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Cardiovascular Health Intervention in Firefighters

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Dedication

This thesis is dedicated to Steve Terry, a fallen firefighter of Hernando County.

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I would like to thank my primary advisor Dominic Stross for all of his help during this process. I would also like to thank Dr. Thomas Gollery for all of his help in interpreting my data. I would lastly like to thank Jennifer Terry for all of her support throughout this thesis.

Abstract

As each year passes, a fatal cardiovascular event continues to be the leading cause of death among on-duty firefighters. Risk factors for a fatal cardiovascular event and cardiovascular health disease (CVD) are obesity, sleep deprivation, weight gain, lack of exercise, unhealthy diet, etc. The research in this thesis lays out the poor association between cardiovascular health and firefighters. Interventional programs that aim to improve the cardiovascular health of firefighters must be implemented universally to all fire departments by the International Association of Firefighters. Pertinent information collected on the cardiovascular health of surveyed firefighters of Hernando County was paradoxical. While most of the surveyed firefighters identified themselves as in optimal cardiovascular health, the collected data stated otherwise.

KEY WORDS: Firefighters, Cardiovascular Health, Cardiovascular Health Disease, Fatal Cardiovascular Event, Firefighters of Hernando County, Firefighting, Risk Factors for Cardiovascular Health Disease, Risk Factors for Fatal Cardiovascular Event, Heart, Interventional Programs on Cardiovascular Health, CVD

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Chapter 1: Introduction

Throughout history, there has been an association between poor cardiovascular health and firefighters. Since 1977 (excluding 2001), the primary cause of death among on-duty firefighters was a fatal cardiovascular event. The profession of firefighting is very dangerous and uncertain. In general, an individual's risk of a fatal cardiovascular event is greatly correlated with their physical health and lifestyle. A firefighter must be in ace health so that the tasks of firefighting can be completed in a safe and efficient procedure.

The purpose of this thesis is to evaluate the cardiovascular health of surveyed firefighters of Hernando County. In the Review of Literature section, risk factors of poor cardiovascular have been identified. It was found that the primary risk factor of poor cardiovascular health is obesity. Furthermore, in the Review of Literature, interventional programs that aim to improve the cardiovascular health of firefighters have been researched. Through the plethora of information, possible interventional programs that aim to minimize the number of firefighter deaths annually due to a fatal cardiovascular event will be proposed by the end of this thesis.

This study is both significant and relevant because not only does poor cardiovascular of firefighters affect the firefighter themselves, but it also affects the people around them. If a firefighter does not have exhibit optimal cardiovascular health, this can put other firefighters and the general public at risk. In the profession of firefighting, time is very valuable. It is necessary for firefighters to reach their place of need as quickly as possible. Once the firefighters reach their place of need, they need to respond to the need as quickly as possible. Poor cardiovascular health of firefighters can increase the time of response to an emergency. This can lead to unfavorable outcomes occurring that could have been prevented.

To assess the cardiovascular health of surveyed firefighters of Hernando County, a questionnaire of 33 questions was created. The questionnaire consisted of collected demographical information as well as open-ended, Likert scale, and yes or no questions relating to the topic at hand. The questionnaire was entirely anonymous and voluntary. The questionnaire was sent out to all firefighters of Hernando County via email by the Hernando County Fire Chief.

The primary limitation of this thesis is that it is not representative of the entire firefighter population as this study was only conducted on the firefighters of Hernando County. Also, there was a small turnout rate of 8.5% for the questionnaire. However, the strength of this thesis is that it obtained statistically significant results on the cardiovascular health of the surveyed firefighters. The collected information contained connected associations of poor cardiovascular health and firefighters. While most of the surveyed firefighters did not consider themselves as at risk for a fatal cardiovascular event and/or cardiovascular health disease (CVD), the accumulated data told a different story.

Review of Literature

Introduction

The purpose of this literature review is to present current knowledge on the cardiovascular health of firefighters as well as display possible methods of treatment in hopes of generating a reliable program and/or protocol for firefighters with poor cardiovascular health. After conducting research throughout various databases, discovering a plethora of articles, and organizing each article by their similarities, five general categories were found that serve as the components of this review of the literature. First, an overview of the heart will go over the structure of the heart as well as common complications of the heart. Second, firefighters' history of poor cardiovascular health is an issue that needs to be addressed. Third, the risk factors of cardiovascular disease will need to be carefully written out. Fourth, an overview of the Candidate Physical Ability Test (CPAT) will be discussed. Fifth, prevention programs that reduce the risk factors of cardiovascular complications in firefighters will serve as a form of treatment in this population. It is reasonable to assume that more and more firefighters will die due to cardiovascular complications if interventions or treatments are not implemented. Therefore, it is critical to understand each category in order for an effective exercise program and protocol that works against the risk factors of cardiovascular complications to be implemented in the near future for this specific population.

An Overview of the Heart

The human heart has a complex structure that allows it to function. The heart can be found anatomically in the thoracic cavity between the third and sixth intercostal cartilages (Miranda, 2018). Structurally, the heart is composed of four chambers that are either closed or opened by several valves. These chambers and valves serve to ensure the regular flow of blood throughout the body. The chambers of the heart are called atria and ventricles. There is a right and left atrium and a right and left ventricle. The atria compose the upper region of the heart, and the ventricles compose the lower region of the heart. These chambers are closed off from one another by valves located in the heart. These valves separate the atria from the ventricles. The valves of the heart include the tricuspid valve, mitral valve, pulmonary valve, and aortic valve. The tricuspid valve is found between the right atrium and right ventricle (Newman, 2020). The mitral valve is found between the left atrium and left ventricle (Newman, 2020). The pulmonary valve is found between the right ventricle and pulmonary artery (Newman, 2020). The aortic valve is found between the left ventricle and aorta (Newman, 2020). The tricuspid and mitral valves are considered as the atrioventricular valves of the heart. The pulmonary and aortic valves are considered as the semilunar valves of the heart. A wall of tissue called the septum also separates the right and left atria and ventricles from each other (Newman, 2020). The heart's walls contain three different types of tissue (Newman, 2020). The tissues are the epicardium, myocardium, and endocardium. The epicardium is the outer layer of the heart (Newman, 2020). The myocardium is the middle layer of the heart, and it is the thickest layer among the three different types of tissue (Newman, 2020). The endocardium is the innermost layer of the heart (Newman, 2020). Many arteries and veins compose the heart. These arteries and veins include the aorta, superior and inferior vena cava, pulmonary arteries, pulmonary veins, coronary veins, circumflex artery, left coronary artery, left anterior descending artery, and right coronary artery. The veins bring deoxygenated blood back to the heart and the arteries deliver oxygenated blood throughout the human body.

