown that FFs who engaged in regular physical training were less likely to incur a serious injury on the fireground [14, 15]. Furthermore, FFs who train regularly and possess higher fitness levels tend to perform job-specific tasks more efficiently than do untrained FFs, emphasizing the importance of implementing an exercise program for FFs [7, 13,

16]. Thus, there is a need for cost-effective training programs targeted at the unique needs and culture of the fire service as a means of improving readiness, decreasing injury, and preventing LODDs related to CVD.

Fire academies provide instruction for new FFs and should instill the importance of physical fitness training as recruits begin a physically demanding career in the fire service [17]. However, current fire academies across the U.S. do little to address physical fitness other than teaching firefighting-specific physical skills during fire training [17]. The applied coursework requires much time spent on the drill ground learning basic FF skills, including donning PPE such as bunker gear and self-contained breathing apparatus (SCBA), navigating through dark search quarters, searching for and removing a victim, climbing ladders, and fighting live fire. FF recruits are also typically required to take the Candidate Physical Ability Test (CPAT) or an equivalent occupational fireground test during the fire academy, which they must pass to be considered for employment in most fire departments across the country [18]. These tests are physically demanding and require high fitness levels.

The purpose of this pilot investigation was to assess the acceptability, feasibility, and relevant fitness and occupational performance outcomes of an innovative FF HIFT program, The First Twenty Tactical High-Performance Program (TF20), among FF recruits. We hypothesized that the intervention group (TF20) would result in greater improvements in performance, fitness, and health outcomes than do the firefighting-specific training courses currently in place.

## Methods

### Design

This pilot study was a randomized 10-week trial. Participants were individually randomly assigned to either the intervention (TF20) or comparison group (CG). Microsoft Excel was used

to generate the random allocation sequence. Both groups completed baseline assessments, 10-weeks of either the TF20 or CG, and follow-up assessments.

## Participants

We solicited study volunteers by visiting a local fire academy that was hosted by a community college fire science degree program, with permission from the Fire Academy Program Director. The institutional review board (IRB) of Kansas State University (KSU) approved the study (IRB #8063). All participants provided written consent prior to the initiation of their involvement in the research.

Participants (n = 13; 92.3% male) reported they were in good health and without physical limitations that prevented them from completing any of the required TF20 workouts and fitness assessments. Because recruits also were students in the community college degree program, passing the CPAT prior to entry into the fire academy was not required. The fire academy provided instruction to prepare recruits to take state tests for FF certification, but they were not professional FFs. Figure 2.1 shows the participant randomization and progress through the study (TF20 = 7; CG = 6).

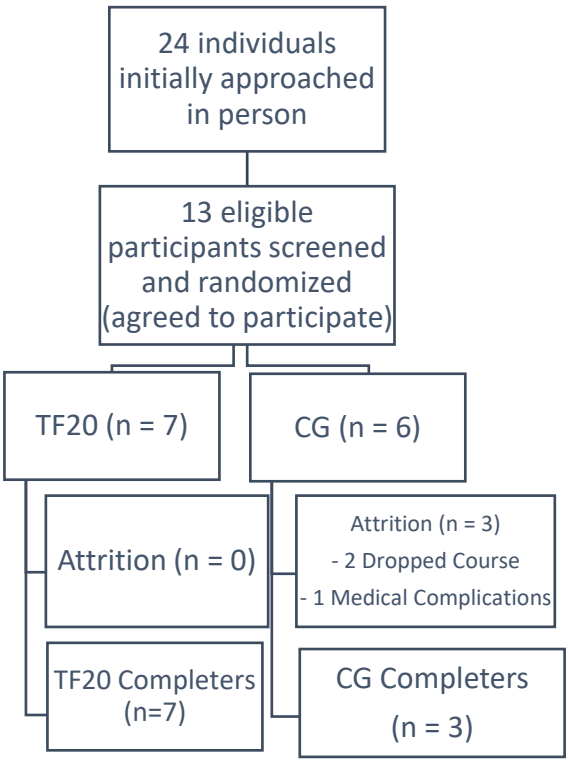


**Figure 2.1.** Randomization and participant flow

## Intervention

TF20 is an innovative online training program developed by FFs specifically for FFs that provides foundational educational principles related to physical fitness, mental wellness, and nutrition. Using a holistic approach combined with empirical evidence [19–21], TF20 is a comprehensive program that addresses FFs' unique physiological challenges by simulating tasks performed on the fireground. Specifically, the program's goals are to optimize FFs' occupational performance, resilience to injury, stability, mobility, strength, and endurance through a series of high-intensity circuits, focused on both resistance and endurance exercises. TF20's online platform allows participants to apply and track these principles daily and record their progress. The portal includes private account settings, health programs, fitness tracking with exercise and workout

videos, nutrition tracking, health education, results tracking, and communication and links to social media.

TF20 (i.e., intervention group) workouts were part of an online training program that provided endurance and resistance exercises, nutritional information, and mental performance guidance. The original program was a 24-week periodized program, and this was condensed into a 10-week exercise program to accommodate the time frame of the study and fire academy academic semester. A National Strength and Conditioning Association (NSCA) Certified Strength and Conditioning Specialist (CSCS) and Tactical Strength and Conditioning Facilitator (TSAC-F) condensed the program but kept the periodization scheme consistent to mimic the longer cycle of workouts. The workouts are summarized in Table 2.1.

**Table 2.1.** The TF20 periodization cycle

| Week | Mesocycle | Exercise Description | Time/Duration (days/week [d/wk]) |
|---|---|---|---|
| 1<br>2 | 1 | Resistance Training<br>Moderate-Intensity Cardiovascular (Cardio) Training | 2 d/wk<br>2 d/wk in 20 min. bouts |
| 3<br>4<br>5 | 2 | Resistance Training<br>Moderate-Intensity Cardio<br>Walk with SCBA | 2 d/wk<br>2 d/wk in 30 min. bouts<br>1 d/wk for 20 min. |
| 6<br>7<br>8 | 3 | Resistance Training<br>Moderate-Intensity Cardio<br>Vigorous Cardio (stair climb with SCBA) | 2 d/wk<br>2 d/wk in 45 min. bouts<br>1 d/wk for 14 min. |
| 9<br><br><br>10 | 4 | Resistance Training<br>Moderate-Intensity Cardio<br>Vigorous Cardio (walk with SCBA)<br>Active Recovery | 2–3 d/wk<br>1 d/wk in 60 min. bouts<br>1 d/wk in 20–30 min. bouts |

Workouts contained a combination of aerobic (e.g., running, rowing, jumping), body weight (e.g., air squats, pushups, sit-ups), and weight-lifting (e.g., presses, back squats, weighted lunges) exercises, with workouts designed to use equipment available in an exercise facility (e.g., weight racks, benches) or in a fire station/on the fireground (e.g., equipment carry, dummy drag).

The 60-minute TF20 sessions included a warm-up, workout, and cooldown. All completed workouts were logged in the online TF20 software program, which was used to assess intervention compliance and adherence.

The CG followed their regular workout routine for 10 weeks. Participants chose the time, duration, frequency, and type of workouts completed. For the study, participants were asked to log all exercise/workouts online using Google Sheets.

Both the TF20 and CG met weekly with an FF fitness trainer with current cardiopulmonary resuscitation (CPR) and First Aid certifications (Firefighter/EMT, CPR/First Aid, TSAC-F certified). Weekly meetings ensured education on the proper movements used in TF20 program and the discussion of proper movement progressions. Both groups were reminded to log their workouts. Any participant questions were also discussed during the meetings.

## Procedures

The research team enrolled participants during the first week of their 16-week fire academy. The research team generated the random allocation and assigned participants to intervention groups. Baseline testing occurred during the second week of the fire academy, the intervention took place over the next 10 weeks, and the follow-up assessments were completed within the following two weeks.

As an incentive to participants, this study took the place of the one credit hour of the physical fitness course requirement for the fire academy. This one-credit-hour course was offered through the local community college and allowed participants to access the community college gym. The class was not associated with the fire academy, nor was it instructor-led; it solely provided access to a gym. The fire academy in this study did not have a structured exercise (i.e., fitness training) component.

## Measures

During the initial (baseline) and follow-up assessments of the study (immediately after the 10-week intervention), participants' health, fitness, and performance were assessed. A Seca stadiometer (Chino, CA) was used to assess height (at baseline). The Tanita TBF-300A digital bioelectrical impedance analysis (BIA) scale (Arlington Heights, IL) was used to assess body composition, including percent body fat (%BF), fat mass (FM in kg), fat-free mass (i.e., muscle mass; FFM in kg), BMI (in $kg/m^2$), and weight (to the nearest 0.1 kg). Research has shown that BIA correlates well ($r > 0.8$) with the gold-standard measure dual X-ray absorptiometry (DEXA) analysis for body composition [22].

The $VO_2$ max was estimated from the linear relationship between heart rate (HR) and work rate during a submaximal graded exercise test using a StairMaster StepMill 7000PT [23, 24]. A standardized protocol recommended for FFs by the Joint Labor Management Wellness Fitness Initiative (WFI) was used [23]. This test is recommended for FFs because, unlike other submaximal graded exercise tests, this one requires the participant to exercise to maximal volitional fatigue, similar to completing a physically exhausting task on the fireground [23, 24]. Additionally, studies using this test and prediction equation demonstrated accuracy and validity, with no false positives or negatives [24].

Upper-body muscular strength (grip strength; GS) was assessed with the Takei 5401 Hand Grip Dynamometer (Digital; Niigata City, Japan). A hand grip dynamometer is a valid and reliable measure ($p < 0.05$) and is a strong correlate ($r > 0.9994$) of upper-body muscular strength [25, 26]. Participants' dominant hand was noted and accounted for in analysis; GS was recorded three times for both hands in an alternating fashion. The best of three attempts was recorded for each hand. GS was examined alone (unadjusted) and in relation to the participant's body weight (adjusted).

Upper-body muscular endurance was assessed with a 2-minute timed push-up (PU) test [27]. The PU test required participants to touch their chin to the mat at the bottom of each repetition, and the score was the number of continuous repetitions completed [27].

Muscular power was assessed with a counter-movement jump (Jump, Sunnyvale, CA). The best of three jumps was recorded. Participants' standing reach height was subtracted from their maximal jump height, so their total vertical displacement was recorded to the nearest cm.

Core strength was assessed with a cadence curl-up test [27]. Two strips of masking tape were placed 12 cm apart. Participants laid supine across the tape, with knees bent at 90°. A metronome was set at 40 beats/min. At each beep the participant curled their body upwards so as to move their hands to the second tape line. Repetitions were counted each time the participant reached the bottom position. The test was concluded either when the participant completed 75 curl-ups or the cadence was broken [27].

Agility was assessed with a timed agility T test [28]. This assessment required participants to move in a T-shaped pattern, requiring lateral and front-to-back movements. The agility test was recorded in seconds to completion.

Trunk flexibility was assessed using a standardized sit-and-reach box (Canadian Trunk Forward Flexion test) [27].

A simulated fireground test (SFGT), the CPAT, was used to measure occupational performance, fitness, and agility [29]. The CPAT provides a traditional frame of reference to evaluate increases or decreases in physical fitness and occupational readiness and provides an FF-specific assessment. The CPAT consists of eight separate events that require the participant to progress along a predetermined path from event to event in a continuous manner. It is a pass/fail test based on finishing all events in a maximum total test time of 10 minutes and 20 seconds or

less. Participants were provided with a familiarization session prior to taking the CPAT for the first time, as is suggested by the International Association of Firefighters (IAFF) and International Association of Fire Chiefs (IAFC) [29]. Participants were able to familiarize themselves with the equipment at each event but did not take the entire test during the familiarization period.

