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Physiological Profile of Rural Structural Firefighters in Southeast Georgia

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PHYSIOLOGICAL PROFILE OF RURAL STRUCTURAL FIREFIGHTERS IN SOUTHEAST GEORGIA

by

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(Under the Direction of Ronald L. Snarr)

ABSTRACT

Many occupational tasks associated with firefighting require a great deal of cardiovascular and muscular demands. However, it is often noted that firefighters throughout the country are not meeting the fitness levels required of the profession. As a result, the proportion of on-duty injury and cardiac death is greater than the general population or similar service professions. *Purpose:* The purpose of this study was to provide an extensive physiological profile of rural firefighters in southeast Georgia. *Methods:* Forty firefighters from one department in southeast Georgia underwent a comprehensive health screening, measuring anthropometrics (i.e., height, weight, waist and hip circumference), body composition, aerobic capacity, muscular strength and endurance, flexibility, lower-body power, resting heart rate, blood pressure, and pulmonary function. Additionally, blood glucose and cholesterol were obtained via blood sample. *Results:* The overall group mean for estimated VO_{2max} fell below the National Fire Protection Association (NFPA) guideline for minimal cardiorespiratory fitness ($\geq$ 42.0 ml/kg/min). Only 35% of the firefighters had an estimated VO_{2max} that met this threshold. Based on group means compared to ACSM norms, the firefighters fell into the overweight category for both BMI and BF%. Upper body muscular strength of the group was considered classified as fair, whereas, lower-body strength was well-above average. Muscular endurance and flexibility were classified in the good category. Lastly, this sample demonstrated elevated LDL concentration and prehypertension. *Conclusions:* Firefighters from this region displayed a similar health status to those from previous studies, advocating the necessity of fitness standards in the fire service. It is possible that exercise training may help improve weight status, cardiorespiratory fitness, and upper-body strength, as well as reduce LDL concentration and prehypertension among this population.

INDEX WORDS: Tactical, Health, Fitness, Strength, Endurance

PHYSIOLOGICAL PROFILE OF RURAL STRUCTURAL FIREFIGHTERS IN SOUTHEAST GEORGIA

by

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CHAPTER 1
PURPOSE OF THE STUDY

The purpose of this study was to gain insight regarding the current health status of structural firefighters in rural Georgia. It is well known that firefighters across the nation are overweight and unfit to complete duties associated with the occupation. Provided that the southern regions of the United States tend to demonstrate higher levels of overweight and obesity than the rest of the nation, it is possible that previous generalized reports on firefighter health do not accurately reflect this region. The information from this study can assist in establishing wellness and exercise programming, as well as contribute to establishing normative data.

How This Study Is Original

This study analyzed the physiological profile for structural firefighters from one rural fire department in southeast Georgia. Unlike many smaller communities, these firefighters are provided with resources to maintain basic health (e.g., fitness center, trained exercise personnel). The data gathered from this study will aid in establishing customized training regimens, focused on weaknesses demonstrated across the department. Moreover, all participants received consultation regarding the individual results from testing.

CHAPTER 2

PHYSIOLOGICAL PROFILE OF RURAL STRUCTURAL FIREFIGHTERS IN SOUTHEAST GEORGIA

INTRODUCTION

Cardiac-related deaths have accounted for the largest proportion of on-duty fatalities among United States firefighters since 1977. Despite 2017 having the lowest number of total deaths on record (n=60), sudden cardiac death remained relatively stable as the leading cause at 48% (1). The most recently published injury statistics reported 62,085 on-duty injuries, with over half (~53%) representing strains, sprains, or muscle pains (2). This data reflects the results of multiple studies and may indicate that United States firefighters are not meeting the fitness levels required for their duties. Additionally, firefighters are more prone to cardiac-related deaths than the general population (3) and employees of service professions (e.g., police, emergency medical services) (4, 5), indicating potential underlying predispositions exposing firefighters to a greater risk. Given the inherent risk associated with the profession, the leading causes of death and injury may be preventable with appropriate physical examinations and conditioning.

Furthermore, several duties of the occupation (e.g., searching, finding, and rescue dragging or carrying victims, climbing flights of stairs while donning protective equipment) require a greater energy expenditure for extended periods of time. However, the trend towards overweight and obesity for firefighters mirrors the general population (6-11). This increase in body weight and adiposity may be attributed to a large amount of sedentary time while on shift, as only 1-5% of a firefighter's duties consist of active fire suppression (12). Although there is evidence to suggest that recruits enter the force relatively fit, due to employment requirements, sedentary behaviors may often accompany time in the force and advancements in ranking. For example, Soteriades and colleagues (6) found that the average firefighter gains ~1.2 pounds per year on the force with this trend being more substantial in younger and obese firefighters. While weight gain is a result of a multitude of factors, among firefighters it has been attributed to disruptions in circadian rhythm, sedentary lifestyle, eating culture in the firehouse, and a lack of mandatory physical activity programs (9, 13).

This disproportion of fatalities that occur responding to or actively combating fires indicates that the cardiovascular demand of fire suppression places a substantial strain on the body. It has been reported that ~32% of sudden cardiac deaths occur during fire suppression, while ~31% occur during the alarm's initial response or return from the call. This is further supported by evidence that the risk of fatality increases with the physiological demand of the strenuous tasks presented during active duty (14). For example, a previous study indicated that the sympathetic response to fire suppression is initiated with the initial siren causing an immediate anticipatory response with an average heart rate increase of 47 bpm (16). Additionally, the weight of personal protective equipment and self-contained breathing apparatuses, which can weigh up to 40kg, increases workload demand, core temperature, and promotes substantial dehydration (15). Because of these conditions, firefighters can approach or exceed maximal predicted heart rates during fire suppression (16-18). Angerer et al., (18) also reported that firefighters expressed feelings of thirst, fatigue, shortness of breath, constriction, dizziness, headache, nausea, cramps, and paresthesia following simulated fire operations. Aside from an increased sympathetic response, anxiety and poor environmental conditions at the scene (e.g., air quality, visibility, deteriorating structures) can further exacerbate strain placed upon the body. Therefore, failing to meet the minimal cardiovascular requirements of the occupation, may not only compromise the safety of the general public, but also put the firefighter at-risk for a sudden cardiac event.

In an attempt to counteract the lack of physical fitness, multiple initiatives have arisen (e.g., The Fire Service Joint Labor Management Wellness-Fitness Initiative [WFI], The National Volunteer Fire Counsel's Healthy Heart Firefighter) to provide firefighters resources and knowledge to improve their health. Even with the push for mandatory training programs, the Fourth Needs Assessment (20) reported that, as of 2015, only 27% of United States fire departments provide their employees with a basic health and fitness program. This report further acknowledges that smaller, rural communities are less likely to provide these resources, primarily due to lack of funding. These programs, however, appear to be worthwhile. A study of firefighters provided a wellness program were significantly less likely to be obese and at a reduced risk of serious illness compared to those employed in departments lacking such programs (9). Additionally, firefighters with a training program also reported higher levels of physical activity and aerobic capacities ~8% greater than those without (9). Along with the lack of mandatory fitness programs, many work-related deaths are partially a result of incomplete, past due, or the absence of annual medical evaluations (11, 14).