The heart functions to circulate blood and distribute oxygen throughout the body (Miranda, 2018). The circulation of blood in the heart begins when deoxygenated blood enters the superior and/or inferior vena cava (Davis, 2020). The superior and inferior vena cava delivers and empties this blood into the right atrium (Davis, 2020). From here, the right atrium contracts and the blood flows from the right atrium to the right ventricle through the tricuspid valve (Davis, 2020). When the right ventricle can no longer receive any more blood, the tricuspid valve closes (Davis, 2020). This mechanism is to ensure that blood does not backflow during circulation in the heart (Davis, 2020). Next, the right ventricle will contract, and the pulmonary valve will open. This valve opening will allow the blood to flow through the pulmonary valve and into the pulmonary arteries (Davis, 2020). The pulmonary arteries will transport the blood to the lungs where the deoxygenated blood will become oxygenated (Davis, 2020). In the lungs, the carbon dioxide in the deoxygenated blood will be exchanged for oxygen (Davis, 2020). From here, the newly oxygenated blood will be transported through the pulmonary veins to the left atrium (Davis, 2020). As the left atrium contracts, the blood will flow to the left ventricle through the mitral valve (Davis, 2020). When the left ventricle is full, the mitral valve will shut (Davis, 2020). Once this occurs, the left ventricle contracts and the aortic valve opens (Davis, 2020). The blood will flow through the aortic valve to the aorta, where the blood will be carried through arteries to all regions of the body (Davis, 2020). Eventually, the oxygenated blood will become deoxygenated and will be transported by veins back to the heart, where this cycle will begin once again (Davis, 2020). To note, a protein molecule in blood called hemoglobin is what allows for blood to become oxygenated again in the lungs (Davis, 2021). Hemoglobin serves to exchange carbon dioxide for oxygen in the lungs during the cardiac cycle (Davis, 2021).

The complex network of circulation is directed by electrical impulses in the heart (Newman, 2020). The sino-atrial node is located on top of the right atrium. At the sino-atrial node is where the first electrical impulse begins (Newman, 2020). This signal is what causes the atria to contract which forces blood to flow into the ventricles (Newman, 2020). The atrioventricular node is located between the atria and ventricles. When the electrical impulse travels from the sino-atrial node to the atrioventricular node, the atrioventricular node signals the ventricles to contract (Newman, 2020). The atrioventricular node also acts as a gatekeeper by coordinating the electrical impulse to be slightly delayed (Newman, 2020). This is necessary so that the atria and ventricles do not contract at the same time (Newman, 2020). After the electrical impulse allows the ventricles to contract, the sino-atrial node sends a signal to the atria to contract and the cycle repeats (Newman, 2020).

Blood pressure can be obtained by measuring systole and diastole of the heart. Systole is when the ventricles contract and the atria relax (Newman, 2020). This leads to the atria being filled with blood (Newman, 2020). Diastole is when the atria contract and the ventricles relax (Newman, 2020). This leads to the ventricles being filled with blood (Newman, 2020). When an individual takes their blood pressure, two values will be recorded. The higher value is the systolic pressure, and the lower value is the diastolic pressure of the heart. Systolic pressure measures the amount of pressure in the arteries during systole (Newman, 2020). Diastolic pressure measures the amount of pressure in the arteries during diastole (Newman, 2020). Normal blood pressure is any value at or less than 120/80 mmHg (Newman, 2020). Also, normal heart rhythm can fall anywhere between 60-100 beats per minute (Newman, 2020).

Cardiovascular disease (CVD) is the number one cause of death in the world (WHO, 2021). CVD is a group of disorders of the heart and blood vessels. Disorders such as coronary heart disease, cerebrovascular disease, and congenital heart disease characterize CVD (WHO, 2021). As a result of CVD, heart attacks can occur when there is a blockage in the inner walls of blood vessels that supply the heart (WHO, 2021). The most common risk factors of CVD are an unhealthy diet, lack of exercise, and harmful use of drugs and/or alcohol (WHO, 2021). These risk factors may be presented as abnormal blood pressure and/or heart rhythm as well as obesity (WHO, 2021). These risk factors of CVD can be reduced by a healthy diet, regular exercise, and stoppage of consumption of alcohol and/or drugs (WHO, 2021).

Firefighters History of Poor Cardiovascular Health

Initially, when attempting to discover if there was a poor association between firefighters and cardiovascular health, it was found immediately in an article by Palmer and Yoos (2019) that cardiac events are strongly associated with line of duty deaths in the firefighter population. This association could be proven by the fact that in 2012, the U.S. Fire Administration reported that out of the 82 firefighters that died that year, between 45% to 60% died due to a cardiac event (Palmer and Yoos, 2019). This article was chosen due to its method of study. The article's method of study assessed firefighters' knowledge of cardiovascular disease before and after cardiovascular health training by a questionnaire. The results of the questionnaire found that in the sample of firefighters who filled out the questionnaire, there was an increase in the firefighters' knowledge of the risk factors of cardiovascular disease after cardiovascular health training when compared to initial knowledge before the cardiovascular training. The results of this study show education of cardiovascular health may serve as a program of intervention for this population. Furthermore, a study by Banes (2014) reiterated the association between firefighters and poor cardiovascular health by discovering that fatal cardiovascular events are "the primary cause of line of duty deaths among firefighters in nearly all years since 1977." It was found that for every fatal death due to a cardiovascular event, there are an estimated seventeen nonfatal cardiovascular events occurring annually in the U.S. fire service (Banes, 2014). This is an issue of interest due to the fact that if firefighters experience a cardiovascular event during the line of duty, this type of incident not only places the firefighter at risk, but also fellow firefighters and the general public (Banes, 2014). Like in the article by Palmer and Yoos, Banes (2014) also associated poor cardiovascular health with the firefighters' perception of cardiovascular health. Firefighters who understood the importance of cardiovascular health tended to be more involved in physical exercise, while the firefighters who did not understand the importance of cardiovascular health tended to be more laid back when it came to exercise.