In all eight events (i.e., stair climb, hose drag, equipment carry, ladder raise and extension, forcible entry, search, dummy drag, and ceiling breach and pull), candidates wore a 50-pound (22.68 kg) vest to simulate the weight of SCBA and FF protective clothing. An additional 25 pounds (11.34 kg), using two 12.5-pound (5.67 kg) shoulder weights that simulated a high-rise pack (hose bundle), was added for the stair climb event. Throughout all events, candidates wore long pants, a hard hat with chin strap, work gloves, and footwear with no open heel or toe. Watches and loose or restrictive jewelry were not permitted. All props were compliant with the IAFF/IAFC WFI CPAT and were designed to simulate critical fireground tasks and test the candidate's physical ability [29]. Participants' HR and blood pressure were taken immediately (within two minutes) following completion of the CPAT.

A questionnaire was completed at baseline and follow-up and included standard demographics (baseline only), health behaviors, physical activity, and current nutritional habits. Physical activity was self-reported using the modified short-form International Physical Activity Questionnaire (IPAQ), which provided a global, physical activity self-rating for the last 30 days [30]. Participants were asked to indicate the amount of moderate and vigorous aerobic activity and strength training completed. From this, researchers created a dichotomous variable for meeting/not meeting the physical activity guidelines (PAGs) for the previous 30 days. Participants were also asked if they followed any current diet/meal plans and if their diet had changed in the previous 12 weeks.

A feasibility analysis was completed to examine participant adherence, their reactions to the intervention, and suggestions for future physical exercise training for the Fire Academy.

## Analysis

Microsoft Excel and SPSS Version 21 (Armonk, NY) were used for statistical analyses. Means, standard deviations (SDs), and proportions were calculated for all variables. However, the small sample size and uneven groups precluded the use of typical parametric between-group comparisons. In order to examine the outcomes of all participants initially recruited in the study, we used an intention-to-treat (ITT) model, carrying forward the baseline observations for those that did not have post-test values. This allowed us to examine all participants, assuming no change for those that did not complete the intervention. The Mann–Whitney U test was used to examine differences between the two groups. Within-group changes over time for both groups were examined for the completers using the Wilcoxon signed-rank test to compare repeated measures (pre- and post-intervention) for each group separately. The Wilcoxon test converts scores to ranks and compares them at Time 1 (pre-) and Time 2 (post-) [31]. Statistical significance was set at $p < 0.05$.

Written responses to questionnaires (baseline and follow-up) were analyzed qualitatively by coding and analyzing recurrent themes, areas of consensus and convergence of opinions, experiences, and perceptions about the wellness program, using a grounded theory approach [32]. Data were then coded by identifying passages exemplifying key concepts or ideas related to the major themes using NVivo 10 (QSR International, 2016). A feasibility analysis also was completed to examine the relevance of offering this intervention in a fire academy. Adherence to the prescribed workouts for the TF20 group and their feedback to the intervention were examined in a follow-up questionnaire.

# Results

Thirteen participants consented to study participation (TF20: n = 7, 100% male, 22.6±2.9 years; CG: n = 6, 83% male, 23.5±3.6 years). The Mann–Whitney U test revealed there were no significant differences at the baseline between the two groups with respect to demographic factors or pre-intervention fitness measures. Ten male fire service recruits (aged 19–27 years) completed the study, including baseline and follow-up assessments and 10 weeks of either the TF20 intervention or self-guided exercise (TF20 n = 7; CG n = 3). Overall, the participants were less physically active than expected at baseline. Of the nine (6 TF20 and 3 CG) that filled out a baseline questionnaire regarding current exercise behavior (over the past 30 days), 44% of the TF20 group (n = 4) and 67% of the CG (n = 2) met either moderate or vigorous aerobic PAGs. Only four (all in the TF20 group) met the current PAGs (aerobic and muscle-strengthening guidelines).

**Table 2.2.** Participant demographic characteristics at baseline

| **Variable** | **CG (n = 6)** | **TF20 (n = 7)** | **Difference** |
|---|---|---|---|
| Age (years) | 23.5 | 22.6 | −0.9 |
| Gender (%Male) | 83.0 | 100.0 | +17.0 |
| Weight (kg) | 72.4 | 90.0 | +17.6 |
| [a]BMI ($kg/m^2$) | 23.9 | 29.2 | +5.3 |
| $VO_2$ max (ml/kg/min) | 42.3 | 38.5 | −3.8 |

n = 13; [a]Body Mass Index: underweight (> 18.5); normal weight (18.5–24.9); overweight (25–29.9), and obese (≥ 30)

## Dropouts

One participant (CG) dropped out of the fire academy only two weeks into data collection and was therefore ineligible to complete the study. One participant (CG) dropped out of the study due to time constraints during the 10-week intervention, and another participant (CG) completed the 10 weeks of self-directed workouts but was unable to complete follow-up testing due to

diabetes-related medical complications. All three of the subjects who dropped out of the study were assigned to the CG, accounting for the subsequent uneven group distribution.

## Between-Group Differences in Fitness Measures

Using the ITT model, we compared differences between groups. The Mann–Whitney U test revealed the two groups differed significantly in two measures. The TF20 group had significantly greater improvements in grip strength, and the CG had significantly greater reductions in BMI after 10 weeks. All results and significance values are presented in Table 3. No participants reported any injuries during the 10-week study.

**Table 2.3.** Fitness and performance changes

| | **Mean Change (M±SD)** | | **Within-Group Comparison[a]** | | **Between-Group Comparison[b]** |
|---|---|---|---|---|---|
| **Variable** | **TF20 (n = 7)** | **CG (n = 6)** | **TF20** | **CG** | |
| Weight (kg) | −0.17±3.0 | −0.72±1.3 | 1.000 | 0.180 | 0.153 |
| **% Fat** | **−6.29±4.1** | −6.40±7.1 | **0.018*** | 0.109 | 0.063 |
| **Fat Mass (FM, kg)** | **−6.74±3.9** | −7.02±7.8 | **0.018*** | 0.109 | 0.053 |
| Lean Mass (FFM, kg) | 2.09±3.5 | 1.27±2.5 | 0.352 | 0.285 | 0.199 |
| **BMI (kg/m$^2$)** | −0.06±2.9 | −1.34±1.5 | 0.933 | 0.109 | **0.046Ɨ** |
| **Grip Strength (adj.)** | **0.08±0.06** | 0.03±0.05 | **0.018*** | 0.109 | **0.038Ɨ** |
| Sit & Reach (cm) | 2.96±3.0 | 1.21±3.4 | 0.063 | 0.593 | 0.086 |
| Vertical Jump (cm) | −1.02±2.7 | −0.85±3.5 | 0.684 | 0.655 | 1.000 |
| Push-Ups | 4.43±11.0 | 0.67±2.1 | 0.249 | 0.414 | 0.830 |
| Curl-Ups | 6.86±22.0 | 10.5±16.2 | 0.176 | 0.180 | 0.315 |
| **Agility (sec)** | **−0.57±0.6** | 0.04±0.1 | **0.028*** | 0.180 | 0.775 |
| **$VO_2$ max (ml/kg/min)** | **2.47±1.1** | 1.99±2.2 | **0.028*** | 0.109 | 0.685 |

%FAT = % body fat; BMI = body mass index; $VO_2$ max = estimated maximal oxygen uptake. *Statistically significant ($p \leq 0.05$) within-group change. ƗStatistically significant ($p \leq 0.05$) difference between groups. [a]Wilcoxon signed rank. [b]Mann–Whitney U.

## Within-Group Changes in Fitness Measures

All variables were examined from pre- to post-intervention. For within-group comparisons, we used the ITT model with baseline observations carried forward for those without follow-up scores. The Wilcoxon signed-rank test revealed no significant changes within the CG (Table 2.3). In the TF20 group, the Wilcoxon signed-rank test revealed statistically significant within-group improvements in body fat percentage, fat mass (kg) (FM), lean mass (kg) (fat-free mass; FFM), GS, agility time, and estimated $VO_2$ max from baseline to follow-up (see Table 2.3).

McNemar's test revealed that neither group showed statistically significant differences in CPAT pass rates from pre- to post-intervention. The average pass rate for the CG at baseline was 60% and remained 60% post-intervention under the ITT assumption of no change. The average pass rate for the TF20 group at baseline was 40% and improved to 86% after the intervention. The individual pass/fail rates and times for the CPAT are listed in Table 2.4.

Though the CPAT is a timed test with a time limit of 10 minutes and 20 seconds, we encouraged the participants to go through the entire course and recorded their overall time to completion. This permitted us to observe improvements in time to completion, even if the candidate did not improve from a failing to a passing time. We did have one participant who, though he had a failing time, completed the test at baseline. However, at post-intervention testing, the candidate chose not to complete the entire CPAT course after failing on the first event (i.e., one that he also failed at baseline but then chose to continue). Two participants were unable to take the CPAT test at baseline due to scheduling conflicts; their post-intervention scores are listed.

**Table 2.4.** CPAT scores at baseline and post-test

| Participant | Baseline Pass/Fail | Time | Post-Test Pass/Fail | Time |
|---|---|---|---|---|
| CG-1 | P | 8:57 | P | 8:21 |
| CG-2 | P | 8:13 | P | 7:46 |
| CG-3 | P | 9:39 | P | 8:31 |
| CG-4 | F | 2:15* | F | 2:15* |
| CG-5 | -- | -- | -- | -- |
| CG-6 | F | 21:58 | F | 21:58 |
| TF20-1 | P | 10:04 | P | 9:07 |
| TF20-2 | F | 11:54 | F | 2:34* |
| TF20-3 | P | 8:36 | P | 8:19 |
| TF20-4 | F | 11:01 | P | 9:33 |
| TF20-5 | -- | -- | P | 9:20 |
| TF20-6 | -- | -- | P | 7:36 |
| TF20-7 | F | 12:32 | P | 10:20 |

P = pass (i.e., completed in 10:20 or less); F = fail; -- indicates the participant did not complete this measure. *Participant chose not to complete the entire CPAT course after failing on the first event.

## Feasibility Analysis

To examine the strengths and weaknesses of the TF20 intervention, a feasibility analysis was conducted. Participants were asked about adherence, whether they found the workouts challenging, any issues they faced, and suggestions for future exercise interventions offered at the fire academy. TF20 participants completed an average of 75% of the assigned workouts, accounting for all workouts participants completed, including those the online system did not log. Participants noted experiencing difficulties logging into the application (app) on their mobile device. They reported that sometimes the app would correctly reflect that they had completed and logged a workout but at other times the system did not save their progress after they logged out of the app.

Participants also noted it was difficult to maintain a workout regimen during the intense 12-credit-hour fire academy program. Although the exercise program was designed to be flexible so participants could complete workouts virtually anywhere, numerous participants noted they had a difficult time completing the workouts without access to a gym or fire station. Multiple participants noted that having a structured exercise program with a trained individual to lead them through workouts may be more beneficial than participants trying to work out on their own.

## Discussion

The purpose of this pilot investigation was to assess the performance outcomes, acceptability, and feasibility of an innovative FF fitness and wellness program (TF20) on FF recruits' health, fitness, and performance. We hypothesized that TF20 participants would demonstrate greater improvements in fireground performance, body composition, and strength than CG participants. Our hypotheses were partially supported. This pilot study examined the program's performance and acceptability in "real-world" conditions to determine if the TF20 training program was helpful to FF recruits as they progressed through a fire academy.