Thus, it can be concluded that the high incidence rate of cardiac death and injuries among firefighters stems from a myriad of unhealthy behaviors and a lack of preparation for the physiological strain associated with job duties. Proper annual health screenings could easily identify areas of concern and help to provide baseline information to firefighters entering a fitness regimen. While the health status of United States firefighters is well and frequently documented, limited literature exists for those in specifically rural areas. Therefore, the purpose of this study was to provide an extensive physiological profile of career firefighters in rural, southeast Georgia.

CHAPTER 3

PHYSIOLOGICAL PROFILE OF RURAL STRUCTURAL FIREFIGHTERS IN SOUTHEAST GEORGIA

METHODS

Participants

Forty career firefighters from one department in rural southeast Georgia were recruited for this study. These firefighters are provided with a fitness center and certified personal trainers, as well as annual physical examinations intended to screen for cardiovascular, metabolic, pulmonary, and neurological disorders. At the time of this study, there was a minimally structured fitness program, including a shift training workout every three weeks and 60 minutes of self-guided exercise required for every 24 hours shift.

Firefighters were contacted through the deputy chief, whom was informed of the studies benefits, risks, and purpose. Those that expressed interest and met the inclusion criteria were further contacted to schedule data collection. To be eligible for this study, individuals must have been over the age of 18 years and a full-time active firefighter in the department. Prior to data collection, all participants completed two questionnaires (i.e., Physical Activity Readiness Questionnaire (PAR-Q) & health history) designed to screen for health risks that would preclude participation in vigorous exercise. Individuals classified as high risk according to the American College of Sports Medicine (ACSM) were not allowed to participate in any exercise testing in this study without prior medical clearance. Seven participants met this criteria; however, all were able to obtain appropriate medical documentation prior to the first visit. Additionally, individuals that currently or recently had (i.e., within the past six months) a musculoskeletal injury were exempt from any testing that could exacerbate the condition, although no participants were excluded on this basis.

The firefighters invited to participate in this study underwent a required annual physical examination during the same time frame. Data from these examinations were interpreted by an affiliated medical doctor and physician assistant. Given consent from the individuals, variables of interest from a blood panel (i.e., glucose, cholesterol) were provided to the investigators of the current study. Individuals that consented to being in the study, but did not consent to releasing the results of the separate, departmental physical examination (conducted by a general physician) were to be excluded from the analysis of any corresponding material, although all of the participants agreed to release this information. This study was approved by the university institutional review board and written informed consent was obtained from each participant prior to any and all testing.

Procedures

Firefighters scheduled two visits to the Human Performance Lab to evaluate the following: body composition, resting blood pressure, resting heart rate, pulmonary function, handgrip strength, vertical jump, and estimated aerobic capacity (VO_{2max}). Additional visits were arranged at the fitness center associated the fire department to assess muscular strength, muscular endurance, and flexibility. For each day of testing, participants were asked to refrain from exercising, eating two hours prior, along with abstaining from alcohol and tobacco use 12 hours prior. All individuals were asked to wear athletic clothing and shoes, as well as compression shorts for all body composition testing. All testing was conducted in accordance with WFI guidelines (19) adopted by the National Fire Protection Association (NFPA) or National Strength and Conditioning Association (NSCA) (21) guidelines and under supervision of trained exercise personnel.

Anthropometrics & Resting Measures

Upon arrival to the lab, participants were instructed to remove shoes and any accessories that could potentially obstruct the accuracy of any of the body composition devices (e.g., jewelry, hats, and socks). Height and weight were measured using a standard physician’s stadiometer (Cardinal Detecto Physician’s Scale, Webb City, MO) and an electronic scale (TBF300 WA, Tanita Corporation, Tokyo, Japan), and used to calculate body mass index (BMI). Waist and hip circumference were measured using a standard cloth tape and measured around the narrowest portion of the torso, between the umbilicus and the xiphoid process (waist) and around the largest portion of the buttocks (hip). Body composition was assessed via the WFI 3-site skinfold test, which consists of measurements taken at the site of the triceps, chest, and subscapular regions. All measurements were taken by the same experienced technician. Resting heart rate was obtained via ECG after five minutes of quiet rest in a supine position; while, resting blood pressure was taken after an additional five minutes of seated rest during both sessions at the Human Performance Lab. Blood pressure was measured in accordance with the *Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7*), where values obtained between the two measurements were averaged, and the mean blood pressure was reported for analysis.

Pulmonary Function

Forced expiratory volume over one second (FEV_1) and forced vital capacity (FVC) were measured via spirometery (Biopac MP36, Biopac Systems, Inc., Goleta, CA) and performed in a seated position. Participants wore a nose clip to ensure exhalation occurred entirely through the mouth. The test administrator instructed the participant to forcefully exhale into the spirometer. The test administrator also verbally encouraged the participant through the direction of the three second exhalation. FEV_1 and FVC was tested three times, and the highest values were recorded.

Aerobic Capacity

Aerobic capacity (VO_{2max}) was estimated following the Gerkin submaximal graded treadmill protocol. A three minute warm up period at 3 mph was provided. Heart rate was continually monitored (Polar T31/T34 Non-Coded Chest Transmitter, Polar Electro Inc., Bethpage, NY), and the test was terminated once the participant met one of the following criteria: 1) exceeded the target heart rate (i.e., 85% of age predicted maximal heart rate) for 15 seconds; 2) following 18 minutes of testing; 3) displayed signs of any abnormal distress (i.e., chest pain, nausea, confusion, etc.); or 4) upon request. For any individual that was on a medication that could affect heart rate response, a rating of perceived exertion of 13 on the Borg scale was used for test termination criteria. Following termination, the participant cooled down for a minimum of three minutes at 3 mph. Estimated VO_{2max} was calculated as: 56.981 + (1.242 x test time) - (0.805 x BMI) (19).

Muscular Strength, Endurance, and Power

Handgrip strength of the dominant and non-dominant hands was measured using a Jamar Hydrologic Handgrip dynamometer (Biometrics Ltd., Newport, United Kingdom). The test administrator ensured that each participant maintained an elbow flexion of 90 degrees and provided verbal encouragement for the 3-second test. Three trials were performed per hand, alternating between each trial with 30 seconds of rest in between each trial. The highest values were recorded for analysis.

Muscular strength of the upper and lower body were evaluated utilizing the bench press and leg press, respectively. Estimated 1-repetition maximum (1-RM) was calculated based on a 3-repetition maximal (3-RM) strength test using the equations provided by the NSCA: (a) %1-RM = 100 - (# of repetitions * 2.5); (b) Estimated 1-RM = weight lifted / (%1-RM / 100). A minimum of two spotters were present on each side of the bar during all bench press attempts, and a trained exercise professional administered the test to ensure that the participant maintained proper form. If exercise technique was improper, the administrator corrected form, and the participant attempted lifting the weight again after two minutes rest. A warm up was allotted, consisting of 8-10 repetitions of 50% of body weight. The participant was given two minutes rest as the test administrator added 2.27-4.54 kg to the bar. If the participant was able to lift the added weight at least 3 times, another rest period was given and an additional 2.27-4.54 kg was added. This process occurred until the participant could no longer perform 3 repetitions with correct form. This protocol was used for both the bench press and leg press exercises.

Muscular endurance of the upper body was assessed through a two minute push up test. Participants were instructed to perform push ups to a metronome set at 80 bpm until muscular fatigue. A ~12.7 cm box was placed underneath the chin as a guide for the participant on the lowering phase. The test administrator ensured that the participant maintained correct form, and terminated the test when the participant was unable to keep pace with the metronome, performed 3 consecutive incorrect push ups, or reached the two minute cut-off time.