In a study by Hollerbach (2019), it was found that firefighters struggle with poor health and fitness habits, while also demonstrating high rates of being overweight or obese and low VO2 max values. The VO2 max is a test that can be used to assess the cardiovascular health of a firefighter. VO2 max is defined as the maximum amount of oxygen that can be absorbed by the respiratory system and be sent to operating muscles (Khazraee et al., 2017). The National Fire Protection Association (NFPA) has the standard of a VO2 max of at least 42 kg/mL/min for firefighters, however, it was found by Hollerbach (2019) that only 38.7% of career firefighters and 23.6% of volunteer firefighters met this standard. While the VO2 max standard serves as a guideline for firefighters, there are no nationally enforced fitness requirements for firefighters (Hollerbach et al., 2019). This information will serve as an issue of focus later on in this review of literature.

It is not surprising that firefighters struggle with their cardiovascular health as the profession of firefighting consists of a multitude of environmental and physical stresses that a firefighter will experience while on duty (Walker et al., 2016). The tasks of firefighting can serve as a trigger for cardiovascular events in firefighters who have underlying heart conditions (Fernhall et al., 2012). An article by Lovejoy (2014) explored the stressors to physical health, barriers to physical health, facilitators of physical health, and motivators of physical health in firefighters and how these components can affect how firefighters handle their job tasks. Physical health stressors were identified as anything that results in a physiological response that can lead to positive or negative adaptation (Lovejoy et al., 2014). Some common physical health stressors that a firefighter may experience while on duty are physical strain, physical exhaustion, and an altered circadian cycle (Lovejoy et al., 2014). Barriers of physical health included anything that prevents a firefighter from participating in physical exercise (Lovejoy et al., 2014). In this study, the firefighters being surveyed identified the fear of being in the middle or at the end of a workout when a call comes in and being too tired to execute the call to their fullest potential as a barrier of physical health (Lovejoy et al., 2014). Facilitators of physical health were identified as the resources that enable firefighters to engage in health-promoting activities (Lovejoy et al., 2014). Some common facilitators of physical health are hands-on training and the availability of a workout room in the fire department (Lovejoy et al., 2014). Motivators of physical health were identified as the extrinsic and/or intrinsic support that a firefighter experienced by participating in physical activity (Lovejoy et a;., 2014). Possible motivators of physical health were identified as competition and group workouts in the fire department (Lovejoy et al., 2014).

Risk Factors of Cardiovascular Disease

The risk factors of CVD need to be carefully understood so that a future exercise program that targets these risk factors of CVD can be implemented. In an article by Banes (2014), smoke inhalation was associated with the risk of CVD. A by-product of incomplete combustion or smoke is carbon monoxide (Banes, 2014). When carbon monoxide enters the human body, it quickly binds to the hemoglobin component of red blood cells (Banes, 2014). The role of hemoglobin is to carry oxygen throughout the body, but when carbon monoxide is also present in the human body, hemoglobin has a greater affinity for carbon monoxide than oxygen (Banes, 2014). As a result, poor oxygen delivery will occur when carbon monoxide is present in the body, and tissue hypoxia occurs consequently (Banes, 2014). Myocardial tissue is one type of tissue of the heart that relies on a constant oxygen supply. Carbon monoxide in the body will lead to myocardial hypoxia, which can lead to ischemia of the tissue of the myocardium (Banes, 2014). Another factor contributing to CVD is sleep deprivation. Generally, firefighters work shifts of either 24 and/or 48 hours and the schedule of a firefighter is unpredictable. Sleep deprivation has been associated with increased blood pressure, CVD, and weight gain (Banes, 2014). Furthermore, in an article by Yook (2019), it was found that in a survey of 37,093 firefighters, it was reported that 36.6% of these firefighters require sleep disorder management and 21.9% required treatment. Not only does sleep deprivation increase a firefighter's risk of CVD development, but it also decreases the quality of performance in tasks of firefighting. A decreased quality of performance in tasks of firefighting can be lethal.

An article by Yook (2019) examined the correlation between occupational stress and CVD development. Yook (2019) explained that accelerated arterial stiffening can be caused by occupational stress, which can lead to the development of CVD. Arterial stiffening leads to stiffened arterial walls, which leads to high blood pressure. As a result, the heart will need to work harder to pump blood throughout the body due to these newly stiffened arterial walls. It was proposed that the pulse wave velocity (PWV) can serve as an indicator of accelerated arterial stiffening. In Yook's (2019) study, the PWV was measured using an automatic waveform analyzer and the PWV was defined as the distance of two points (m) divided by the pulse wave transit time (w). A PWV of 1.4 m/s or more was found to be an indicator of high arterial stiffening levels. Yook (2019) concluded that firefighters with high occupational stress levels are at an increased risk of a PWV value of 1.4 m/s or more compared to firefighters with low occupational stress levels. A high value of the PWV is a risk factor for CVD.

A primary predictor of CVD is obesity. A review of cardiovascular events experienced by firefighters while on duty found that 90% of fatalities and 89% of survivors were considered to be obese or overweight (Banes, 2014). Being obese is a primary risk factor for CVD due to the conditions that go along with it. “Obese firefighters are more likely to suffer from arterial stiffness, hypertension, low HDL cholesterol, high LDL cholesterol, high triglycerides, and more frequent fatal cardiac events (Poston et al., 2013).” Another study by Baur (2012) examined the weight perception of 786 career firefighters. It was found that a high amount of obese and overweight firefighters underestimated their weight categories (Baur et al., 2012). As a result, these firefighters will be at risk of CVD due to the fact that they are unaware that they may be obese or overweight. It was found that a small amount of weight loss can decrease the risk of CVD factors (Baur et al., 2014). A different study by Yang (2013) also associated obesity with an increased chance of sudden cardiac events in firefighters. Furthermore, a study by Fernhall (2012) found that approximately 90% of firefighters are obese or overweight and firefighters who experienced fatal and nonfatal cardiac events had an average body mass index (BMI) above 30. Another study by Korre (2016) found obesity to be a factor of left ventricular (LV) hypertrophy. LV mass is a strong predictor of CVD events (Korre et al., 2016). LV hypertrophy relates to firefighters as an increased LV mass is common among firefighters (Korre et al., 2016). The prevalence of an increased LV mass among firefighters can be reduced by firefighters losing weight. Most risk factors for CVD arise by a firefighter being obese.