It is interesting to note that, prior to participating in the training program, all FF recruits in this study demonstrated aerobic capacity levels below that which is deemed essential for safe and effective fireground operations [29, 33]. Previous reports have stated that the most demanding FF tasks, which are also the most commonly encountered, require a mean of 41.5 ml/kg/min (in a range of 36.6 to 44.0 ml/kg/min) [33]. The WFI recommends a $VO_2$ max of at least 42 ml/kg/min to meet the aerobic demands of the job [29]. Prior to training, the FF recruits in this study possessed an estimated average $VO_2$ max of 38.9 ml/kg/min (CG mean = 39.8 ml/kg/min; TF20 mean = 38.5 ml/kg/min). After the 10-week intervention, the CG had a mean estimated $VO_2$ max of 43.8 ml/kg/min and the TF20 group had a mean estimated $VO_2$ max of 41.1 ml/kg/min.

The American College of Sports Medicine (ACSM) classifies $VO_2$ max values of between 38.0 and 41.0 ml/kg/min as within the "poor" range for males between the ages of 20 and 29 years [27]. In line with previous FF research, individuals with decreased comprehensive fitness levels (i.e., $VO_2$ max) are at an increased risk of injury, clearly showing a need to better prepare all FFs for the physical demands of firefighting [9, 15, 27]. Our study findings also support the current literature that suggests the general public is not as fit as they should be [36], thereby effectively lessening the number of those qualified for physically demanding jobs such as firefighting and other tactical occupations (e.g., military and police).

At the baseline, 67% of the CG and 80% of the TF20 group reported meeting moderate/vigorous PAGs [34]. At the end of the 10-week study, all nine of the participants that took the follow-up questionnaire (TF20 = 6; CG = 3) reported meeting or exceeding the aerobic portion of the PAGs. Four TF20 participants met the full PAGs at the baseline and at follow-up. These findings may be due, in part, to the physically demanding nature of the fire academy (e.g., climbing ladders and navigating through dark search quarters). Fireground activities may increase aerobic activity, so the nature of the fire academy itself may be the reason for the increase in reporting meeting aerobic guidelines.

The CPAT was used as a critical occupational performance measure because it (or an equivalent test) is required for employment by most fire departments across the country. TF20 participants showed marked improvement on their CPAT performance, even with a small sample size. It is possible that improvement on the CPAT was due to familiarization with fireground-related tasks in the fire academy and not the intervention itself; the only two participants who failed the test at the baseline and passed it at post-intervention were in the TF20 group. However, occupationally relevant physical agility tests are related to several fitness and body composition

parameters [16]. Thus, recruits may learn the basic FF skills while in an academy yet lack the physical fitness to pass the CPAT. This shows the importance of implementing a culture of fitness early in an FF's career. If fitness programs can be implemented at the fire-academy level, physical fitness training can become habitual for young FFs.

Results from this study show promise for utilizing TF20 as part of a fire academy-specific training program to begin instilling the importance of a physically fit fire service at the start of FFs' careers. Findings from this and other fitness intervention studies [6, 35, 36] support the development and implementation of physical training programs for FFs. Future research should examine the TF20 program in a larger population to determine whether it significantly impacts the fitness and performance of FF recruits as well as career and volunteer FFs.

## Limitations

This study was designed primarily as a pilot study, with the goals of testing the feasibility of implementing the intervention, carrying out the assessment protocol, and deriving parameter estimates from the primary outcomes and attrition. Given the pilot nature of this study, there are several limitations that should be noted, including the small initial sample size (n = 13). The fire academy from which we recruited only had a very small initial group from which we could recruit (n = 24), thus limiting our starting sample size.

Second, because this was a pilot study with minimal funding, we were limited in the amount of contact we could provide participants with and were unable to offer any incentives, unlike other exercise studies. This resulted in a third study limitation, which was high and differential attrition in the CG (50%) versus the TF20 group (0%). This high CG attrition and the small initial sample led to an even smaller post-treatment sample size for the completers' analysis (and further limited power to detect group differences in outcomes), as well as negatively

impacting our ability to address missing data using common imputation methods for ITT analysis as suggested in the Consolidated Standards of Reporting Trials (CONSORT) guidelines for clinical trials.

Another limitation was equipment availability. For example, because the site of data collection was two hours away from our laboratory, we were unable to complete $VO_2$ max tests for each participant. Instead, based on recommendations from the WFI, we used a StepMill submaximal graded exercise test to estimate $VO_2$ max. Though there are errors associated with submaximal exercise tests, a recent review article found that submaximal step tests provide a simple, effective, and valid method of submaximally assessing $VO_2$ max [37].

While weighted vests required for use in the CPAT do not elicit the same physiologic burden as firefighting in full turnout gear, the weighted vest, as well as the other equipment used in the CPAT, were designed to provide the highest level of consistency, safety, and validity in measuring each participant's physical ability and occupational readiness. In addition, they represent the recommended "gold standard" set by the IAFF/IAFC WFI for FF recruit fitness testing [24, 29]. Load carriage decreases exercise tolerance, capacity, and efficiency, although the shape (i.e., of a weighted vest vs. protective clothing) and the placement of the load do have an impact on physical performance [38, 39].

Additionally, a longer intervention (> 10 weeks) may be beneficial, as the current 10-week intervention did not show as many improvements as have some 16-week interventions [1, 36]. However, fitness improvements were found for military personnel after only 8 weeks of trainer-led circuit-based training [8], which was a suggestion from our study participants.

## Conclusion

This study is the first to systematically document the effects of TF20 and is one of few to examine FF recruits specifically. This investigation provides promising results for the feasibility, acceptability, and potential efficacy of high-intensity training programs designed for the fire service. It also provides useful information that will aid in the design and implementation of a larger randomized controlled trial and provides alternative guidance for exercise prescription specifically for FFs. Further investigation is necessary with a larger sample population to examine different types of physical training and their effects on the FF population, specifically FF recruits. Future studies should also examine the impact of load carriage on FF performance and examine the difference between weighted vests and full FF turnout gear on physiologic performance.

## Declarations

*Ethics approval and consent to participate* – The KSU IRB approved this study (IRB #8063, approved 01/04/2016); all participants provided written informed consent prior to participation.

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# Chapter 3 - Current Female Firefighters' Perceptions, Attitudes, and Experiences with Injury

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## Background

Firefighting is an inherently dangerous occupation, with high rates of injuries and fatalities. Although women are substantially underrepresented in the fire service, their numbers are growing, and research must be directed toward female-specific injuries, fatalities, and training. Nearly a quarter of a century after women first entered firefighting as a career, the NFPA reports that more than 10,000 women hold career-level fire suppression positions in nearly 1,000 fire departments in the U.S. The national annual average percentage of female career FFs from 2008 to 2012 was 3.8% (NFPA, 2015). Of the 1,134,400 career and volunteer FFs in the U.S. in 2014, 82,550 (7%) were women (Haynes & Stein, 2016).

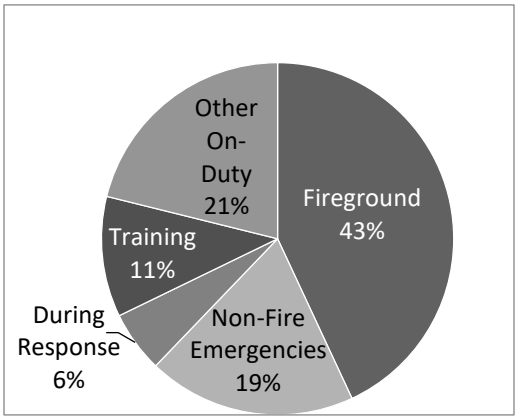


**Figure 3.1.** Injury occurrence (%; Haynes & Molis, 2016)

Firefighting has one of the highest rates of occupational injuries and fatalities (Poplin, Harris, Pollack, Peate, & Burgess, 2012). Each year, the NFPA conducts a Survey of Fire Departments for the U.S. Fire Experience to study FF injuries and fatalities in order to provide national statistics on their frequency, severity, and characteristics. Figure 1 illustrates the distribution of FF injuries in 2015.

The NFPA estimated that 68,085 FF injuries occurred in the line of duty in 2015 (Haynes & Molis, 2016). Almost half (42.8%; n = 29,130) of these injuries occurred during fireground operations, which included structure fires, vehicle fires, and brush fires, among others, and included all activities from the moment of arrival at the scene to departure time, including setup, extinguishment, and overhaul (Haynes & Molis, 2016). Approximately 13,275 injuries occurred at non-fire emergency incidents: 3,800 while responding to and returning from an incident, 7,560 during training activities, and 14,320 during other on-duty activities (Haynes & Molis, 2016). Strains, sprains, and muscular pain accounted for 52.7% of fireground injuries (Haynes & Molis, 2016). In fact, among emergency medical services (EMS), firefighting, and police occupations, sprains and strains were the leading injuries treated in U.S. hospital emergency departments between 2000 and 2001 (Reichard & Jackson, 2010). While general rates are informative, data are not reported by gender due to the small numbers of female FFs, so little is known about how the tasks and roles of firefighting impact women in the fire service.

Most emergency response activities require awkward positioning and significant exertion, increasing the likelihood of injury (Poplin et al., 2012). In order to perform fire suppression and rescue duties safely and effectively, it is necessary that FFs possess strength, stamina, and agility (Hulett, Bendick, Thomas, & Moccio, 2008). Women must be equally trained and equipped in such a way as to avoid injury and enable them to safely perform the job of an FF. However, according to iWomen, the largest organization of female FFs in the U.S., more than half (58%) of women FFs reported ill-fitting protective gear. In addition, 14% of women reported ill-fitting SCBA face pieces, a vital piece of protective gear (Hulett et al., 2008). With females representing a small percentage of the fire service, the lack of properly fitting equipment and specific training for women may be overlooked by leadership and training officers (Hulett et al., 2008; U.S.

Department of Labor, 2009). However, because there are more than 82,000 female members of the U.S. fire service (which has explicit goals for increasing diversity), it is imperative that women are as well prepared, equipped, and trained as their male counterparts.

A qualitative study was completed in 2008 that examined recruitment and retention issues in the fire service. Several reasons why the number of females in the fire service is still so low were noted, including the following: 1) discrimination and harassment; 2) recruitment; and 3) physical testing and equipment issues, echoing issues noted by iWomen nearly 20 years prior (Federal Emergency Management Association [FEMA], 1996; Hulett et al., 2008). Injury was not specifically explored in the 2008 report, but it has been suggested that the exclusion of women in the emerging scientific literature on FFs may also contribute to low rates of women in the fire service (Jahnke et al., 2012). The current study is novel because there are few systematic data on injuries among women FFs. Although the fire service has a mission of increasing diversity, current studies demonstrate that women face similar challenges as those noted more than 20 years ago (FEMA, 1996; Hulett et al., 2008; Jahnke et al., 2012).

We utilize the person–environment fit (PE-fit) model for the study of occupational stress and relate this model specifically to women in the fire service. The PE-fit model posits that when occupational demands and pressures exceed the capability of an employee to deal with them or when these demands do not align with one's morals, this "lack of fit" contributes to overburden, role ambiguity, and conflicting role demands (Quick & Tetrick, 2003, p. 187). The resulting physical and psychological stress can then lead to adverse behavioral consequences such as lower productivity, absenteeism, turnover, employee burnout, and health-related problems (Quick & Tetrick, 2003).