Participants also performed a static, forearm plank until fatigue to determine muscular endurance of the trunk. The test administrator terminated the test once the participant declared volitional fatigue or was unable to maintain correct form (i.e., improper body alignment). Per the WFI protocol, the test was automatically terminated after 4 minutes, which three participants achieved. Time until termination was recorded.

Lower-body power was assessed through vertical jump on a switch mat (Just Jump!, Probotics Inc., Huntsville, AL). Participants performed three countermovement jumps as high as possible, with instruction to reach arms towards the ceiling on the ascent. The best trial was included in data analysis.

Flexibility

Flexibility of the lower back and hamstrings was measured using a standard sit-and-reach box. Participants sat on the ground with their shoes off and back flat against a wall and were instructed to bend at the hips, pushing the measurement gauge as far forward as possible in a slow and controlled movement. Test administrators ensured that participants maintained extended legs throughout each trial. Three trials were conducted, and the highest value was incorporated into the results of this study.

Statistical Analysis

Data was analyzed using IBM SPSS Statistics 25 (IBM Corp., Armonk, NY). Descriptive statistics (mean±SD) and frequency analyses were performed on all variables and compared against normative values established by the ACSM (22).

CHAPTER 4

PHYSIOLOGICAL PROFILE OF RURAL STRUCTURAL FIREFIGHTERS IN SOUTHEAST GEORGIA

RESULTS

All firefighters recruited for this study agreed to participate (n=40), however, only 39 were used in VO_{2max} or blood analysis due to time conflict and inaccurate reading. Demographics and anthropometric data are included in Table 1. Frequency distributions of age and years of service are displayed in Figure 1.

Table 1. Descriptive statistics of rural firefighters in southeast Georgia.

	Mean ± SD	Max	Min
Age (yr)	34.18 ± 8.86	56	21
Service (yr)	9.95 ± 8.87	38	1
Height (cm)	178.90 ± 5.81	193.04	167.64
Weight (kg)	93.16 ± 14.98	133.17	68.49
BMI (kg/m2)	29.13 ± 4.74	45.98	21.67
WC (cm)	95.51 ± 10.94	124.46	76.84
HC (cm)	108.67 ± 7.13	121.92	95.89
W:H Ratio	0.88 ± 0.06	1.02	0.79

Note: BMI= Body mass index; WC= waist circumference; HC= hip circumference; W:H= waist to hip ratio.

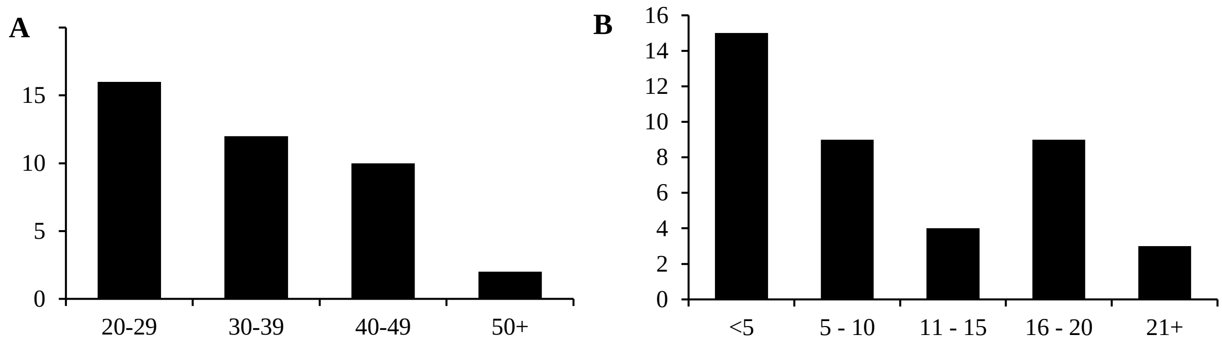

Figure 1. Frequency distribution of age (A) and years of service (B) of firefighters in rural Georgia.

Health Metrics

Values for body fat percentage, resting heart rate, resting blood pressure, cholesterol, blood glucose, and pulmonary function are included in Table 2. Data indicates that the mean group systolic blood pressure was considered elevated, whereas diastolic was stage 1 hypertensive. While no participant presented signs of diabetes, three individuals demonstrated blood glucose concentrations representative of prediabetes. Total cholesterol, HDL, and triglycerides were reported within healthy ranges, although values obtained for LDL were considered just above optimal concentrations (i.e., 100-129 mg/dL). Moreover, the mean pulmonary function was within normal ranges for 37 (93%) participants.

As shown in Figure 1, the vast majority of participants included in this study were considered to be either overweight (38%) or obese (43%). Only 20% were considered to be a normal weight status based on BMI, and 33% had a normal body fat percentage when adjusted for age.

Table 2. Health metrics of rural firefighters in southeast Georgia.

	Mean ± SD	Max	Min
BF%	23.92 ± 6.10	33.7	8.6
SBP (mmHg)	128.28 ± 12.16	159	114
DBP (mmHg)	81.25 ± 6.11	96	69

RHR (bpm)	66.38 ± 11.70	89	44
Total Cholesterol (mg/dL)	175.42 ± 31.86	245	117
HDL (mg/dL)	44.12 ± 11.98	92	21
LDL (mg/dL)	110.26 ± 29.86	179	48
TG (mg/dL)	95.69 ± 63.02	387	29
Blood Glucose (mg/dL)	88.90 ± 7.66	116	78
FEV1 (L)	3.86 ± 0.87	5.59	2.26
FVC (L)	4.64 ±1.05	7.22	2.59
FEV1:FVC	83.48 ± 7.76	99.63	67.71

Note: BF%= body fat percentage; SBP= systolic blood pressure; DBP= diastolic blood pressure; RHR= resting heart rate; HDL= high-density lipoprotein; LDL= low-density lipoprotein; TG= triglycerides; FEV1= forced expiratory volume over 1 second; FVC= forced vital capacity.

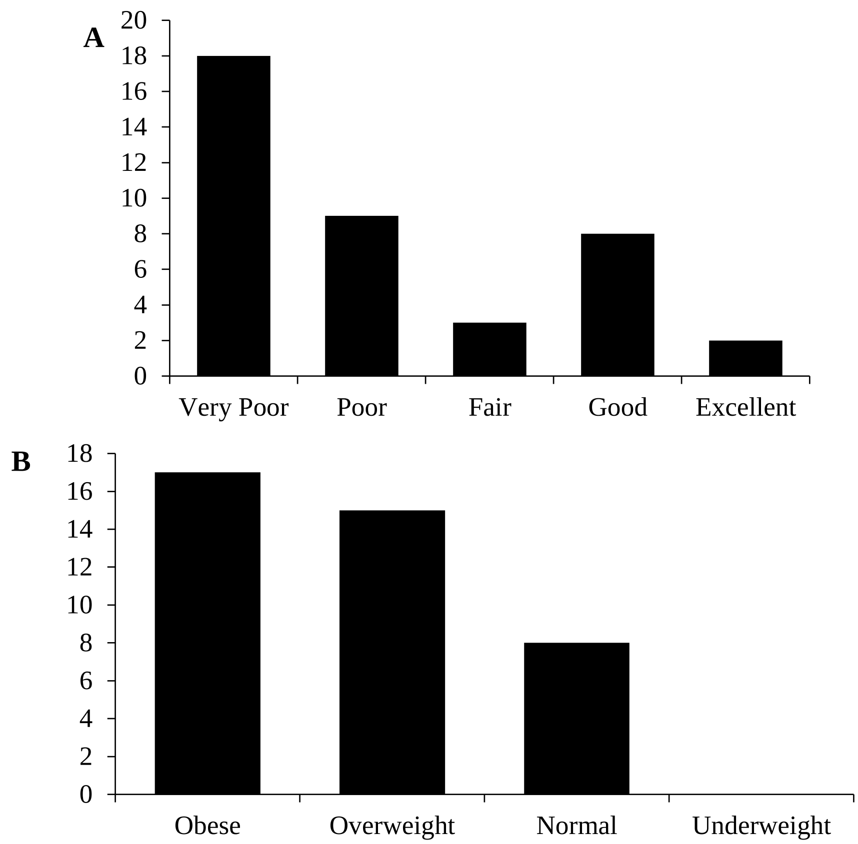

Figure 2. Frequency distribution of body fat percentage (A) and body mass index (B) classifications among rural firefighters in southeast Georgia.