Cardiorespiratory fitness (CRF) evaluates the health of the cardiovascular system. CRF refers to the capability of the heart to supply blood throughout all parts of the human body. CRF is usually measured through VO2 max. As stated earlier in this review of literature, the NFPA has the standard of a VO2 max of at least 42 kg/mL/min for firefighters, however, it was found by Hollerbach (2019) that only 38.7% of career firefighters and 23.6% of volunteer firefighters met this standard. In a study by Cameron (2018), it was found that there is a decline in CRF in firefighters as they age. This is of importance because the energy demands of firefighting do not decrease with age (Cameron et al., 2018). Also, not only is an increase in age associated with poor CRF, but also an increase in age is associated with significant weight gain. Hollerbach (2019) found that the weight gain over a 25-year career for a firefighter can range between 29-85 pounds gained. Accordingly, low CRF and significant weight gain increases the risk of CVD (Yook, 2019). Improvements in CRF and weight can reduce the prevalence of other risk factors for CVD such as hypertension and obesity.

Metabolic syndrome (MetSyn) is a group of different states that increases the risk of CVD. A firefighter can be categorized as having MetSyn if he displays any three or more of the following states: a BMI above 30, elevated blood pressure, hypertriglyceridemia, reduced HDL-chol, and/or hyperglycemia (Baur et al., 2012). Using this information as criteria for MetSyn, Baur (2012) assessed the prevalence of MetSyn and its association with CRF in a sample of 957 firefighters. The average age and BMI in this sample was 39.6 and 29.3 respectively. It was found that 28.3% of firefighters from this sample met the criteria for MetSyn, 21.7% did not meet any of the criteria for MetSyn, 28.2% met one of the criteria for MetSyn, and 21.7% met two of the criteria for MetSyn (Baur et al., 2012). From this data, Baur (2012) established that the more criteria for MetSyn that the firefighters met, the more likely of a lower CRF level in these firefighters. Also, Baur (2012) examined the prevalence of MetSyn among the different ages of firefighters and found that the youngest group of firefighters had a prevalence of MetSyn at 15.1%, while the oldest group of firefighters had a prevalence of MetSyn at 34.9%. While an increase in age is a contributor to the prevalence of MetSyn, low CRF has a greater influence on the prevalence of MetSyn than an increase in age has. Improvements in CRF serve as a method of treatment for decreasing the prevalence of MetSyn experienced by firefighters.

The potential of a thrombotic event is greatly increased during tasks of firefighting. Smith (2016) explains that strenuous physical activity can increase platelet numbers and platelet function and activates both coagulation and fibrinolysis. A procoagulant state is associated with the increased incidence in cardiovascular events during and after physical activity (Smith et al., 2016). Two procoagulant states that a firefighter can experience is an increase in body heat and dehydration. “Heat stress and fluid losses can result in decreases in cardiac output of firefighters (Holsworth et al., 2013).” Among other states, firefighters can also exhibit an increase in heart rate while experiencing heat stress and dehydration. With these states combined, the chance of a cardiovascular event is greatly increased due to the increases in demand on the cardiovascular system. Heat stress experienced by firefighters can result in elevated core temperatures and near maximal heart rates (Smith et al., 2016). Decreased stroke volume can transpire when these events occur in firefighters. When this occurs, the left ventricle of the heart is not able to pump as much blood out to the body as usual. When firefighters exhibit heat stress, an elevated core temperature, and dehydration, stroke volume can be decreased by 20% of normal stroke volume (Fernhall et al., 2012).

A study by Holsworth (2013) examined the association between dehydration and rehydration after a physically demanding firefighter simulation on whole blood viscosity (WBV). Dehydration from the simulation resulted in elevated WBV levels, and rehydration 45 minutes after the simulation improved WBV levels but these levels did not return to baseline values.

WBV levels during dehydration and after rehydration are of importance due to the viscosity of blood having an influence on the level of intensity that the heart needs to pump so that perfusion can continue throughout all regions of the body. A heart that needs to consistently pump blood at intense rates will be prone to congestive heart failure (Holsworth et al., 2013).

Energy drinks are frequently consumed by firefighters who desire an increase in energy levels. While energy drinks do provide this increase in energy levels, they also can lead to significant dehydration and hypertensive states (Dennison et al., 2013). Combined with the other conditions that a firefighter may experience while performing their tasks of duty, consumption of energy drinks can significantly increase the chance of occurrence of a cardiovascular event. It is important for firefighters to not confuse energy drinks as drinks used to replace electrolytes and fluids lost during physical activity (Dennison et al., 2013). Firefighters should aim to stay away from energy drinks so that their risk of CVD can be minimized.

In 2010, the American Heart Association (AHA) listed criteria for ideal cardiovascular health. This criterion is a presence of four health behaviors and three health factors. These four health behaviors are: non-smoking, BMI less than 25, physical activity at recommended levels, and a diet consistent with current guidelines (Banes, 2014). These three health factors are: total cholesterol, untreated blood pressure, and fasting blood glucose (Banes, 2014). The presence of one of the criteria for ideal cardiovascular health is associated with a decreased risk of CVD. The more criteria for ideal cardiovascular health that an individual exhibits, the less likely CVD will occur.

An Overview of the Candidate Physical Ability Test

Before an individual can become a firefighter, the individual will first have to pass the CPAT. The CPAT is a nationally required assessment for individuals who want to become firefighters. An individual cannot become a firefighter if they do not pass the CPAT. This test consists of eight exercises that are common in the profession of firefighting. Each exercise must be completed as prescribed. There are two circumstances that can occur which would result in the failure of completion of the CPAT. These two circumstances are if a candidate fails any one exercise of the eight exercises, then they will fail the test and if the candidate does not complete the CPAT in the required time of ten minutes and thirty seconds, then they will fail the test (Firefighter Candidate Testing Center, 2020).