The present study uses qualitative methods to explore perceptions, beliefs, and attitudes regarding injury among current female FFs and key leaders from the fire service community. The aim of this research is to build upon the current literature and bridge the gap in knowledge, training, and education regarding female FFs and their experiences in the fire service by examining key themes regarding current female injury rates, experiences with injury, perceptions, and training.

# Methods

## Study Design and Measures

This qualitative study used grounded theory to develop themes based on feedback from participants. Seventy-three subjects participated in one of eight focus groups. Focus groups occurred at national conferences and in areas/departments where the research team had access to large groups of women FFs. Interviews took place with women in leadership positions across the U.S. based on recommendations from our fire service advisors. After explaining the purpose and procedures of the study, participants were provided an opportunity to ask questions. Participants then signed informed consent documentation and completed a brief demographic questionnaire. The discussion began with the question, "What are the biggest health concerns facing the fire service?" The following analysis is of the responses to that question that were related to injury, as well as the responses to specific questions regarding injury such as, "What are the biggest threats to safety [in the fire service]?" All focus groups were transcribed verbatim. After the initial question, domains covered in the sessions included task-related stress and safety, standard operating procedures (SOPs) relating to safety and gender differences, on-the-job injuries, and training differences between men and women. Responses from the resulting discussion are presented below.

### Participants

A national sample of 73 current female FFs and fire service leaders, aged 25 to 66 years, participated in this study. The number of years in the fire service (i.e., experience) ranged from 3 to 30 years. Focus groups were convened by inviting past participants from our research as well as by recruiting participants at national fire service conferences (e.g., iWomen). There were 27 female fire service leaders and 46 female FFs.

### Data Analysis Procedures

A two-phase process was used to capture the meaning behind the transcribed text, with the overall purpose of understanding major themes across and between transcripts. First, researchers reviewed the transcribed documents to develop a familiarity with the text and began a thematic analysis by searching for patterns and themes that occurred frequently in a single interview or were common across interviews. The data were then coded by identifying major patterns and themes. The use of multiple reviewers assisted in establishing the thematic framework. Next, the transcripts were uploaded to NVivo 10, a qualitative data analysis software that allows researchers to highlight and code data into "parent" nodes for overall themes and "child" nodes for subthemes. Summaries were then made within each major/parent theme. The two primary coders compared their analyses, and any discrepancies were discussed. A third researcher reviewed the findings of the two primary analyses to confirm that the summary of the findings was reflective of the data collected.

## Results

The following major themes were identified, not in order of importance or occurrence: 1) similar rates/types of injury regardless of gender; 2) the impact of working in a male-dominated field; 3) a focus on functional movement techniques/muscular endurance; 4) inadequate fire

service training; 5) ill-fitting gear; and 6) harassment affecting performance on the job. Because responses were similar across the leader and FF groups, the results were combined.

In general, participants thought that males' and females' experiences with injury types and rates were similar across genders. Perceived common injuries for females mostly included upper-body injuries—such as those of the back, neck, and shoulder—but they also noted knee and ankle injuries. Participants stated the following: "Fire doesn't discriminate. It will kill you either way, whether you're male or female"; "so, I think the danger's equal whether you're male or female," and "I think the injuries are pretty much [the same] across the board."

Others noted that females being in a male-dominated field contributed to an increased risk of injury. Being the minority group pushed women to try harder, to get stronger, and, often, to not ask for the help they need, even on tasks that, to be completed safely, required more than one person:

> I think we put ourselves at risk sometimes for trying to do more than we're capable of because of that risk of scrutiny that, you know hey, I'll go that extra mile, I'll pick up that extra piece of equipment. I'll do something instead of asking for help.

Another participant stated the following:

> [S]ometimes not wanting to ask for help, like, wanting to prove themselves so they're going to try to lift something instead of asking for help … and it's probably too heavy for them to be lifting … but they want to prove that they can do it. And … they're not using proper technique … to do things.

A different participant added the following:

> I think that we push ourselves so hard that, we are operating outside of probably what's safe for us … whether it's having to reach further to vent or um, physically, where, you

> know—something hurts and you know in your brain, "Oh crap. That's a hurt." That's just not an "I'm working too hard," and working anyways.

Participants often noted a constant need to "prove" themselves. This led to injury by taking on too great a work load or by avoiding asking for help because male workers would have concluded females were not cut out for the job even though male counterparts asked for help in similar situations.

Some of the most difficult tasks for women included activities requiring upper-body strength. Participants noted that back injuries were common for both sexes, usually due to inadequate strength and poor lifting techniques, but participants also noted shoulder, neck, knee, and ankle injuries were common among women due to a smaller body size and ill-fitting gear. A gap was also identified in traditional training methods. Often, only one method for completing a task was taught when, in reality, there are multiple different ways to complete the task, depending on the situation and the strengths and weaknesses of the crew completing that task"

> [T]here was a training exercise where you're supposed to get someone out of a window, down a ladder, and carry them down. And there was one way where your arms are across and they're lying on your arms and you're walking down the ladder, but he was, like, a wider person. He wasn't heavy, but it's just that my one arm couldn't reach.… We just had to tweak his bottle [air pack] a little this way—and, like, tilt him, and then I could reach on both sides. I'm not going to go down with my friend because we're playing training and I drop him.

Women have different musculature and often use different body mechanics when lifting, moving equipment, and doing work on the fireground. Females and males with less upper-body

strength experienced difficulty executing tasks in a traditional manner. It was suggested that alternative methods for accomplishing tasks be offered:

> You know, it's certainly peer reviewed that they could pull from. And I guess, bottom line, it's OK to admit that women are not stronger, and we accept that. We know we're not stronger, but we're going to figure out how to do it. We're going to adapt.
>
> So we're going to be smarter and use our body. Because if you're spent because you have to do a certain drill a certain way on the fireground and you're spent, then what good are you for your team for the rest of the work that needs to be done?

As mentioned previously, many participants identified inadequate training as a threat to safety and increased risk of injury. Education was identified as a limiting factor regarding training: "I think that there is a huge gap [in] fitness training. Even for the men, it's very traditional, like the CPAT and Cooper's test and push-ups, sit-ups, and military press. And women's bodies are different." Participants identified the need for training in different methods of accomplishing the same task to allow those with different body types to use a method that compliments their strengths as opposed to enhancing their weaknesses. Participants suggested females use more leg strength to complete a task where males may use more upper-body strength:

> I would say [we use] our waist and legs … our upper body is not, not as [inaudible] as theirs. I mean, we can work out all we want, but we're not going to be as strong as them up top. So, we just have to do things differently, so obviously technique. We can be just as strong, we just have to do it differently. I mean, we look funny, but we're going to do it.

Also, as FFs aged, they needed different training and techniques to accommodate their changing bodies: "… women's bodies are different, especially between 30 and 45. First of all, there are the hormonal changes …"

Another participant added the following:

> When I was 35 … what I could do at 35 and what I could do at 45 was—there was a decline from there. But then … (from 45 or 35) to what I am now, which is 48, there's an even more drastic decline. The decline is even more significant. And it could be because of injury, but I don't know.

One participant also noted that "policy and practice are two different things," when talking about what training and policies were in place to ensure safety and what was actually done on the fireground. This was an important note for higher ranking officers and the organization as a whole regarding aligning training with SOPs to ensure safety for all members of the organization.

Participants identified issues with ill-fitting gear as one of the biggest threats to safety and increased risk of injury among female FFs. Ill-fitting boots, in particular, were identified as leading to ankle injuries. Women reported that the bunker gear in their respective departments was made for males: "…you know, gear and clothing, recognizing that women and small men have not been fit properly for decades," and "…women are getting [inaudible] leftover gear, and when they buy things, they buy them in bulk…" One participant noted her department had to go through a lawsuit before they offered female-specific PPE, or bunker gear: "Our gear is good now. We had to go through unfortunately a lawsuit to, uh, make it right. But now, it's no problem with the gear. They have female's, they have men's. It fits pretty good." SCBA masks were often reported as being "unisex" but were made to fit a wider jaw, so many females with narrower faces could hardly get a good seal. It was stated that, if the mask did not seal tightly around the face, the FF had an increased exposure to inhalation hazards during a fire, where the SCBA should be their first line of defense: "…it's not correctly sized. And it does pass the fit test initially, but … there's no

smaller size available. Our faces are narrower, so that if they get stretched out in the least, they're not going to make a seal."

Harassment was an interesting factor identified as leading to injuries. Women noted that they did not have the support of their male crew members and were even threatened by them. Some of the participants interviewed reported being threatened by or made uncomfortable by male co-workers on the job. One participant said she was told, "You're just here looking for a husband." This harassment was not only inappropriate, but females noted that comments like this made them less confident and impacted their performance on the job. Participants stated that adversity to females came from both older and younger members of the fire service: "[S]ometimes I think [it was] not the older guys but some of the younger guys [that] got intimidated that a girl came in and could do the job." One participant noted, "male counterparts that don't want them [females] there" as the biggest threat to safety for female FFs:

> [T]hey'll berate you and belittle you so much that you start doubting yourself. And when you doubt yourself, and you worry, that's when you're more apt … to have an accident or get hurt. I've had firefighters tell me to my face that if they were going to hurt me or kill me … they could get me alone in a house fire. It's my word against theirs, so … you know, what are they going to do? Nothing.

One participant said, "training officers or leadership in the department have said, 'Let's make this hard enough so the women won't pass.'"

## Discussion

The purpose of this study was to explore current themes reported by female FFs related to their perceptions, attitudes, and experiences with injury to build upon what is currently known. This study exposes similar issues that have been experienced by females in the fire service for

years. Many of the issues identified in this study echo and expand on problems identified as early as 1995, when iWomen conducted its initial survey of women in the fire service (FEMA, 1996). More than 20 years later, women still represent a similar percentage of the fire service and are experiencing similar issues, exposing possible problems with the recruitment and retention of females in the fire service and identifying some issues with training and education. Our results reinforce the need for further research, as well as policy and guideline/SOP changes in the fire service to increase the possible recruitment pool of new female FFs, improving retention and providing a healthier occupational environment. Diversity education for the entire fire service is also necessary to enhance a culture of change.

A National Report Card on Women in Firefighting (2008) examined the inclusion, acceptance, training, testing, and promotion of women in fire and emergency services (Hulett et al., 2008). The study identified key factors that may act as barriers to women entering or remaining in the fire service: 1) discrimination and harassment; 2) unfair recruiting methods; 3) inadequate uniforms/equipment; 4) firehouse living; 5) sexual harassment; and 6) unfair promotional processes, all of which may be a part of an underlying workplace culture that does not fully accept female FFs. Nine years later, our research found similar themes regarding women in the fire service and, specifically, how factors that have been identified for years still impact female injury rates on the fireground, and gives insight into how we can improve these factors.

Sinden et al. (2013) conducted qualitative research about the occupational experiences of female FFs and identified similar themes including physical demands/difficulties, gender-related physiological differences, compensatory strategies, equipment mal-adaptation, earning respect, the negative attitudes of male counterparts, and the recognition of injury risk. Studies have shown that female FFs experience higher rates of injury than do male FFs, but these studies neglect to capture

the reasons behind these findings (Liao, Arvey, Butler, & Nutting, 2001; Sinden et al., 2013). Neglecting to research this subset of the population can lead to negative outcomes, as discussed in our findings. An unhealthy occupational environment, one in which the employee feels undervalued, constantly challenged, and/or undermined, leads to negative health outcomes, both physically and psychologically (Quick & Tetrick, 2003).