Performance Metrics

Data associated with performance is represented in Table 3. The group mean estimated VO_{2max} was just below the 42 mL/kg/min threshold set forth by the NFPA (15). While only 33% (n = 13) of participants achieved this value, 56% (n = 22) were considered to be within the 35-41 mL/kg/min range, suggesting a fitness consultation. An additonal three were classified between 28-34 mL/kg/min indicating prescription may be necessary, and one individual was below 28 mL/kg/min. It may be worth noting, however, that when compared to an age-matched general population, 33% were considered to have poor aerobic capacity.

Frequency distributions of muscular strength are shown in Figure 3. The mean lower-body strength among this sample was considered well-above average when compared to age-matched healthy males. In contrast, upper-body strength was considered fair, and the average total handgrip strength of both hands combined was considered poor. Furthermore, muscular endurance of the upper-body was reported as very good, and trunk flexibility was considered fair. Although there are no established normative values for plank, a 2010 study stratified 401 firefighters based on time held until failure. When compared to these age-matched peers, the department from this study was below average (23).

Table 3. Performance metrics of rural firefighters in southeast Georgia.

	Mean ± SD	Max	Min
Est. VO2max (mL/kg/min)	41.39 ± 4.57	50.18	25.84
Vertical Jump (cm)	48.26 ± 11.32	72.64	25.15
HGSdom (kg)	42.27 ± 7.37	56.82	25.45
HGSnondom (kg)	39.76 ± 9.20	56.36	14.09
HGScombined (kg)	82.03 ± 15.91	111.36	48.18
Bench Press Est. 1-RM (kg)	90 ± 24	143	49
Leg Press Est. 1-RM (kg)	232 ± 72	454	113
Plank (s)	102.57 ± 57.69	240	39.25
Pushups (reps)	23 ± 10	48	3
Sit and Reach (cm)	29.22 ± 8.30	47	12

Note: HGSdom= handgrip strength of dominant hand; HGSnondom= handgrip strength of non-dominant hand; HGScombined= sum of dominant and non-dominant handgrip strengths; 1-RM= 1-repetition maximum.

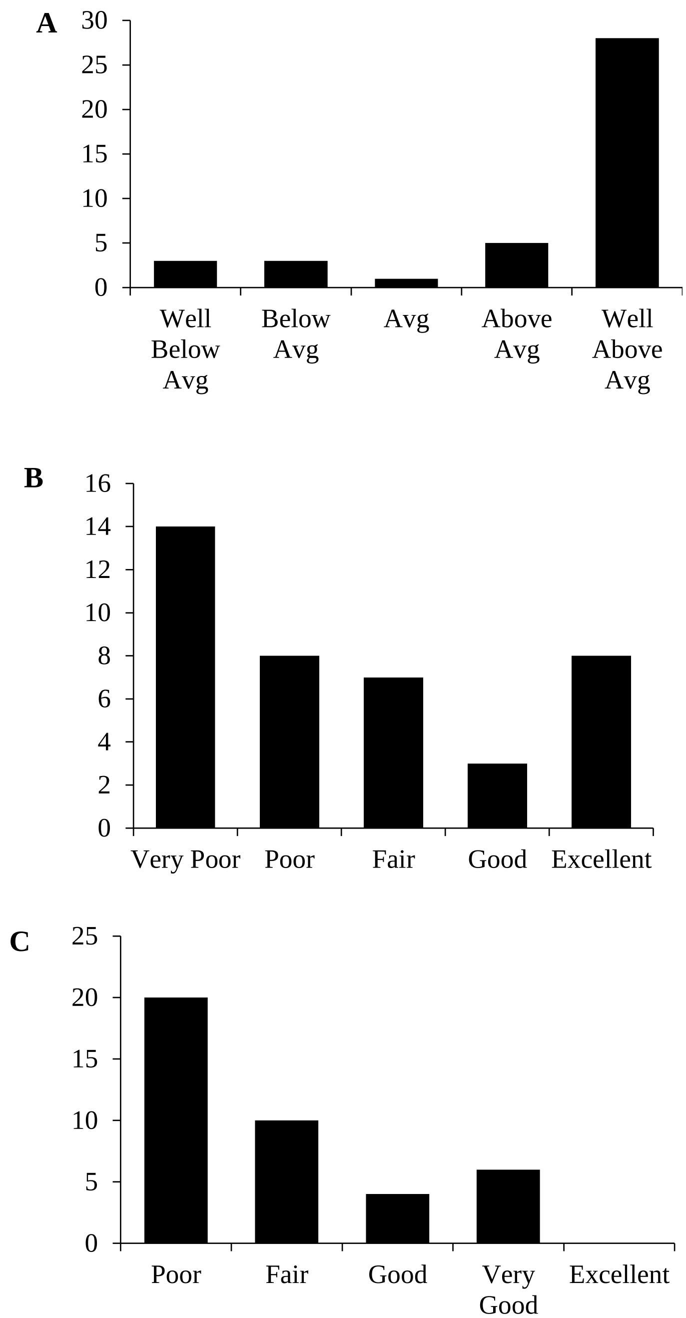

Figure 3. Frequency distribution of lower-body strength (A), upper-body strength (B), and handgrip strength (C) classifications among rural firefighters in southeast Georgia.

CHAPTER 5

PHYSIOLOGICAL PROFILE OF RURAL STRUCTURAL FIREFIGHTERS IN SOUTHEAST GEORGIA

DISCUSSION

Although firefighting is an incredibly strenuous profession, many firefighters do not meet fitness levels required of various essential job tasks. Coupled with this, departments across the nation lack the appropriate resources to maintain basic fitness and wellness (20). This may attribute to the increased risk of on-duty cardiovascular incidents and injury among this population (1,2). While the health status of career firefighters is well documented, little research is contributed from rural regions or the southeastern United States. Therefore, the purpose of this study was to provide a physiological profile of career firefighters in rural, southeast Georgia.

Somewhat concerning, but not unique to this sample, was the high presence of overweight and obesity. Nearly all previous literature among this population reports a similar overweight status when using BMI as the criterion (7-10,24-28). While there is often discrepancy over the use of BMI, particularly among muscular individuals, measures of BF% also classified this cohort as overweight or obese. This metric is of particular importance, as past research has reported poorer job performance among those with a high BMI or BF% (28-31), and that overweight or obese firefighters tend to demonstrate multiple other impaired health parameters (e.g., blood pressure, cholesterol, aerobic capacity) (8). Moreover, excess adipose tissue is considered a risk factor for many disorders, including cardiovascular disease, of which this population is already at a heightened risk (12).