The importance of the CPAT for firefighters is that it assesses if firefighter candidates would be able to physically handle the many tasks of the firefighting profession. It is no secret that firefighting is a physically demanding profession. A firefighter can expect a highly unpredictable work schedule that can result in deprivation of sleep and physical and mental stress. Firefighters need to display great physical health if they are to complete the roles of their profession to a high level. The CPAT will determine if a firefighter candidate displays the physical health components necessary for firefighting. As stated previously, firefighter candidates can only become firefighters if they pass the CPAT. However, while the CPAT is a great method for establishing a candidate's entry into firefighting, there is no requirement of annually passing the CPAT for each year of firefighting. As a result, the epidemic of poor health in firefighters has been prevalent. The profession of firefighting would be improved if the requirement of passing the CPAT for each year of firefighting was instituted. Further consideration to this point should be taken by the IAFF. A mandatory requirement of an annual CPAT would not only improve the quality of performance of firefighters, but it would also improve the quality of physical health of firefighters. This would be due to the fact that firefighters would need to stay physically active in order to pass the CPAT each year.

The CPAT consists of eight exercises that are separated by 25.9 m. While performing these exercises, the firefighter candidate will be wearing a 50-pound weight vest. This weight vest simulates the breathing apparatus that a firefighter wears during live fire events. The first exercise is the stair climb. The goal of the stair climb is to assess a candidate's aerobic capacity, lower body muscular endurance and ability to balance (International Association of Firefighters (IAFF), 2007). The stair climb is performed by a StepMill machine. During this exercise, the firefighter candidate will wear an additional 25 pounds of weight in the form of a hose bundle (IAFF, 2007). The candidate is required to walk on the StepMill for three minutes at a rate of sixty steps per minute (IAFF, 2007). The candidate is not allowed to grasp the handrails of the StepMill during this time. Completion of the three minutes on the StepMill indicates the conclusion of this exercise. Reasons for failure of the stair climb exercise would be if the candidate fell during the exercise and/or if the candidate grasped the handrails at any point during the three-minute interval (IAFF, 2007). These circumstances indicate failure because falling demonstrates poor balance and/or muscular endurance and grasping the handrail gives a mechanical advantage that may not be available during a live firefighting event (IAFF, 2007).

The second exercise is the hose drag. The goal of the hose drag is to assess a candidate's aerobic capacity, lower body muscular strength and endurance, upper back muscular strength and endurance, grip strength and endurance, and anaerobic endurance (IAFF, 2007). The purpose of the hose drag is to simulate the critical tasks of dragging an uncharged hose line from the fire apparatus to the fire occupancy and pulling an uncharged hose line around obstacles while remaining stationary (IAFF, 2007). The candidate will begin this exercise by grasping an automatic nozzle attached to 200 feet of a hose (IAFF, 2007). The candidate will place the hoseline over the shoulder and begin to either walk or run 75 feet of the hose to a prepositioned drum (IAFF, 2007). Once the candidate reaches the drum with the hose, a 90 degree turn around the drum will immediately be conducted for 25 feet (IAFF, 2007). At this point, the candidate will get on at least one knee and pull 50 feet of the hose across the finish line (IAFF, 2007). Once 50 feet of hose is pulled across the finish line, the hose drag exercise will be concluded (IAFF, 2007). Reasons for failure include the candidate failing to go around the drum, not keeping at least contact of one knee with the ground during the hose pull, and traveling out of the marked path (IAFF, 2007). These circumstances indicate failure due to traveling out of the marked path can decrease the required distance traveled and not keeping one knee in contact with the ground can decrease grip and upper body strength activity (IAFF, 2007).

The third exercise is the rescue circular saw carry. This exercise assesses the candidate's aerobic capacity, upper body muscular strength and endurance, lower body muscular endurance, grip endurance, and balance (IAFF, 2007). The purpose of the rescue circular saw is to simulate the critical tasks of removing power tools from a fire apparatus, carrying them to the emergency scene, and returning the equipment to the fire apparatus (IAFF, 2007). The candidate will begin this exercise by removing two saws from a designated area, and with each saw in one hand, the candidate will walk with the saws for 75 feet around the drum and back to the starting position (IAFF, 2007). Once the candidate reaches the start position, the candidate will place each saw back into their designated position (IAFF, 2007). This signifies the end of this exercise. Reasons for failure would be if the candidate drops a saw and/or runs with the saws (IAFF, 2007). These circumstances indicate failure due to dropping a saw demonstrates poor grip strength and/or muscular endurance and running with the saws could lead to injury if the candidate trips at any point (IAFF, 2007).

The fourth exercise is the ladder extension and raise. The ladder extension and raise assesses a candidate's aerobic capacity, upper body muscular strength, lower body muscular strength, balance, grip strength, and anaerobic endurance (IAFF, 2007). The purpose of the ladder extension and raise is to simulate the critical tasks of placing a ground ladder at a fire structure and extending the ladder to the roof or window (IAFF, 2007). The candidate will begin this exercise by walking to the top rung of a 24-foot extension ladder (IAFF, 2007). From here, the candidate will lift the fist rung at the unhinged end from the ground and walk it up until it is stationary against the wall (IAFF, 2007). The candidate is not allowed to use the ladder rails to raise the ladder (IAFF, 2007). The candidate will extend the fly section of the ladder hand over hand until it hits the stop (IAFF, 2007). Once the stop is reached, the candidate will lower the fly section of the ladder hand over hand until the starting position is reached (IAFF, 2007). This completion of movement concludes this exercise. Reasons for failure include the candidate dropping the ladder, the ladder falling to the ground during raise, and failure to complete the raise (IAFF, 2007). These circumstances indicate failure due to these types of events for failure demonstrates poor upper body muscular strength and grip strength (IAFF, 2007).