Women are an integral part of the workforce. Better understanding how they differ from their male counterparts in size, stature, and training requirements will allow for advances in training and equipment, increased female recruitment and retention, decreased time away from the job due to injury, and decreased injury costs for fire departments. The discrimination and harassment that women in the fire service face may affect job performance physically as well as mentally. Work-related stress has been shown to lead to decreased health (Quick & Tetrick, 2003).

As discussed above, the PE-fit model suggests that when occupational demands and pressures exceed an employee's ability to cope with them, the employee becomes overburdened and must deal with role ambiguity and conflicting role demands (Quick & Tetrick, 2003). The resulting physical and psychological stress can lead to adverse behavioral consequences such as lower productivity, absenteeism, turnover, employee burnout, and health-related issues (Quick & Tetrick, 2003). The harassment and adversity females in the fire service face may be a reason why there are still so few women in the fire service today. Correcting these issues can increase recruitment and retention within the fire service.

The current body of literature shows the need for change in the fire service with respect to female FFs. By accessing women in the fire service at various national conferences, we were able to obtain numerous responses and, as our results are similar to those of the current literature available, they are likely representative of the female FF population as a whole. In general, the

findings offer an interesting glimpse of the perceptions of the health of women in the fire service, with some unique challenges. The findings also highlight some of the similarities and differences between male and female FFs and bolster the argument for studying female FFs as a unique occupational sub-population.

### Limitations

Similar to other qualitative studies, this study has some important limitations, although the findings do mirror the results of other research. For example, our study supports previous findings that identified occupational risk factors for female FFs and the interrelationship between gender and psychosocial work factors. The interview questions were developed to elicit personal insights into the experiences of females working in a physically demanding, male-dominated field. Questions surrounding experiences with gender issues may have influenced their responses; however, the questions were developed to understand the general experiences of female FFs. The identified themes represent the synthesis and analysis of all interview questions. Also, although the focus groups and key informant interviews were drawn from a national sample of female FFs, with females representing such a small percentage of the fire service, it is possible that some "voices" of female FFs may have been missed in this investigation. Future research should focus on further examining the experiences of females in the fire service.

## Conclusion

Qualitative studies such as this one can be used to develop questions that guide future research. Further research should be directed at investigating female FFs and their performance and risk of injury on the fireground. It is important to examine how barriers faced at work affect the work climate as well as one's ability to do the job effectively. Research must also examine the negative health outcomes of a hostile work environment. Research should examine the impact

these issues have on recruitment and retention. This is a major public health issue, as females are part of the group of responders that protect communities all across the U.S. In order to better protect our communities, we must make an effort to better recruit, protect, train, and educate these first responders and those who work with them. Educating fire service trainers on diverse methods of training and accomplishing fireground tasks will ensure a more well-rounded fire service. In addition, education for the fire service as a whole regarding diversity, inclusion, and harassment in the work place is imperative.

Future research to mitigate injury should examine task components of firefighting and consider the interaction between gender and performance demands in firefighting tasks. Training is a significant opportunity in the fire service. In a job in which one depends on one's crew members for one's life, it is dangerous if there are crews that do not watch out for the entire team's safety solely because of gender differences. There is a need not only for changes in physical training but also in education and training regarding diversity in the workplace. Training programs for FFs, both male and female, must be evaluated for effectiveness and to ensure they reflect the most current training recommendations. Additional data regarding women FFs must be gathered to assess female-specific injuries, injury rates, and ways to prevent injury in this subset. Research also should be directed towards the fit of equipment and protective gear for females.

Addressing the issues identified in this study will require policy change for injury prevention. The data suggest that the fire service must include female-specific training for drills and fitness training, including strength training, with a consideration for female anatomy and musculature. The National Fire Incident Reporting System (NFIRS) needs to be organized in such a way that data can be collected with regard to women FFs. Also, the NFPA might consider collecting gender-specific data. SOPs must be reviewed by fire service leadership for relevance to

today's female fire service personnel. Given the high rates of injury among FFs and the physically demanding nature of the job, it is important to fully understand the risks. Very little data exist in the published literature focusing on injuries among female FFs.

In order for changes in knowledge and training to be effective, a significant push to include representation from organizations such as the IAFF, the fire service training leadership as represented by the International Fire Service Training Association (IFSTA), and the overall fire service leadership represented by the IAFC is critical. It is suggested that these associations be contacted with respect to this current information to request input as to the methods and information needed moving forward. By the inclusion of such methods and information, the ability to reach many more female FFs can become a reality and, by extension, conclusions and recommended changes can be disseminated to those who can affect this change.

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# Chapter 4 - An Examination of Predictors of Injury Among a National Sample of Women Firefighters

In preparation as Hollerbach, B. S., Kaipust, C. M., Poston, W. S. C., Haddock, C. K., Heinrich, K. M., & Jahnke, S. A. An examination of predictors of injury among a national sample of women firefighters.

## Introduction

Firefighting is a dangerous, occupation with high injury rates and LODDs [1–4]. The NFPA estimates 62,085 reported FF injuries occurred in the line of duty in 2016 [1]. An estimated 39.2% of these occurred during fireground operations. The leading types of injury were strain, sprain, or muscular pain (45.7%), followed by wounds, cuts, bleeding, and bruises (14.2%) [1].

FF injuries have significant costs resulting in both indirect and direct out-of-pocket expenses [2]. Research suggests the average FF worker's compensation claim is $5,168 [5]. Costs of injuries sustained by FFs nationally were estimated in 2002 to be between US$6 and 7.8 billion annually [2]. Given the high prevalence of injury and the associated costs, examining risk and protective factors for FF injury is an important topic in occupational health research.

While a wealth of research exists examining injury among male FFs, women FFs often are excluded from occupational safety and health research due to their significant underrepresentation [6, 7]. While the national annual average percentage of women career FFs from 2008 to 2012 was 3.8%, the NFPA reports that more than 12,850 women hold career-level fire suppression positions in nearly 1,000 fire departments in the U.S. [8]. Few studies have examined injury risk among women FFs. The NFPA released its first report specific to the patterns of injury among women FFs in 2017 [4]; however, unlike the NFPA's annual injury report, this women-specific report only examined injuries that occurred on the fireground and likely underestimates the prevalence of

injury among women FFs. Despite its limitations, the report found that women FFs experience similar injury types (the majority being overexertion/strain) on the fireground as those of their male counterparts [4]. Our research expands upon this women-specific injury report.

Liao et al. [9] examined predictors of injury frequency and duration in a 12-year longitudinal FF cohort (women and men; n = 171) and found that age, tenure, gender, marital status, injury type, and wage were significant predictors of injury duration, with unmarried women FFs having a 49% longer injury duration [9]. They also found that women FFs experienced 33% more injuries ($p < 0.05$; this relationship persisted even after controlling for age, race, and tenure) [9]. This study combined all FF injuries, however, which limits the ability to look at whether predictors varied by injury type.

A national qualitative study of 73 women FFs and fire service leaders identified several perceived injury predictors [6]. Participants noted being part of an underrepresented group pushed them to try harder, get stronger, and often not ask for help, even with tasks that required multiple people for safe completion. Echoing research completed nearly 20 years earlier [10], women FFs identified ill-fitting gear and inadequate training as major factors leading to fireground injury [6]. Chronic pain/injury may be more prevalent among women FFs because there is evidence that those who suffer an injury are less likely to report it due to trying to fit in or not show weakness [6].

Previous research bolsters the argument for studying women FFs as a unique occupational sub-group. Given the cost of FF injuries for individuals and departments, this has important implications for the fire service. With more than 12,850 career women FFs, it is imperative they are as well prepared, equipped, and trained as men FFs. Although the fire service has explicit goals for increasing diversity, the lack of data on the safety and health of women FFs may hinder recruitment. Our study supplements previous work by examining the largest cohort of women FFs

to date. Previous research suggests there are numerous predictors of injury among FFs including demographics such as age; health variables such as weight status, fitness, and depression; and health behaviors such as physical activity, substance use, and sleep [11, 12]. This study bridges the gap in FF injury research by examining injury type, frequency, and predictors in a national sample of more than 3,000 career women FFs.

## Methods

### Participants and Procedures

The participants were 3,012 U.S. career women FFs. Data are from the baseline assessment of the Health and Wellness of Women Firefighters Study (FEMA grant #EMW-2007-FP-02571). The project was approved by relevant IRB and compliance offices, and data were collected between July and October 2017. Surveys were distributed via the Internet for both career and volunteer FFs. Because there is not a national database of women FFs from which to sample, we carefully selected recruitment channels to capture a broad national sample of FFs. Solicitation included participants from our previous studies (including a database of more than 2,000 career women FFs [7]), distribution through "TheSecretList" (a fire service listserv with more than 300,000 subscribers worldwide), fire service media outlets and organizations, Facebook posts, and recruitment emails sent to fire service colleagues, resulting in a large diverse sample of women FFs.

### Measures

Demographics (e.g., age, race/ethnicity) and occupational history (e.g., current rank and position, years in the fire service) were collected. Fire service-specific questions were modeled

after items from the National Institute of Standards and Technology [2] review of workers' compensation data collection tools and were tailored with the assistance of fire service experts.

Injury questions were preceded with the following explanation: "The following questions are about injuries you have incurred in the past 12 months. An injury is anything for which you have completed an accident report for the department, reported to workers' compensation, or received medical care (by a physician or other medical professional)."

Participants were then told, "We would like to ask you a few questions about any injuries you might have sustained while you were working as a firefighter. We are only interested in injuries while on duty regardless of the activity you were performing." They were asked to indicate the number of injuries they sustained during the prior 12 months, similar to that which was done in previous research [11].

Injuries were dichotomized into "not injured" and "at least one injury" for use in logistic models. FFs were asked to indicate the injury type and location (i.e., on their body), duty being performed, and activity (e.g., lifting people, overhaul) in which they were engaged. Participants completed a separate description for each injury reported. For FFs who indicated an injury, the descriptions of their injuries were reviewed and classified. In many instances, FFs typed a short explanation of their injury rather than classifying it. Participants also were asked, "Have you experienced a chronic injury due to your role as a firefighter?" and the response options were "yes" or "no." If they indicated they had experienced such an injury, they were asked to provide the type of chronic injury (fill-in answers). Two members of the research team reviewed any that were not clearly classified. Participants also were asked if they missed any workdays due to injury (for injuries 1, 2, and 3) and if they were assigned any light (i.e., restricted) duty days due to injury (for injuries 1, 2, and 3).

Height (feet/inches) and weight (pounds) were collected via self-report; BMI was also calculated. Self-reported height, weight, and BMI have been found to be valid estimators in FFs [13]. BMI was categorized based on Centers for Disease Control and Prevention (CDC) cut-points: underweight (< 18.5 kg/m$^2$), normal weight (18.5–24.9 kg/m$^2$), overweight (25.0–29.9 kg/m$^2$), and obese (≥ 30.0 kg/m$^2$) [14].

Tobacco use questions were modeled after those from the Department of Defense Survey of Health-Related Behaviors Among Military Personnel [15] and the National Household Survey on Drug Abuse [16]. The following categories were used: non/never-smokers (FFs who had never smoked a cigarette, even just a puff); experimental smokers (FFs who had smoked less than 100 cigarettes in their lives); former smokers (those who had smoked 100+ cigarettes BUT none in the past 30 days); and current smokers (those who smoked 100+ AND smoked in the past 30 days) [17].