Other risk factors for cardiovascular disease reported in this study include blood glucose, cholesterol, and blood pressure. In regards to blood glucose, the vast majority of participants fell within normal levels, which may be a result of the NFPA's guidelines on employing diabetic firefighters. For example, uncontrolled diabetes is considered, by the NFPA, to be a Category A medical condition that would preclude the individual from performing as an active member of the department. Although LDL concentration was slightly above desirable levels, cholesterol was otherwise considered within healthy ranges. Furthermore, in line with previous studies on firefighters, this sample was considered to have elevated blood pressure (systolic) or stage 1 hypertension (diastolic) (7,8,10,24-28). These values are consistent with previous literature that demonstrates an estimated two-thirds of emergency responders displaying an impaired blood pressure (32). Possible explanations may be attributed to the increased stress associated with this occupation, comorbidities of obesity, and frequent exposure to harsh noises (e.g., sirens) (32). Although some of these factors are inevitable, regular exercise and lifestyle modifications (e.g., weight loss and diet) may promote a more desirable LDL concentration and blood pressure (22).

Another important health metric for occupations requiring strenuous, prolonged physical activity is aerobic capacity (i.e., VO_{2max}). The average estimated VO_{2max} obtained from this sample was slightly below the ideal threshold established by the NFPA (i.e., 42 mL/kg/min) (15). Firefighting occupational tasks have been shown to require a VO_2 demand of up to 44 mL/kg/min (33, 34), and failure to meet the recommended guidelines can impair job performance in critical high-intensity situations. Furthermore, firefighters with lower levels of aerobic fitness have shown more cardiac abnormalities during exercise testing (35) and appear to be at a greater risk of injury (36) than more fit counterparts.

Additionally, the cohort in this study was considered to have well-above average lower-body strength, fair upper-body strength, poor handgrip strength, and very good upper-body endurance. It may be worth noting that these comparisons are made against the general population and that firefighters likely require greater levels of fitness. For instance, this profession requires carrying heavy loads while climbing multiple stories, navigating machinery overhead, and victim rescue; thus, high levels of muscular strength and endurance are also to be expected. For example, while upper-body endurance was considered ‘very good’ by ACSM standards, the firefighters in this study performed worse on the push up test than those from previous studies (27, 28, 31). In a controlled setting (i.e., fitness center) the firefighters in this study also demonstrated an average upper body strength of 90 ± 24 kg. Gledhill and Jamnik (15) have reported forces associated with the profession can reach up to 68 kg, indicating that some tasks may require individuals from this department to work at 75% of maximal capacity for an extended period of time. Increased emotional distress and the addition of protective gear worn at fire grounds may also increase workload demand; thereby, causing an earlier onset of fatigue as compared to the controlled testing environment. Furthermore, the high incidence rate of sprain, strain, and muscular pain reported among firefighters is likely a result of poor movement patterns exhibited among this population (37) or insufficiently trained firefighters exerting themselves beyond physical capability (2, 38).

While aerobic and anaerobic conditioning are important for all individuals, long-term exposure to harsh environmental factors, that may be specific to tactical athletes, may play a larger role in overall health and well-being. For example, firefighters experience greater exposure to smoke, gases, and other chemicals that can be harmful when inhaled. Therefore, monitoring pulmonary function is critical to detecting dysfunction at an early stage. Overall, this department displayed normal levels of pulmonary function as compared to the general population. A possible explanation could be the distribution of age, as well as years of service among this cohort. Provided that 60% had 10 years or fewer of service, it can be assumed that these individuals may have had less exposure than their more experienced counterparts.

As with any study, this investigation did have its limitations. Although receiving verbal encouragement and multiple trials when appropriate, it is possible that some participants did not provide true maximal efforts on some of the performance tests. Additionally, there is very limited, if any, literature supporting the validity of multiple tests in the WFI (i.e., 3-site skinfold locations, estimated VO_{2max}). For example, the Gerkin protocol, used to estimate VO_{2max} in this study, has shown to overestimate aerobic capacity among less fit firefighters and underestimate among more fit by an error margin of 11% (39, 40). Finally, many participants were on medications that could interfere with heart rate (e.g., blood pressure, anxiety) and subsequently affect values obtained for multiple variables (e.g., resting heart rate, estimated VO_{2max}).

CHAPTER 6

PHYSIOLOGICAL PROFILE OF RURAL STRUCTURAL FIREFIGHTERS IN SOUTHEAST GEORGIA

CONCLUSIONS

The results from this study add to the abundance of literature advocating for mandatory health initiatives and fitness standards in the United States fire service. While the firefighters in this study were generally comparable to those from previous research, multiple metrics (e.g., body fat percentage, upper-body and handgrip strength, flexibility, aerobic capacity) were considered average or below average when compared to the general population. This data indicates that firefighters from this region may particularly benefit from training programs focused on weight reduction, as well as improving cardiorespiratory fitness and upper-body strength. Moreover, these results can aid in establishing much needed normative data for firefighting populations.

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APPENDIX A- PARTICIPATION FORMS

HEALTH HISTORY QUESTIONNAIRE

Name *(Last, First, M.I.):*		◻ **M** ◻ **F**	**DOB** *(xx/xx/xx):*	**Age:**
Emergency Contact *(name):*			*(phone):*	

HEALTH HABITS AND PERSONAL SAFETY	
ALL QUESTIONS CONTAINED IN THIS QUESTIONNAIRE ARE OPTIONAL AND WILL BE KEPT STRICTLY CONFIDENTIAL.	
Aerobic Exercise	◻ Sedentary (No exercise)
	◻ Mild exercise (i.e., climb stairs, walk 3 blocks, golf)
	◻ Occasional vigorous exercise (i.e., work or recreation, less than 4x/week for 30 min.)
Resistance Training	◻ No experience and not currently training (never resistance trained)
	◻ Some experience and not currently training (have trained in the past but not currently)
	◻ Currently Training (total body ≥ 2 days per week)

PERSONAL HEALTH HISTORY

Check if you have, or have had, any symptoms in the following areas to a significant degree and briefly explain.

◻	Allergies	◻	Chest Pain or Shortness of Breath	Briefly explain if you checked any boxes to the left:
◻	Arthritis	◻	Back Pain	
◻	Asthma	◻	Orthopedic Problems	
◻	Diabetes	◻	Recent Surgery	
◻	Dizziness	◻	High Blood Pressure	
◻	Epilepsy	◻	Dysmenorrhea (females only)	
◻	Migraines	◻	Pregnant* (currently)	

List your prescribed drugs or medications you take on a regular basis		
Name the Drug	Reason	Frequency Taken

Please check the box below to state you are have answered all of the questions above to the best of your knowledge and wish to participate in the physical activity requirements of the class.			
☐	Print Name:	Signature:	Date:

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their physician before they start becoming more physically active. ***Please complete this form as accurately and completely as possible.***

PAR-Q FORM Please mark YES or No to the following:	**YES**	**NO**
Has your doctor ever said that you have a heart condition and recommended only medically supervised physical activity?	______	________
Do you frequently have pains in your chest when you perform physical activity?	__	__
Have you had chest pain when you were not doing physical activity?	__	__
Have you had a stroke?	____	___
Do you lose your balance due to dizziness or do you ever lose consciousness?	__	__
Do you have a bone, joint or any other health problem that causes you pain or limitations that must be addressed when developing an exercise program (i.e. diabetes, osteoporosis, high blood pressure, high cholesterol, arthritis, anorexia, bulimia, anemia, epilepsy, respiratory ailments, back problems, etc.)?	__	__
Are you pregnant now or have given birth within the last 6 months?	__	__
Do you have asthma or exercise induced asthma?	__	__
Do you have low blood sugar levels (hypoglycemia)?	__	__
Do you have diabetes?	____	___
Have you had a recent surgery?	__	__

If you have marked YES to any of the above, please elaborate below:

Do you take any medications, either prescription or non-prescription, on a regular basis? Yes/No

What is the medication for? ____

How does this medication affect your ability to exercise or achieve your fitness goals?