The fifth exercise involves forcible entry. This exercise assesses the candidate's aerobic capacity, upper body muscular strength and endurance, lower body muscular strength and endurance, balance, grip strength and endurance, and anaerobic endurance (IAFF, 2007). The purpose of this exercise is to simulate the critical tasks of using force to open a locked door or to breach a wall (IAFF, 2007). This exercise begins by the candidate using a 10-pound sledgehammer and striking a measuring device until a buzz signal is activated (IAFF, 2007). After the buzzer is activated, the candidate will place the sledgehammer on the ground (IAFF, 2007). Once the buzzer goes off and the sledgehammer is on the ground, this exercise is completed. A reason for failure is if the candidate fails to maintain control of the hammer while swinging (IAFF, 2007). This circumstance indicates failure because it indicates poor grip strength and muscular endurance (IAFF, 2007).

The sixth exercise is the search maze. The search maze assesses the candidate's aerobic capacity, upper body muscular strength and endurance, agility, balance, anaerobic endurance, and kinesthetic awareness (IAFF, 2007). The purpose of this exercise is to simulate the critical task of searching for a fire victim with limited visibility in an unpredictable area (IAFF, 2007). The candidate will begin this exercise by crawling on their hands and knees through a tunnel maze. The maze is 3 feet high, 4 feet wide, and 64 feet in length with two 90-degree turns (IAFF, 2007). During the maze, the candidate will need to navigate around, over, and under obstacles (IAFF, 2007). At two locations, the space in the maze will be narrowed and the candidate will need to crawl through these two spaces (IAFF, 2007). Once the candidate reaches the exit of the maze, the exercise is completed. A reason for failure would be if the candidate needs help out of the maze at any point (IAFF, 2007). This circumstance indicates failure due to needing help out of the maze demonstrates a lack of confidence in dark and/or confined spaces (IAFF, 2007).

The seventh exercise is rescue. The rescue exercise assesses a candidate's aerobic capacity, upper and lower body muscular strength and endurance, grip strength and endurance, and anaerobic endurance (IAFF, 2007). The purpose of this exercise is to simulate the critical task of removing a victim or injured partner from a fire scene (IAFF, 2007). This event will begin by the candidate grasping a 165-pound mannequin by the handle on the shoulder of the harness (IAFF, 2007). While grasping the mannequin, the candidate will drag the mannequin 35 feet to a pre-positioned drum, make a 180-degree turn around the drum, and continue for 35 feet to the finish line (IAFF, 2007). Once the entire mannequin crosses the marked finish line, the exercise is finished. A reason for failure would be if the candidate rests on the drum at any point and/or the mannequin after a warning was already given (IAFF, 2007). These two circumstances indicate failure due to these events indicating a candidate's lack of muscular strength and endurance (IAFF, 2007).

The eighth exercise is the ceiling breach and pull. The ceiling breach and pull exercise assesses the candidate's aerobic capacity, upper and lower body muscular strength and endurance, grip strength and endurance, and anaerobic endurance (IAFF, 2007). The purpose of this exercise is to simulate the critical task of breaching and pulling down a ceiling to check for fire extension (IAFF, 2007). This exercise begins by the candidate picking up a pike pole and placing the tip of the pole on the hinged door in the ceiling (IAFF, 2007). The candidate will fully push on the 60-pound hinged door three times (IAFF, 2007). The candidate will then hook the pike pole to the 80-pound ceiling device and pull the pole down five times (IAFF, 2007). The candidate will repeat these movements for four sets of three pushes and five pulls (IAFF, 2007). The exercise and total time for the CPAT will end when the candidate completes the last push of the fourth set (IAFF, 2007). A reason for failure would be if the candidate is unable to stay in bounds during the pushes and pulls (IAFF, 2007). This circumstance indicates failure due to this event indicating poor grip strength and muscular strength of the candidate (IAFF, 2007). If the candidate completes all exercises without failure and in a time that is under ten minutes and thirty seconds, the candidate is now qualified to become a firefighter.

Cardiovascular Health Interventional Programs

Promoting fitness is vital in eliminating the number of deaths due to cardiovascular events prevalent in the profession of firefighting. Currently, there are no exercise programs required to be done by firefighters at both the national and local level. The only exercise required by a firefighter is the passing of the Candidate Physical Ability Test (CPAT). However, the CPAT is conducted by an individual who wants to become a firefighter. Once this firefighter candidate passes the CPAT, the candidate can now become a firefighter and will never have to experience the CPAT ever again during the entirety of their firefighting career. To diminish the prevalence of CVD in the profession of firefighting, CVD risk assessment should begin as soon as a new firefighter enters a department (Ratchford et al., 2014). By doing this, firefighters who have an increased risk of CVD can be identified and targeted for preventive strategies (Ratchford et al., 2014).

Knowledge of risks of CVD by educational programs is a method of treatment for decreasing the risks of CVD experienced by the firefighting profession. A study by Palmer and Yoos (2019) examined the knowledge of CVD before and after cardiovascular health training in a sample of firefighters. Post training, it was found that these firefighters demonstrated an increase in knowledge of CVD, in that they were able to identify risk factors of CVD more easily than before the training (Palmer and Yoos, 2019). In another study by Han (2019), it was found that an individual's greater knowledge of symptoms and signs of CVD are associated with quicker access to emergency care, which can lead to a better outcome and a higher survival rate. These results from both studies indicate that all firefighters would benefit from cardiovascular health training. A simple educational intervention can end up saving the lives of many firefighters. These educational interventions do not only have to focus on cardiovascular health, but they can also focus on the components of exercise.

As mentioned previously, firefighters can experience low CRF for three main reasons. The first reason being that most firefighters do not meet the requirement of a VO2 max of at least 42 kg/mL/min set forth by the IAFF (Hollerbach et al., 2019). The second reason is that CRF usually decreases as a firefighter ages (Cameron et al., 2018). The third reason is that firefighters can experience significant weight gain throughout their career (Hollerbach et al., 2019). Fire departments must understand the components that can lead to low CRF and institute programs that encourage fitness among all firefighters (Cameron et al., 2018). However, fewer than 30% of fire departments require any health or wellness programs (Cameron et al., 2018). As a result, not only will a firefighter's CRF get lower over time, but also their risk for the factors of CVD will increase. Fire departments who already had a firefighter die from a cardiovascular event do not exhibit any variability in institutions of health or wellness programs compared to other fire departments without fatal firefighter deaths due to cardiovascular events. Only 39% of such departments report voluntary fitness programs and only 8% set mandatory fitness standards (Banes, 2014). Department emphasis on the importance of physical activity may be valuable in eliminating the number of firefighter deaths by a cardiovascular event each year. Exercise can reduce stress and enhance CRF of firefighters (Yook, 2019). As a general rule, firefighters should aim to get five minutes of exercise per every hour awake (Lovejoy et al., 2015).