Items assessing alcohol use were modeled after common substance use questions in the U.S. population on surveys such as the National Survey of Drug Use and Health and were identical to those used in past studies of male FFs [16, 18, 19]. In the questionnaire, participants were informed that "One drink is equivalent to a 12-ounce beer, a 5-ounce glass of wine, or a drink with one shot of liquor." Binge drinking was assessed with the following item: "Considering all types of alcoholic beverages, how many times during the past 30 days did you have 4 drinks or more on an occasion?" Problematic alcohol use was measured using the CAGE questionnaire which asks questions such as, "Have you ever felt you should cut down on your drinking?" [20]. Affirmative responses were totaled for a score range of 0 to 4. Scores >2 are considered indicative of problematic alcohol use. The CAGE questionnaire has been validated [21] and used to identify problem drinking among FFs [18, 19].

Depression was assessed using the modified Center for Epidemiological Studies Short Depression Scale (CES-D 10). Total scores were calculated, and those scoring > 4 were considered in the range of concern for clinical depression. The CES-D has been found highly reliable in the general population (Spearman-Brown, split halves r = 0.85) and in patient samples (r = 0.90) [22].

A modified version of the Trauma Screening Questionnaire (TSQ) was used to assess symptoms of post-traumatic stress disorder (PTSD). Participants were asked to indicate which of 10 symptoms (intrusive thoughts, upsetting dreams, reliving of the experience, physical responses [e.g., fast heartbeat, churning stomach], sleep disturbances, irritability or angry outburst, difficulty with concentration, heightened awareness, and feeling jumpy or easily startled) they experienced in the past 12 months related to being on the job. Scores of six or more were considered to be in the range of concern for PTSD symptoms [23].

Physical activity was measured using the Self-Report of Physical Activity (SRPA) questionnaire [24, 25]. The SRPA questionnaire provides a global physical activity self-rating during the last 30 days. Participants were asked to indicate their level of physical activity on a scale of 0 (i.e., sedentary) to 7 (i.e., 3 or more hours of vigorous activity per week). We dichotomized physical activity into "heavy exercisers" (categories 6 and 7) and "not heavy exercisers" (categories 0 to 5) to examine those highly and consistently active [25]. The SRPA's validity has been established by comparing it to measured $VO_2$ max levels [24, 26].

We developed and validated a job satisfaction question about participants' role in the fire service [7]. Job satisfaction is an indicator of overall wellbeing and is related to individual health outcomes [27]. Job satisfaction was determined based on responses to the following statement: "I am satisfied with my job in the fire department." The response options included "very much disagree," "disagree," "neutral," "agree," and "very much agree." For analysis, job satisfaction

was dichotomized into “satisfied with job” and “not satisfied with job”; “neutral” was included in “not satisfied with job.”

### Approach to Statistical Analysis

Data were analyzed using SPSS Version 25 (SPSS, Armonk, NY, USA). Volunteer FFs were excluded from this analysis because firefighting is not their primary occupation. For analysis, the first three reported injuries were examined among career women FFs. Logistic regression examined associations between any injury and demographics, occupational exposures, health outcomes/behaviors (i.e., BMI, exercise, tobacco and alcohol use) and mental health variables (depression, PTSD, and job satisfaction). All models were controlled for age. Additionally, chronic injuries were examined in relation to having suffered an injury in the past 12 months. The types of chronic injuries reported were examined qualitatively, and common responses were noted.

## Results

Of the 3,686 women who began the survey, 3,012 (82%) completed the injury questions and were included in the analyses. Participants were 38.8±10.2 years of age, with an average of 13.2±8.4 years of experience in the fire service. FFs’ demographic characteristics are presented in Table 4.1.

**Table 4.1.** Participant demographic characteristics

| Characteristic | All (n = 3,012) | No injury (n = 2,058) | One or more injuries (n = 954) |
|---|---|---|---|
| Age, years M (SD) | 38.8 (10.2) | 38.7 (10.2) | 38.9 (10.3) |
| [a]Race (%) | | | |
| Non-Minority | 92.6 | 93.1 | 91.4 |
| Minority | 4.6 | 4.4 | 5.0 |
| Other | 2.8 | 2.4 | 3.6 |
| Years of Service M (SD) | 13.2 (8.4) | 12.9 (8.1) | 13.9 (8.7) |
| [b]Rank (%) | | | |
| Firefighter | 63.5 | 60.6 | 69.8 |
| Company Officer | 7.7 | 7.3 | 8.6 |
| Chief | 2.4 | 2.5 | 2.1 |
| Other | 2.0 | 2.2 | 1.7 |
| [c]Body Mass Index (BMI), $kg/m^2$ (%) | | | |
| Normal Weight | 44.9 | 47.9 | 38.3 |
| Underweight | 0.7 | 0.7 | 0.5 |
| Overweight | 34.8 | 32.8 | 39.3 |
| Obese | 19.6 | 18.6 | 21.9 |
| Physical Activity (%) | | | |
| Regular Heavy Exerciser | 56.1 | 58.0 | 51.8 |
| Not Regular Heavy Exerciser | 43.9 | 42.0 | 48.2 |
| Health Behaviors | | | |
| Smoking (%) | | | |
| Never | 44.2 | 47.1 | 37.7 |
| Experimental | 31.1 | 29.8 | 33.8 |
| Former | 18.6 | 17.1 | 21.7 |
| Current | 6.2 | 5.9 | 6.8 |
| Alcohol (%) | | | |
| ≤ 2 CAGE | 88.5 | 89.7 | 86.1 |
| > 2 CAGE | 11.5 | 10.3 | 13.9 |
| Not Binge | 65.0 | 67.3 | 60.0 |
| Binge | 35.0 | 32.7 | 40.0 |
| Depression (%) | | | |
| ≤ 4 CES-D-10 | 64.0 | 68.2 | 54.9 |
| > 4 CES-D-10 | 36.0 | 31.8 | 45.1 |
| PTSD (%) | | | |
| < 6 TSQ | 79.6 | 83.3 | 71.8 |
| ≥ 6 TSQ | 20.4 | 16.7 | 28.2 |
| Job Satisfaction | | | |
| (% agree/very much agree) | 77.9 | 79.5 | 74.3 |

[a]Race: non-minority (Caucasian) and minority (not Caucasian). [b]Rank: firefighter = firefighter, paramedic, firefighter/paramedic, driver/operator; company officer = lieutenant, captain; chief = battalion chief, deputy chief, fire chief, other chief. [c]BMI categories = underweight (> 18.5 $kg/m^2$), normal weight (18.5–24.9 $kg/m^2$), overweight (25.0–29.9 $kg/m^2$), and obese (≥ 30.0 $kg/m^2$) [13]. Missing: age (n = 0); race (n = 1); years of service (n = 734); rank (n = 734); BMI (n = 68); physical activity (n = 584); smoking (n = 11); CAGE (n = 12); binge (n = 27); depression (n = 63); PTSD (n = 60); job satisfaction (n = 91).

## Type of Injury

The most common type of injuries reported were dislocations, sprains, and strains (61.3% of all injuries), followed by superficial injuries/open wounds (21.0%) and fractures (5.5%). Details are provided in Table 4.2. Note that participants could classify one injury by choosing multiple types of injuries, so percentages may add up to more than 100%.

**Table 4.2.** Types of injuries incurred by women FFs

| **Type of injury (%)** | **Injury #1 % of injuries (n = 674)** | **Injury #2 % of injuries (n = 212)** | **Injury #3 % of injuries (n = 47)** | **% of all injuries (n = 954)** |
|---|---|---|---|---|
| Dislocation, strain, sprain | 59.2 | 66.5 | 68.1 | 61.3 |
| Superficial injury, open wound | 16.3 | 31.6 | 40.4 | 21.0 |
| Fractures | 4.9 | 7.5 | 4.3 | 5.5 |
| Concussion, internal injury | 3.0 | 3.3 | 2.1 | 3.0 |
| Thermal stress/heat exhaustion | 2.4 | 5.7 | 4.3 | 3.2 |
| Fire/chemical burn, scald, frostbite | 1.0 | 4.7 | 0 | 1.8 |
| Respiratory injury | 1.0 | 3.3 | 2.1 | 1.6 |
| Eye injury | 0.6 | 1.9 | 0 | 0.9 |
| Amputation | 0.4 | 0 | 0 | 0.3 |
| Heart attack, stroke | 0.1 | 0 | 0 | 0.1 |
| Other | 18.7 | 18.9 | 10.6 | 18.3 |

*NOTE: The percentages may add up to more than 100% as participants could select multiple responses.

The most commonly injured parts of the body included the back (22.5%), hand (17.1%), knees (16.0%), and shoulders (13.1%). Injury distribution by location on the body is represented in Figure 4.1. The three most common types of injury are listed in red.

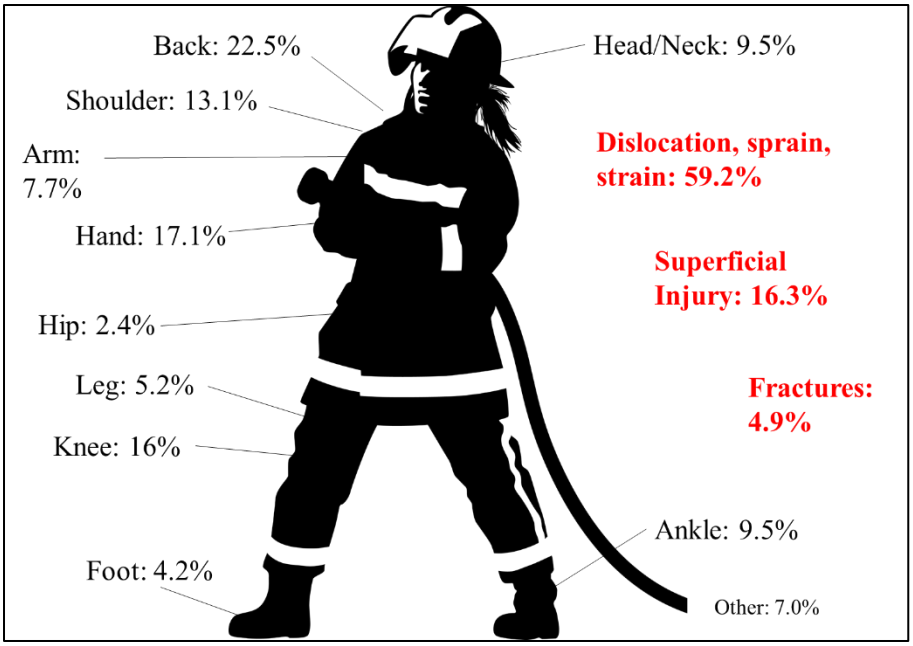


**Figure 4.1.** Location and primary type of injuries

The largest percentage of injuries occurred during training operations (24.9%), while 22.0% occurred during fire/rescue activities (see Table 4.3).

**Table 4.3.** Type of duty being conducted when injury occurred

| **Type of duty (%)** | **Injury #1 % of injuries (n = 674)** | **Injury #2 % of injuries (n = 212)** | **Injury #3 % of injuries (n = 47)** | **% of all injuries (n = 954)** |
|---|---|---|---|---|
| Training | 24.9 | 25.0 | 23.4 | 24.9 |
| Fire/rescue activities | 21.7 | 22.6 | 23.4 | 22.0 |
| On scene, non-fire | 15.6 | 19.3 | 19.1 | 16.6 |
| On-duty exercise | 9.5 | 7.1 | 6.4 | 8.8 |
| Responding/returning | 4.6 | 3.8 | 4.3 | 4.4 |
| Roadway operations | 1.3 | 0.9 | 0 | 1.2 |
| Other on-duty | 21.2 | 20.8 | 21.3 | 21.1 |

*NOTE: Percentages in table may add up to more than 100% because participants could select more than one response.