Please note: If your health changes such that you could then answer YES to any of the above questions, tell your trainer/coach. Ask whether you should change your physical activity plan.

I have read, understood, and completed the questionnaire. Any questions I had were answered to my full satisfaction.

Print Name:____________________Signature: ________________________

Date: ________________________

Release of Medical Information
PHYSIOLOGICAL PROFILE OF RURAL FIREFIGHTERS IN SOUTHEAST GEORGIA

I, ____________________________________, release the results of my full blood panel to the investigators of the study Physiological Profile of Rural Firefighters in Southeast Georgia. I understand that this information will be kept confidential and de-identified for storage.

Printed name: _______________________________________

Signature: ____ Date: ___________________

APPENDIX B: INFORMED CONSENT

WATERS COLLEGE OF HEALTH PROFESSIONS

DEPARTMENT OF HEALTH SCIENCES AND KINESIOLOGY

Informed Consent

PHYSIOLOGICAL PROFILE OF RURAL FIREFIGHTERS IN SOUTHEAST GEORGIA

You are being invited to participate in the **Physiological Profile of Rural Firefighters in Southeast Georgia** study. The purpose of this study is to provide a comprehensive physiological profile of career firefighters in rural, southeast Georgia. The primary investigator, Emily Langford, is a current Master's student at Georgia Southern University. You may contact her with questions at any point by phone (586-623-2991) or by email (el02241@georgiasouthern.edu). For questions concerning your rights as a research participant, contact Georgia Southern University Institutional Review Board at 912-478-5465.

Your participation in this study is completely voluntary and you may end your participation at any time by telling the primary investigator, Emily Langford. Please understand that you do not have to answer any questions that you do not want to answer. You may withdraw from the study at any time without penalty. The investigator may in her absolute discretion terminate the investigation at any time. You will not receive any compensation for this study and you will not be responsible for any additional cost of this study.

You are invited to participate if you are:

- A full time employee of a fire department in southeast Georgia
- Over the age of 18
- Not currently pregnant
- Fluent English speaker

There is no deception involved in this study. As a participant in this study, you will receive information regarding your current health status. Data obtained from this study may be used to help researchers and departments understand the current health status of firefighters from this region. Given this information, departments may choose to address weaknesses and structure training regimens appropriately.

If you agree to participate in this study you will be asked to come to the Human Performance Lab in Hanner Fieldhouse for 2 visits and the City Gym for a minimum of 1 visit. Visits to the Human Performance Lab should last approximately 30 minutes to 1 hour, and total testing at the City Gym should last approximately 1.5 hours. During these visits we will assess the following:

<u>Human Performance Lab:</u>

- Height, weight, and body composition via a stadiometer, a scale, and a variety of different body composition methods.
    - Body fat percentage will be measured 6 different ways. The most basic method will consist standing on a metal scale. One method involves being pinched in 7 different locations (i.e., upper chest, arm, stomach, hip, thigh, upper back, and side of the body underneath the arm). Two methods involve the application of electrodes to your hands and wrists. Another method will require you to sit still in a small chamber for approximately 3 minutes. Lastly, one technique will perform a low dose x-ray of your entire body.
- Hydration status
    - A small urine sample will be requested to determine hydration status.
- Handgrip strength
- Vertical jump
- Resting blood pressure, heart rate, and ECG
- Lung function
    - You will be asked to exhale forcefully through a small tube for ~5 seconds.
- Aerobic capacity
    - Cardiorespiratory endurance will be measured using a submaximal test. For this test, you will walk or jog on a treadmill until your heart rate reaches a predetermined limit based upon your age. Each minute of testing, the treadmill will alternate increasing speed or grade until completion.
    - <u>This will be done during the second visit to the Human Performance Lab.</u>

<u>City Gym:</u>

- Muscular strength
    - Upper and lower body strength will be assessed using the bench press and leg press, respectively. You will be asked to perform a test will only allow you to lift a weight a maximum of 3 times, and from that we will estimate your 1-repetition maximum
- Muscular Endurance
    - Trunk endurance will be measured by performing a plank until fatigue. To assess upper body endurance we will ask you to perform push ups at a set pace. The test will stop upon fatigue or automatically after 2 minutes.
- Flexibility
    - Lower back and hamstring flexibility will be assessed using a sit and reach test. To assess trunk flexibility we will ask you to lie face down on the floor and raise your upper body as far off the ground as you can. To assess shoulder flexibility we will ask you to lift your arms above your head while still lying on the floor.
- Mobility
    - Dr. Melton or Dr. Ryan will determine your mobility through a functional movement screen (FMS). During this test you will be asked to perform a deep squat, hurdle step, in-line lunge, straight leg raise, push up, and specific tests for rotary stability and shoulder mobility.

This study has few risks involved:

- There is a risk of muscle soreness and fatigue commonly associated with exercise which is no greater than a traditional exercise routine.

- Muscle soreness may occur during the days after testing.
- General feelings of fatigue, light-headedness, and general discomfort.
- Injuries, such as strains and sprains, can also occur during body weight training.
- Additionally during traditional resistance training, there is a risk of the barbell falling on your chest during the movement.
- There is minimal radiation exposure with the dual energy x-ray absorptiometry (DEXA).
- Risk of allergic reaction to skin adhesives.

Risks will be minimized by:

- Monitoring you during measurements and making sure you are comfortable at all times.
- Stopping procedures if you appear uncomfortable during measurements (i.e., unable to complete
  exercises due to fatigue, appear dizzy or lightheaded, etc).
- Stopping the test if you show any signs or symptoms of illness.
- Having trained personnel present during all testing.
- Having 2 spotters to guide the barbell and aide in lifting.
- Individuals that have had a high dose x-ray in the past 12 months will not participate in the DEXA scan.

I understand that medical care is available in the event of injury resulting from research but that neither financial compensation nor free medical treatment is provided. If needed, Georgia Southern University Health Services can be reached at (912) 478-5641 and is located at 984 Plant Drive on the Georgia Southern campus.

Only the investigators of this study will have access to your complete data set. Previously collected data will be de-identified using a random number generator to maintain confidentiality. You will not be identified by name in the data set or any reports using information obtained from this study, and your confidentiality as a participant will remain secure. Subsequent uses of records and data will be subject to standing data use policies, which protect the anonymity of individuals and institutions. Data from this study will be stored in an investigator's office and maintained in a de-identified manner for future use.

If you sign this document, you give permission to the investigators of this study at Georgia Southern University to use or disclose (release) your health information that identifies you for the research study described here: A Physiological Profile of Rural Firefighters in Southeast Georgia. The health information that we may use or disclose (release) for this research includes the results of your physical examination: your body composition, aerobic capacity, pulmonary function, ECG, blood pressure, and cholesterol.