Two types of prevention commonly used against CVD are primary prevention and secondary prevention. Primary prevention aims to prevent initial clinical events in individuals who are at risk of CVD, while secondary prevention aims to prevent the recurrence of clinical events in individuals with CVD (Banes, 2014). A new prevention strategy called primordial prevention has been identified by the AHA as a new method of treatment for the risk factors of CVD. This type of prevention aims to prevent the development of risk factors of CVD (Banes, 2014). These three types of prevention can be put into practice by educating firefighters on the behaviors of ideal cardiovascular health (Banes, 2014). As in the study by Palmer and Yoos, it was also identified by Banes (2014) that education is an essential component in reinforcing ideal cardiovascular health behaviors. Health care personnel have many opportunities to promote ideal cardiovascular health behaviors through primary and primordial prevention. The number of cardiovascular events experienced by firefighters can be reduced with the previous information put into practice.

A possible method of exercise for firefighters is exercise with peer support. In an article by Lovejoy (2015), a sample of firefighters were surveyed to identify motivators to physical health in their profession. These firefighters identified competition, group workouts, and a desire to perform more efficiently in the tasks of firefighting as their primary motivators to physical health (Lovejoy et al., 2015). As a result, future exercise programs for firefighters should contain components that require group cohesion. It was found in an article by Banes (2014) that group cohesion leads to less accidents and fatalities in the profession of firefighting because familiarity, awareness, and interpersonal harmony enhance safety among firefighters. These exercise programs that require group cohesion will not only allow for the improval of physical health of firefighters, but they will also lead to better and safer work performance by firefighters (Banes, 2014). Also, in the same article by Lovejoy (2015), the firefighters that were sampled also responded that department-required health screenings could be a motivator for improving their physical health. However, currently, there are no such department-required health screenings in this profession. A future implementation of a department-required health screening by the IAFF could assist in eliminating the amount of fatal cardiovascular events experienced by firefighters.

A study by Stone (2020) examined the effects of an eleven-week strength and conditioning program on the physical fitness characteristics of firefighter trainees. The number of firefighter trainees that participated in this study was twenty-three (Stone et al., 2020). The firefighter trainees' body mass, BMI, upper body strength, lower body strength, and aerobic fitness were measured before the program and after the program. The exercise program consisted of a dynamic warmup, agility training, speed and power training, strength training, mobility and conditioning, and a cooldown. This part of the program was performed on two of the four days that the firefighter trainees were at the academy each week. Aerobic fitness training was performed separately on a different day of the week by the trainees as a group. Upon completion of the eleven-week training program, it was determined by a comparison of measurements before and after the program that there were decreases in body mass and BMI and significant increases in upper and lower body strength and aerobic fitness in these firefighter trainees (Stone et al., 2020). Additionally, a study by Hollerbach (2019) examined BMI and VO2 max between a control group of firefighters and an experimental group of firefighters. The control group exercised as normal for ten weeks, while the experimental group participated in a ten-week training program. At the end of the ten weeks, it was found that the experimental group's BMI decreased and VO2 max levels increased. In a post-training survey, the experimental group noted that having a structured exercise program with a trained person to lead them through may be more beneficial than doing the program alone (Hollerbach et al., 2019). Using the above information as applicable, future exercise programs can incorporate the same components of the training program used in Stone's and Hollerbach's study to help reduce a firefighter's risk of developing CVD. Furthermore, firefighters need to display an ideal combination of muscular strength and endurance in order to perform tasks of firefighters to their fullest potential (Stone et al., 2020). By the IAFF implementing a mandatory exercise program for firefighters, it will not only allow firefighters to reach an ideal combination of muscular strength and endurance, but it will also allow firefighters to decrease their BMI, which is a primary indicator of risk of development of CVD.

A study by Poston (2013) evaluated the health of firefighters in fire departments who require their firefighters to participate in health programs (FDYHP) and fire departments who do not require their firefighters to participate in such programs (FDNHP). The results of this study are intriguing because it demonstrated that firefighters would be better off physically if they were required to participate regularly in a health program. Firefighters from FDYHPs were healthier than firefighters from FDNHPs. These firefighters from FDYHPs were less likely to be obese, displayed higher levels of self-reported physical activity, and exhibited a higher estimated VO2 max (Poston et al., 2013). Not only did firefighters from FDYHPs show superior physical health when compared to firefighters from FDNHPs, but they also were more likely to report greater optimism and job satisfaction when compared to firefighters from FDNHPs (Poston et al., 2013). This study by Poston (2013) demonstrated that requiring a health program among all fire departments can greatly increase a firefighter's physical health and occupation satisfaction. This is of importance because it has already been stated in earlier parts of this review of literature that poor physical health and high occupational stress levels increase the risk of development of factors for CVD. Also, educating firefighters on their BMI and associated CVD risk factors can serve as a mechanism for decreasing the development of these CVD risk factors. It was proposed by Yang (2013) that the profession of firefighting should impose an entry-level obesity standard due to the fact that obesity is so prevalent in the firefighting profession and is strongly associated with CVD.

A study by Sell (2018) wrote out components of an effective training program for firefighters. The Health Belief Model and the Reasoned Action Approach advise that an individual's level of physical activity is influenced by the individual's perception of need or severity of harm that may occur if physical activity action is not taken (Sell et al., 2018).

Individuals who acknowledge their low fitness levels as negatively affecting their physical health are more likely to participate in physical activity so that they can improve upon their low fitness levels. As a result, the first step in getting firefighters to participate in daily physical activity is to educate them on if they exhibit poor fitness levels and how these poor fitness levels are detrimental to their health and increase their chance of CVD. The NFPA Standard 1583 recommends that a training program should incorporate recurring fitness assessments, a professional head of the program, and educational efforts for all participants (Sell et al., 2018). While most fire departments give their firefighters autonomy when it comes to physical activity and its frequency, based on the poor health frequently experienced by firefighters, there needs to be a fitness program implemented by the IAFF that mandates firefighters to participate in it regularly.