Missed workdays due to injury ranged from 0 to 365 days/injury (for the first, second, and third injury). An average of 18.3 (SD: 54.3), 15.2 (SD: 45.5), and 16.4 (SD: 52.3) days were missed due to injury 1, injury 2, and injury 3, respectively. Chi-Square analysis revealed the patterns were statistically similar ($p < 0.05$) for the first, second, and third reported injuries; therefore, only the

proportion of missed workdays by category (days missed and light duty) for the first injury are represented in Figure 4.2.

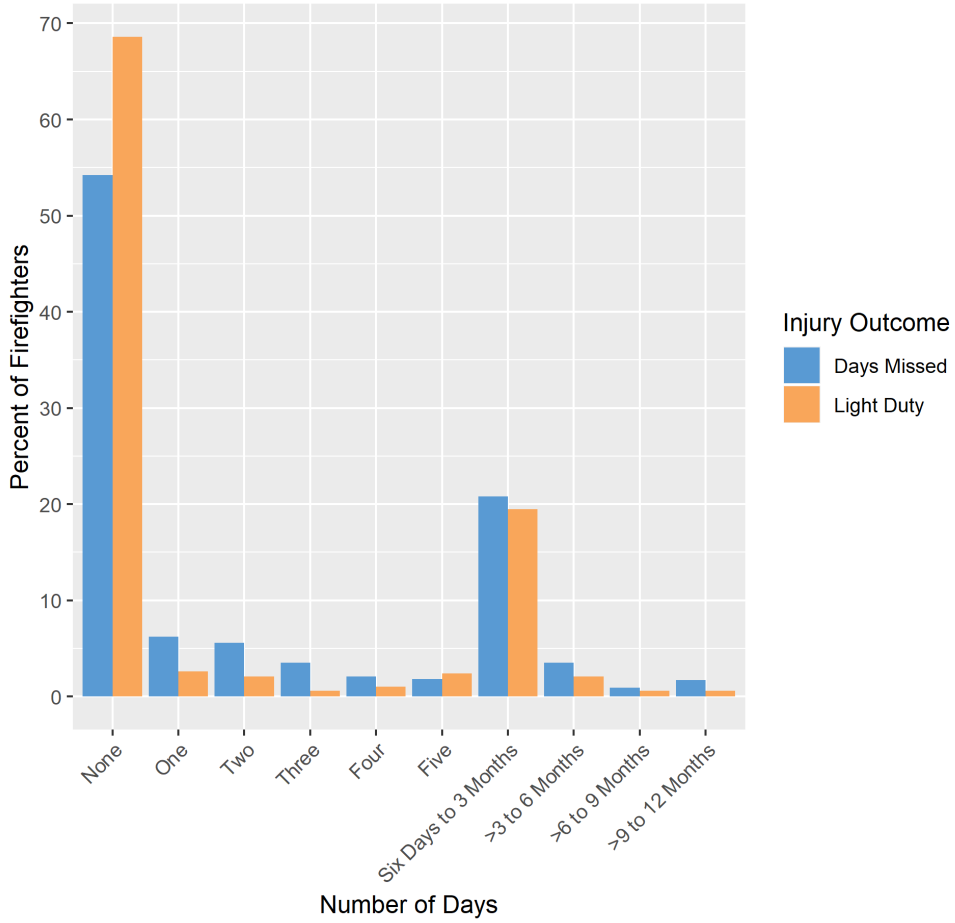


**Figure 4.2.** Missed and light duty days due to injury

Most injuries did not result in any light duty assignments (74%). Injured FFs were assigned an average of 13.2 (SD: 40.7) light duty days due to injury 1, 8.9 (SD: 29.8) light duty days for injury 2, and 9.4 (SD: 29.4) light duty days for injury 3. Patterns of light duty assignments also were statistically similar ($p < 0.05$) across all three injuries. Therefore, we also present the proportions of light duty day assignments for injury 1 in Figure 4.2.

**Risk Factors for Injury**

Table 4.4 presents the predictors of any injury (for injuries 1, 2, and 3). The odds of injury increased significantly based on BMI, physical activity, substance use, depression, PTSD, and job satisfaction (all $p < 0.05$). The odds ratios (OR) and confidence intervals (CI) are also presented in Table 4.4.

**Table 4.4.** Logistic model for predictors of any injury

| | OR (CI)[a] |
|---|---|
| Body Mass Index (BMI) | |
| Normal Weight | - |
| Underweight | 0.90 (0.33–2.51) |
| **Overweight** | **1.51 (1.26–1.80)*** |
| **Obese** | **1.48 (1.20–1.83)*** |
| Physical Activity | |
| Heavy Exercisers | - |
| **Not Heavy Exercisers** | **0.77 (0.65–0.92)*** |
| Health Behaviors | |
| Smoking | |
| Never | - |
| **Experimental** | **1.42 (1.18–1.70)*** |
| **Former** | **1.59 (1.28–1.96)*** |
| **Current** | **1.44 (1.04–1.99)*** |
| Alcohol | |
| ≤ 2 CAGE | - |
| **> 2 CAGE** | **1.39 (1.10–1.76)*** |
| Not Binge | - |
| **Binge** | **1.38 (1.17–1.62)*** |
| Depression | |
| ≤ 4 CES-D-10 | - |
| **> 4 CES-D-10** | **1.76 (1.50–2.07)*** |
| PTSD | |
| < 6 TSQ | - |
| **≥ 6 TSQ** | **1.96 (1.63–2.36)*** |
| [b]Job Satisfaction | |
| Satisfied | - |
| **Not Satisfied** | **1.34 (1.12–1.62)*** |

NOTE: All models controlled for age. *Statistically significant ($p < 0.05$). [a]Odds ratios given with confidence interval. [b]Job satisfaction: satisfied = very much agree, agree; not satisfied = disagree, very much disagree.

### Chronic Injuries

More than 25% of respondents reported having a chronic injury. Incurring an injury in the past 12 months significantly increased the odds of reporting a chronic injury (OR = 2.19; 95%CI = 1.84–2.59). Of the FFs who reported having a chronic injury, only 11.5% also reported an injury in the past 12 months, meaning most of those suffering a chronic injury had been dealing with that injury for more than a year. Most respondents suffered from chronic back, knee, and shoulder injuries. Participants also reported mental health/PTSD and cancer as "chronic injuries."

## Discussion

Our study is the first to document the prevalence and types of injuries sustained by women FFs in a large, national sample that represents nearly 25% of the estimated number of U.S. women career FFs. Our sample is demographically similar to that in previous research with men FFs [4, 11], except with regard to rank. Our sample was primarily FFs (84%), with 10% being company officers, 3% chief officers, and 3% other. In contrast, Jahnke et al. (2013) found that among men FFs, 72% held the rank of FF, while 22% were company officers, 5% chief officers, and 1% other [11]. Given that fewer of our participants reported being company or chief officers, this suggests that women FFs are not advancing into the higher ranks in the fire service in a similar manner as are men FFs.

Despite differences in rank, our sample experienced a similar breakdown of injury and duty types when compared to men FFs [1, 3, 4, 5, 11]. The most common type of injury among both women and men were dislocations/sprains/strains. Most injuries occurred during training (33.7%) or fire/rescue operations (31.2%). Nearly 43% of FF injuries in our sample resulted in missed workdays. In 2016, only 31% of a national sample of FF injuries resulted in lost work time [1].

## Correlates of Injury

Participants classified as overweight or obese according to CDC BMI cut-points [14] were statistically significantly more likely to have incurred an injury in the past year compared to normal weight individuals. In fact, overweight and obese individuals were 51% and 48%, respectively, more likely to have sustained an injury in the past 12 months. And while those that reported not participating regularly in heavy exercise were less likely to have incurred an injury compared to their heavy-exercising peers, injuries typically sustained during exercise tend to be minor strains and sprains that do not usually result in missed work days [3].

Previous research found women FFs who screened positive for problem drinking were also 42% more likely to report an occupational injury in the past year [17]. Approximately 74% of our sample consumed alcohol and 11.5% scored in the "at risk" category according to the CAGE questionnaire. Similar to previous research, those "at risk" of an alcohol problem were 39% more likely to have sustained an injury than were those not at risk. Similar to previous research [7, 16], a small proportion of women (6.2%) reported currently smoking. Nevertheless, being a current, former, or experimental cigarette user were significantly related to an increased risk of injury.

Research suggests that elevated levels of alcohol and tobacco use are related to higher rates of depression [28] and may be associated with an increased injury risk [17, 29]. Our study echoed previous research [11], with those scoring in the clinically depressed range on the CES-D more likely to incur injuries than those not depressed.

Participants that were not satisfied with their job had an increased risk of injury. Job satisfaction is an indicator of overall wellbeing and is related to individual health outcomes [27]. Reported levels of job satisfaction are, however, difficult to accurately assess. For example, women tend to report higher levels of job satisfaction even though, by many objective measures,

their jobs are worse, which could stem from having lower expectations [27, 30, 31]. Most studies find that men FFs have high levels of job satisfaction [32, 33]. Although research shows that women FFs are at an increased risk of injury due to job-related psychological and physical stressors [34], 78% of the women in our study reported they were satisfied with their job.

More than a quarter of the sample reported chronic injuries. It will be necessary to further investigate chronic injuries in the fire service with an emphasis on prevention and training. Additionally, research should examine the relationship between chronic and acute injuries sustained in the fire service, with an examination of the type of injuries, frequency of injury, and days missed due to either a chronic or acute injury.

The rates and types of injuries among women FFs should be compared to women in other tactical professions, such as the military and law enforcement, where they represent a higher percentage of the workforce. Policies for training and injury prevention in other occupations should be examined for implementation in the fire service to mitigate chronic injuries and promote the recruitment and retention of women FFs.

## Study Limitations and Strengths

Due to the cross-sectional nature of this study, it is not possible to determine the direction of the associations between injury risk and the predictors examined. Prospective studies are needed to examine injury risk among women FFs over time. Additionally, we did not examine volunteer FFs as a part of this analysis. Volunteer FFs may face different risk factors and predictors of injury and should be examined in future research.

Another limitation was the use of self-reported injury data. While collecting injury data this way has been found to be more sensitive than is reviewing workers' compensation claims or medical records [35], particularly for less severe injuries, self-reports present a different picture of

an injury than do administrative methods. For instance, the NFPA reported that nearly half of all injuries happened on the fireground, but these data come from fire departments. Department-level data collection is insensitive to less severe injuries that do not result in lost workdays or medical care. In addition, department-based data may miss FFs who are already on light duty or missing from work due to injury or those who want to avoid interaction with workers' compensation. Further, there may have been a misinterpretation of the questions based on the responses observed. Participants answered the questions regarding days missed due to injury and days of light duty assigned due to injury very similarly, leading investigators to wonder if they misinterpreted the question.

Despite these limitations, our study has a number of strengths, including being the largest national sample of career women FFs from departments across the U.S. Findings from the current study bridge a gap in the literature on FF injury with a large, national sample using well-validated measures to examine risk factors associated with injury among women FFs. We found numerous health behaviors related to injury, such as physical activity, substance use, PTSD, depression, and job satisfaction. This novel information can inform fire service policies and practices to increase the safety of all FFs.