The health information listed above may be used by and/or disclosed (released) to:

- Dr. Ron Snarr (Co-Principal Investigator),
- Dr. Greg Ryan (Investigator), and
- Dr. Bridget Melton (Investigator)

Georgia Southern University is required by law to protect your health information. By signing this document, you authorize Georgia Southern University to use and/or disclose (release) your health information for this research. Those persons who receive your health information may not be required by Federal privacy laws (such as the Privacy Rule) to protect it and may share your information with others without your permission, if permitted by laws governing them.

You must be 18 years of age or older to consent to participate in this research study. If you consent to participate in this research study and to the terms above, please sign your name and indicate the date below.

You will be given a copy of this consent form to keep for your records. This project has been reviewed and approved by the GSU Institutional Review Board under tracking number H19098.

Title of Project: Physiological Profile of Rural Structural Firefighters in Southeast Georgia

Principal Investigator: Emily Langford, Hollis 1104A, 912-478-5979, el02241@georgiasouthern.edu
Faculty Advisor: Dr. Ron Snarr, Health Sciences & Kinesiology, P.O. Box 8076, 912-478-5979, rsnarr@georgiasouthern.edu

____ ______________________

Participant Signature Date

I, the undersigned, verify that the above informed consent procedure has been followed.

____ ______________________

Investigator Signature Date

APPENDIX C: IRB APPROVAL

Georgia Southern University
Office of Research Services & Sponsored Programs

Institutional Review Board (IRB)

Phone: 912-478-5465
Fax: 912-478-0719
IRB@GeorgiaSouthern.edu
Veazey Hall 3000
PO Box 8005
Statesboro, GA 30460

To:	Langford, Emily; Snarr, Ron; Ryan, Greg; Melton, Bridget
From:	Office of Research Services and Sponsored Programs
Initial Approval Date:	3/12/2019
Expiration Date:	2/28/2020
Subject:	Status of Application for Approval to Utilize Human Subjects in Research – **Full Medical Board Review**

After a review of your proposed research project numbered **H19098**, and titled **"Physiological Profile of Rural Firefighters in Southeast Georgia,"** it appears that (1) the research subjects are at minimal risk, (2) appropriate safeguards are planned, and (3) the research activities involve only procedures which are allowable. You are authorized to enroll up to a maximum of 75 subjects.

Therefore, as authorized in the Federal Policy for the Protection of Human Subjects, I am pleased to notify you that the Institutional Review Board has approved your proposed research.

Description: The purpose of this study is to provide and interpret an extensive physiological profile of career firefighters in a rural southeast region of Georgia.

If at the end of this approval period there have been no changes to the research protocol; you may request an extension of the approval period. In the interim, please provide the IRB with any information concerning any significant adverse event, **whether or not it is believed to be related to the study**, within five working days of the event. In addition, if a change or modification of the approved methodology becomes necessary, you must notify the IRB Coordinator **prior** to initiating any such changes or modifications. At that time, an amended application for IRB approval may be submitted. Upon completion of your data collection, you are required to complete a *Research Study Termination* form to notify the IRB Coordinator, so your file may be closed.

Sincerely,

Eleanor Haynes

Eleanor Haynes
Compliance Officer

APPENDIX D: LITERATURE REVIEW

PHYSICAL FITNESS INITIATIVES IN THE FIRE SERVICE: BARRIERS, BENEFITS, AND CONSIDERATIONS

INTRODUCTION

Firefighters across the United States are not meeting the recommended fitness levels based on the cardiovascular and metabolic demands of the occupation. Recent statistics indicate that firefighters are at an increased risk of cardiovascular incidents or injury (11, 17), which may stem from the strenuous nature of the profession combined with a high prevalence of overweight and obesity (28). Although recruits are required to undergo extensive training programs, many departments fail to uphold the same fitness standards among active firefighters. As individuals settle into firehouse culture, unhealthy behaviors (e.g., lack of physical activity, poor sleep habits, unhealthy diet) may arise and leave firefighters physically unprepared for duty (16). While many of the governing bodies of the United States Fire Service (e.g., National Fire Protection Association (NFPA), International Association of Fire Chiefs (IACF), International Association of Firefighters (IAFF)) encourage mandatory annual health screenings and on-duty exercise, only an estimated 27% of United States departments actually provide such resources (13). Therefore, the purpose of this article is to identify the barriers and benefits of training initiatives among professional firefighters.

BARRIERS

Intrapersonal

Barriers to physical training may occur at the individual or departmental level. A qualitative study analyzing the perception of training initiatives identified that firefighters may avoid working out while on shift for fear that it could interfere with response to an emergency call (20). For instance, it was reported that training on-duty was avoided as to not arrive at a scene fatigued. While this is a major concern for firefighters, a study by Dennison et al., (10) sought to examine the effects of exercise on occupational performance. To represent a worst-case scenario, participants engaged in simulated fireground tasks (i.e., stair-climb, hose drag, equipment carry, ladder raise, forcible entry, and search and rescue) 10 minutes following a fatiguing protocol.

Results indicated that while exhaustive exercise hindered fireground performance, physically trained firefighters outperformed their untrained counterparts, even in a fatigued state. Thus, it has been recommended to avoid exhaustive exercise (e.g., near max lifts) while on-duty or to exercise during low call volume times (1).

Another potential barrier is that many firefighters are unaware of their current health status. Baur et al., (4) reported that of 768 professional firefighters, approximately 68% underestimated their respective BMI classification. Moreover, firefighters self-perceived fitness levels did not align with actual fitness measured by aerobic capacity (26). Due to this lack of personal awareness, the perceived need to improve health may be diminished (31). Through the provision of mandatory health screenings and appropriate consultations, firefighters can potentially identify these weaknesses and begin improving upon poorer components of health.

Interpersonal

Similarly to the general population, lack of self-motivation and ambivalence are frequently reported deterrent to exercise among firefighters which can be highly influence by social groups such as the firehouse culture (6). One recent study noted the negative impact food cultural such as snacking, grazing and eating out can influence on exercise routines in the firehouse (22).

However, interpersonal relationships can also have a positive influence on fitness. Competition and camaraderie appear to be particularly strong motivators among this profession (20, 21). It is possible that the initiation of group-based exercise sessions may improve exercise adherence, shift cohesion, and create a sense of accountability. Additionally, firefighters can become certified Peer Fitness Trainers through organizations, such as the American Council on Exercise, qualifying them to lead such sessions.

Institutional

One prominent barrier from the departmental level is a lack of funding, especially among many smaller communities (13). However, a lack of space or equipment should not be considered an impediment to exercise. Although supplying each station with fitness equipment may be unfeasible, recommended alternatives include incorporating one centralized location, involving a contracted fitness center, or utilizing available outdoor space (18). Moreover, body weight exercises and plyometrics can sufficiently improve strength and force production (9), with the addition of firehouse equipment (e.g., stairs, hoses, chains) to be used as external weight when appropriate. Grants are also available from organizations, such as the United States Fire Administration, intended for the promotion of health initiatives.

BENEFITS

Physical Health

Firefighters have shown to demonstrate multiple impaired health metrics, including increased levels of adiposity, hypertension, and dyslipidemia (7, 14). This is of concern, as each is considered a risk factor for cardiovascular disease. Of particular importance, high blood pressure has been shown as a strong predictor of fatal cardiovascular incidents (14). Fortunately, lifestyle changes, such as increased physical activity and improved diet, can help promote favorable body composition and blood panels. Additionally, more fit firefighters have shown less cardiac abnormalities during stress testing (5) and less injury prevalence (27) than less fit counterparts.