## Clinical Significance

By examining injury among women FFs, we are better able to understand the differences between men and women with regard to injury. The identification and characterization of injury risk can help focus injury prevention efforts in the fire service. Further, an increase in the scientific literature focused specifically on women FFs can inform fire service-specific literature, such as trade journals and information presented at fire service conferences, and can increase the recruitment and retention of women in the fire service, promoting a more diverse workforce.

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# Chapter 5 - Conclusion

This dissertation and the body of work it represents has clear implications for the fire service and adds important information to the existing scientific literature, particularly for recruit and women FFs. The overall hypothesis of this work was that understudied minority groups in the fire service experience varying and differential health outcomes when compared to average U.S. men FFs. These differing behavioral health outcomes adversely impact recruit and women FFs' health. In the first study of the dissertation, we reported that FF recruits did not meet the minimal physical occupational requirements for FFs. However, after a brief physical activity intervention, FF recruits saw improvements in aerobic capacity and their ability to pass a simulated fireground test (i.e., CPAT; Chapter 2). During our investigation of the fire recruits, we noticed the low numbers of women in the fire academy, and the only woman participant in our study dropped out of the fire academy during the study. Along with my previous experience as a woman FF, this led us to further explore the experiences of women in the fire service.

Our second study (Chapter 3) examined the perceptions, attitudes, and experiences of women in the fire service, with an emphasis on exposures to and perceptions of occupational injuries. Interestingly, women identified six key themes related to injury in the fire service: similar rates and types of injury regardless of gender; the impact of working in a male-dominated field; a focus on functional movement techniques and muscular endurance; inadequate fire service training; ill-fitting gear; and harassment. The results from this study show that more than thirty years after women first entered firefighting as a career, they still face different treatment that impacts their ability to safely and effectively do their job. This qualitative analysis led us to question the rates and types of injuries women in the fire service were experiencing for our third investigation.

Our final investigation quantitatively examined the rates, types, and predictors of injury for a large national sample of women FFs (Chapter 4). This was the first large, women-specific self-report of injury data in the fire service, significantly adding to the current FF literature. Although the women in our study experienced similar types of injuries as those of men FFs, it seemed they experienced a higher rate of chronic injuries. Further, our study identified a number of significant predictors of injuries in general, including weight status (BMI), exercise amount and intensity, substance use, depression, PTSD, and job satisfaction.

In conclusion, this series of studies adds to the information currently available related to understudied groups in the fire service. This novel information can inform fire service policies and procedures regarding fitness training and injury prevention. Fitness training focused on those joining the fire service is important for improving the fitness of the recruitment pool and better preparing candidates for arduous physical fitness testing. Policies and standard operating procedures should be updated to include women in the fire service with a focus on different exercise and occupational training and movement techniques. Additional attention should be paid to decreasing injury rates among women FFs. The potential implications of our work may help better protect and support the entire fire service, as well as promote diversity.

# Chapter 6 - Appendix

## The First Twenty Periodization Scheme

Program goals: Weight loss; improved occupational performance; injury reduction through movement pattern proficiency and enhanced stabilizer capacity; anaerobic and aerobic endurance, muscular endurance, strength
Total caloric expenditure from fitness program (kcal): 20697
Total weight loss from fitness program (lb) (conservative estimate): 5.9
RT: Resistance Training
ET: Endurance Training

| Mesocycle | Week | Microcyle goal | Objective |
|---|---|---|---|
| 1 | Week 1 | GPP | Technique |
| | Week 2 | GPP / Transmutation | Foundation |
| | Week 3 | GPP / Transmutation | Foundation |
| | Week 4 | GPP / Realization | Functional / Performance |
| | Week 5 | GPP / Realization | Functional / Performance |
| | Week 6 | Active recovery | Recovery |
| 2 | Week 7 | Transmutation | Metabolic conditioning /Apparatus |
| | Week 8 | Transmutation | Metabolic conditioning /Apparatus |
| | Week 9 | Transmutation | Metabolic conditioning /Apparatus |
| | Week 10 | Realization / Tactical | Functional / Performance |
| | Week 11 | Realization / Tactical | Functional / Performance |
| | Week 12 | Active recovery | Recovery |
| 3 | Week 13 | Transmutation | Metabolic conditioning /Apparatus |
| | Week 14 | Transmutation | Metabolic conditioning /Apparatus |
| | Week 15 | Transmutation | Metabolic conditioning /Apparatus |
| | Week 16 | Realization / Tactical | Functional / Performance |
| | Week 17 | Realization / Tactical | Functional / Performance |
| | Week 18 | Active recovery | Recovery |
| 4 | Week 19 | Transmutation | Metabolic conditioning /Apparatus |
| | Week 20 | Transmutation | Metabolic conditioning /Apparatus |
| | Week 21 | Transmutation | Metabolic conditioning /Apparatus |
| | Week 22 | Realization / Tactical | Functional / Performance |
| | Week 23 | Realization / Tactical | Functional / Performance |
| | Week 24 | Active recovery / Assessment | Performance |

| Cycle Details (Resistance Training + Endurance Training) |
|---|
| Conduct Full USAFOA (record time); Practice basic movement patterns |
| Develop aerobic base / exercise technique; Apparatus circuit (RT: 2 d/wk; Mod intensity cardio: 2 d/wk-20 min-walking 3 mph) |
| Develop aerobic base / exercise technique; Apparatus circuit (RT: 2 d/wk; Mod intensity cardio: 2 d/wk-25 min-walking 3 mph) |
| Develop aerobic base / exercise technique; Functional circuit (RT: 2 d/wk; Mod intensity cardio: 2 d/wk-30 min-walking 3 mph) |
| Develop aerobic base / exercise technique; Functional circuit (RT: 2 d/wk; Mod intensity cardio: 2 d/wk-30 min-walking 3 mph) |
| Mod intensity cardio (3 d/wk-45 min-walking 3 mph) |
| Apparatus circuit (RT: 2 d/wk; Mod intensity cardio: 2 d/wk-30 min-walk 3 mph; 1 d/wk: walk w/ SCBA 20 min) |
| Apparatus circuit (RT: 2 d/wk; Mod intensity cardio: 2 d/wk-30 min-walk 3 mph; 1 d/wk: walk w/ SCBA 25 min) |
| Apparatus circuit (RT: 2 d/wk; Mod intensity cardio: 2 d/wk-30 min-walk 3mph; 1 d/wk: stair climb 8 min (2 min intervals/1 min rest)) |
| Functional circuit (RT: 2 d/wk; Mod intensity cardio: 1 d/wk-30 min-walk 3mph; 1 d/wk: stair climb 10 min (2 min intervals; 1 min rest)) |
| Functional circuit (RT: 2 d/wk; Mod intensity cardio: 1 d/wk-30 min; 1 d/wk: stair climb 12 min (2 min intervals; 1 min rest) |
| Mod intensity cardio (3 d/wk-60 min-walk 3mph) |
| Apparatus circuit (RT: 2 d/wk; Mod intensity cardio: 2 d/wk-45 min-walk 3 mph; Vig intensity intervals: 1 d/wk-walk w/ SCBA 25 min) |
| Apparatus circuit (RT: 2 d/wk; Mod intensity cardio: 2 d/wk-45 min-walk 3 mph; Vig intensity intervals cardio: 1 d/wk-walk w/ SCBA 25 min) |
| Apparatus circuit (RT: 2 d/wk; Mod intensity cardio: 2 d/wk-45 min-walk 3 mph; Vig intensity cardio: 1 d/wk-Stairclimb w/ SCBA 12 min-2 min work/1 min rest) |
| Functional circuit (RT: 2 d/wk; Mod intensity cardio: 2 d/wk-45 min-walk 3 mph; Vig intensity cardio: 1 d/wk-Stairclimb w/ SCBA 14 min (2 min work/1 min rest intervals) |
| Functional circuit (RT: 2 d/wk; Mod intensity cardio: 2 d/wk-45 min-walk 3 mph; Vig intensity cardio: 1 d/wk-Stairclimb w/ SCBA 16 min (2 min work/2 min rest) |
| Mod intensity cardio (3 d/wk-60 min-walk 3mph) |
| Apparatus circuit (RT: 3 d/wk; Mod intensity cardio: 1 d/wk-60 min-walk 3 mph; Vig intensity intervals cardio: 1 d/wk-walk w/ SCBA 30 min) |
| Apparatus circuit (RT: 3 d/wk; Mod intensity cardio: 1 d/wk-60 min-walk 3 mph; Vig intensity intervals: 1 d/wk-walk w/ SCBA 30 min) |
| Apparatus circuit (RT: 3 d/wk; Mod intensity cardio: 1 d/wk-60 min-walk 3 mph; 1d/wk stairclimb w/ SCBA 18 min (2 min work/1 min rest) |
| Functional circuit (RT: 2 d/wk; Mod intensity cardio: 1 d/wk-60 min-walk 3 mph; 1 d/wk stairclimb w/ SCBA 20 min (2 min work/1 min rest) |
| Functional circuit (RT: 2 d/wk; Mod intensity cardio: 2 d/wk-60 min-walk 3 mph) TAPER |
| Mod intensity cardio (2 d/wk-2 days: 30 min) + USAFOA |

***Perform 20 min of cardio at moderate intensity after each RT bout.**

| Resistance training (work:rest ratio); Circuit Parameters |
|---|
| **USAFOA-Turnout Gear + SCBA-on air** |
| 1:2; 30 on:60 off; 2-3 min off b/t circuits; 2 rotations; 5 exercises per circuit |
| 1:2; 30 on:60 off; 2 rotations; 5 exercises per circuit |
| 1:2; 30 on:60 off; 2 rotations; 5 exercises per circuit |
| 1:1.5; 30 on:60 off / **USAFOA-Turnout Gear + SCBA-on air** (only 1 d); 2 rotations; 5 exercises per circuit |
| 1:2; 30 on:60 off; 2 rotations; 6 exercises per circuit (*INCREASED VOL*) |
| 1:2; 30 on:60 off; 2 rotations; 6 exercises per circuit |
| 1:2; 30 on:60 off (3 rotations)(*INCREASED VOL/DECREASED RECOVERY*) |
| 1:2; 30 on:60 off; 3 rotations; 6 exercises per circuit |
| 1:2; 30 on:60 off; 3 rotations / **USAFOA-Turnout Gear + SCBA-on air** |
| 1:1.5; 30 on:45 off; 3 rotations; 7 exercises per circuit (*INCREASED VOL*) |
| 1:1.5; 30 on:45 off; 3 rotations; 7 exercises per circuit |
| 1:1.5; 30 on:45 off; 3 rotations; 7 exercises per circuit |
| 1:1.5; 30 on:45 off; 3 rotations; 7 exercises per circuit |
| 1:1.5; 30 on:45 off; 3 rotations / **USAFOA-Turnout Gear + SCBA-on air** |
| 1:1; 45 on:45 off; 2 rotations; 6 exercises per circuit (*INCREASED RT FREQUENCY / INCREASED SET TIME / DECREASED VOL*) |
| 1:1; 45 on:45 off; 2 rotations; 6 exercises per circuit |
| 1:1; 45 on:45 off; 2 rotations; 6 exercises per circuit / **USAFOA-Turnout Gear + SCBA-on air** |
| 1:0.7; 45 on:30 off; 2 rotations; 6 exercises per circuit (*DECREASED RT FREQUENCY / DECREASED RECOVERY*) |
| 1:0.7; 45 on:30 off; 2 rotations; 6 exercises per circuit (*DECREASED FREQUENCY / TAPER*) |
| **USAFOA-Turnout Gear + SCBA-on air (1 d)** |