Many previous studies have evaluated the efficacy of training initiatives among the fire service. For example, a study by Poston and colleagues (29) sought to determine the benefits of health promotion programs within the fire service. In this study, researchers compared 10 departments that complied with multiple crucial components of the IAFC and IAFFs' Wellness Fitness Initiative (WFI) to 10 departments that did not. Results indicated that the departments that provided employees with annual health screenings, a health and fitness coordinator, peer fitness trainers, and time to exercise while on-duty tended to demonstrate more desirable physical, behavioral, and mental health. More specifically, WFI compliant departments were 42% less likely to be obese and more likely to be cognizant of current weight status. Additionally, these firefighters reported more physical activity, greater estimated aerobic capacity (VO_{2max}), job satisfaction, and lower incidence of hypertension.

Likewise, a recently published meta-analysis by Andrews and colleagues (3) calculated that exercise interventions among firefighters were capable of eliciting significant moderate-to-large improvements in body fat percentage (-7.73%), aerobic capacity (+8.7%), endurance (+17.61%), strength (+8.83%), and power (+5.28%). Controls, in contrast, demonstrated a <1% mean change in the same metrics, with the exception of strength (+2.48%). Furthermore, the authors concluded that a program structured around resistance training may be the most efficacious among firefighters, as those studies in particular observed the greatest number of improvements. It may be worth noting that while exercise improved four of the five components of physical fitness, non-significant improvements were reported for flexibility. These results, coupled with those from Cowen (8), may suggest that emphasizing flexibility training (e.g., yoga) may be necessary for improving flexibility or mobility.

Job Performance

Departments may also benefit from health promotion programs as it applies to improved job performance. Occupational tasks can require high amounts of aerobic fitness (≥44 $mL \cdot kg^{-1} \cdot min^{-1}$) and muscular strength (≥68 kg) for extended periods of time (15). Adding strain caused by the environment (e.g., heat, anxiety, dehydration), these tasks are performed in protective gear weighing at least 23 kg (25). If a firefighter is physically unable to execute these tasks in harsh conditions, the safety of the public, engine, and self are placed at risk.

Provided the physical demand associated with the job, it is apparent that more fit individuals better execute job tasks. To further support this, an abundance of previous literature has reported associations between fitness and job performance. For instance, Michaelides et al., (23) found that upper-body and abdominal strength, upper-body endurance, and anaerobic power all contributed to enhanced performance on time to completion of a simulated fireground test (i.e., stair climb, rolled hose lift and move, Keiser sled, hose pull and hydrant hookup, mannequin drag, charged hose advance). Whereas, performance decreased with increased resting heart rate, body mass index, body fat percentage, age, and waist circumference. This is in agreement with the findings of Rhea and associates (30), which indicated that upper-body strength and endurance, lower-body endurance, and sprint time were associated with time to completion of a similar test (i.e., hose pull, victim drag, stair climb, equipment hoist). These results lend support to the notion that physical training is essential for peak job performance.

Economic

Training programs may also appeal to departments from an economical standpoint. Seven years post implementation, the WFI reports that despite a 5% increase in total injury claims, the average cost per claim decreased by 23%. In comparison, non-WFI compliant departments observed a 22% increase in claims and a 35% increase in average cost per claim. Moreover, engaged departments demonstrated fewer missed days and less of an increase in total incurred costs than those not. While a study by Poston and colleagues (29) surprisingly found that departments complying with multiple components of the WFI reported higher workers compensation claims than non-compliant, the authors note that these claims may be a result of more physical activity or that these firefighters were more comfortable reporting injuries.

In agreement with these findings, another study by Poston et al., (28) identified that the number of missed work days due to injury was proportional to increasing weight status/body mass index. Subsequent costs associated with these absences ranged from ~$5,076 for healthy weight firefighters to ~$25,271 for those that were class I or II obese. With that, there was no difference in the prevalence or type of injury between healthy and overweight or obese firefighters. Additionally, poor physical fitness has been reported among the leading causes of on-duty injury (24).

CONSIDERATIONS

While implementing fitness programs for the fire service is essential to increasing health and wellness measures, several considerations are warranted prior to their adoption. For instance, a needs assessment should be performed to determine available funds and resources. Additionally, fitness assessments should be performed to identify weaknesses in physical capabilities, though results should not be used for punitive purposes. These assessments may also screen for firefighters at high risk for disease, and clear employees for physical activity before beginning a program. Data collected from these assessments can further provide information regarding weaknesses among the department as a whole, and funds can be allocated where deemed most necessary.

Other considerations should be made in terms of optimal training styles. As previously discussed, resistance training should account for a large proportion of regimens among this population (3). Tactical athletes, though, may find functional or circuit training modalities appealing, as they stress both the aerobic and anaerobic systems and transfer well to job specific requirements. Furthermore, they also require less time commitment, less costs, and can be modified for varying skill levels. To evaluate the physiological responses to circuit training compared to actual fireground tasks, Abel et al., (2) monitored blood lactate and heart rate before and following an extensive training circuit. Participants completed two rotations of the following exercises interspersed with 30 seconds rest: cable pulldown, seated row, leg press, shoulder press, deadlift, step-up, wood chop, 1 arm cable pull, step-up, push-up, and abdominal crunch. While heart rate was comparable to performing smoke-diving tasks, it did not elicit a heart rate response similar to fire suppression tasks. Therefore, these results imply that circuit training may be an appropriate training stimulus for firefighters; although, this form of exercise should be periodized with an additional emphasis on higher-intensity cardiovascular exercise.

While exercise has shown beneficial, it is important that individuals also learn fundamental movement patterns. Strain, sprain, and muscular pains caused by overexertion are consistently among the leading causes of injury within the service (17), and are often accompanied by poor mobility or flexibility (19). Frost et al. (12), emphasized the role of corrective exercise techniques in a study comparing the movement patterns of firefighters while completing typical movements associated with the occupation (i.e., lifting from floor to waist height, squat, lunge, push, pull). Participants were categorized into either a standard exercise group, with emphasis on promoting performance and peak fitness; a movement-guided training group, with emphasis on execution of key movement patterns (e.g., spinal control); or a control group. Following 12 weeks of training, both exercise groups demonstrated improvements in body composition, aerobic capacity, grip strength, upper-body endurance, lower-body power, and flexibility. The movement-guided group, though, exhibited less spine and frontal plane knee motion during occupational-related tasks. It is within reason to speculate that these adaptations could result in fewer injuries. Given this information, training initiatives should strive to teach proper form and the avoidance of potentially harmful movement patterns.

PRACTICAL APPLICATIONS

Provided the aforementioned benefits of physical training programs, it is apparent that fire departments should implement and actively support exercise initiatives. Barriers of physical health initiatives can often be overcome, and the benefits can occur in health, performance, and economic domains. Baseline health screenings are encouraged to identify weaknesses and contraindications to exercise, although results should not be used for punitive purposes. Furthermore, functional or circuit style training modalities may be particularly efficacious among this population, given the reduced cost and time commitment, as well as the transfer to job specific tasks. Finally, programs should ideally be under supervision of experienced personnel who emphasize the importance of correct movement patterns.

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