Earlier in this literature review, the hydration states of firefighters were examined. It was found that dehydration can lead to thrombotic events, which increases the chance of a cardiovascular event. During intense tasks of firefighting, dehydration can quickly occur. One method to combat this is enhanced access to water and fluid intake during such tasks (Walker et al., 2016). One predictor of dehydration in firefighters is the measurement of WBV. When dehydration occurs, the cells of the body become thickened, which can lead to a clot. Future physical assessments of firefighters need to incorporate measurements of WBV in order to evaluate the hydration status of firefighters. Adequate hydration in firefighters will decrease the chance of a cardiovascular event.

For many years, aspirin has been thought of as a treatment option in the prevention of CVD, however, the role of aspirin as primary prevention for CVD is controversial. The Food and Drug Administration (FDA) has never labeled aspirin as a method of primary prevention for

CVD (Raber et al., 2019). The mechanism of aspirin is that once it is consumed, it inhibits cyclooxygenase (COX), which exists as two isoforms: COX-1 and COX-2 (Raber et al., 2019). COX-1 is involved in platelet aggregation and COX-2 is involved in the upregulation of prostaglandins that have vasodilators and anti-aggregatory actions (Raber et al., 2019). Also, just as important, both isoenzymes are associated with protection of the gastric mucosa (Raber et al., 2019). Low-dose aspirin inhibits COX-1, reducing platelet aggregation and formation of a thrombus (Raber et al., 2019). "Higher aspirin doses inhibit COX-2, leading to reduced production of prostacyclin and prostaglandin, which are responsible for aspirin's analgesic and antipyretic effects (Raber et al., 2019)." Due to aspirin inhibiting COX-1 and COX-2 when consumed, the risk of gastrointestinal bleeding is increased. When it comes to aspirin being used as a method of primary prevention for CVD, the conclusions of different studies are conflicting. The 2016 European Society of Cardiology suggests that aspirin should not be used in individuals without CVD, while the 2016 US Preventive Task Force and 2015 AHA recommends that aspirin should be thought of as a method for primary prevention in individuals with a 10% or greater CVD risk and a low risk of bleeding (Raber et al., 2019). A study by Raber (2019) concluded that aspirin does not reduce fatal cardiovascular events in individuals who have not yet had a first event, but it does increase the risk of bleeding. However, a different study by Stegeman (2015) concluded that aspirin is effective as primary prevention for CVD and its benefits are greater than its harms. Due to the uncertainty surrounding aspirin as a method for primary prevention for CVD, it may be best to treat aspirin as a method for secondary prevention of CVD until further research is able to reliably determine the association between aspirin and primary prevention of CVD.

The effect of aspirin supplementation on hemostatic function before and after live firefighting events in older firefighters was evaluated in a study by Smith (2016). It was hypothesized that aspirin supplementation would have an antiplatelet effect at rest and that aspirin supplementation would potentially prevent procoagulant events from occurring in firefighters during live firefighting events (Smith et al., 2016). Results from the study found that aspirin supplementation had an antiplatelet effect that decreased platelet aggregation at rest and during live firefighting events (Smith et al., 2016). From this study, it was concluded that aspirin can be effective in reducing fatal cardiovascular events. Although, the US Preventive Services Task Force has recommended against the use of aspirin for CVD prevention in individuals younger than 45 years old and for its use in men aged 45 to 79 years old only when the potential benefit of reducing a fatal cardiovascular outweighs the potential risk of gastrointestinal bleeding (Smith et al., 2016). As a result, aspirin as a means of prevention of CVD in firefighters needs to carefully be considered between firefighters and their physicians.

In a study by Behzadi (2020), the feasibility of an Apple Watch Series 4 obtaining 3-lead ECG measurements was evaluated. The first lead of the ECG was recorded for thirty seconds from the left wrist and right index finger (Behzadi et al., 2020). The second lead of the ECG was recorded for thirty seconds from the lower abdomen and the right index finger (Behzadi et al., 2020). The third lead of the ECG was recorded for thirty seconds from the left index finger (Behzadi et al., 2020). In this study by Behzadi (2020), 300 smartwatch ECG tracings were obtained and compared to the tracings of a standard ECG. It was found that the smartwatch ECG's tracings had a similar duration, amplitude, and polarity when compared to a standard ECG (Behzadi et al., 2020). These results show that the Apple Watch Series 4 can effectively obtain a 3-lead ECG. As a result, the ECG technology of smartwatches can be used as a method of identifying CVD in firefighters who do not have regular access to standard ECG facilities (Behzadi et al., 2020). While the 12-lead ECG is the most commonly used procedure used in early diagnosis of CVD, the 12-lead ECG needs to be conducted by trained personnel and specialized equipment (Behzadi et al., 2020). As a result, smartwatches can provide immediate access to tracings of a 3-lead ECG to individuals who do not have access to a 12-lead ECG. In another study by Hernando (2018), it was also found that an Apple Watch can reliably detect HRV. This is of importance because a low HRV has been associated with an increased risk of CVD. To note, HRV is the time period between heart beats. Furthermore, HRV measurements are necessary in the firefighting profession because HRV is known to decrease in occupations that are susceptible to high stress situations (Shin et al., 2016). One such high stress situation in the profession of firefighting is exposure to intense heat.

Conclusion

Because of the clear association between firefighters and cardiovascular health, the purpose of this review of literature was to first establish the poor association between firefighters and cardiovascular health. Throughout a wide range of articles and studies, this association was accurately displayed. It was found that the majority of firefighter deaths annually are due to a fatal cardiovascular event. The second aim of this literature review was to discuss risk factors that can increase the likelihood of a fatal cardiovascular event. It was determined that, among the various risk factors for a fatal cardiovascular event, obesity was the primary indicator for CVD. The third topic of interest in this review was an overview of the CPAT. The CPAT is an assessment of eight exercises common to the firefighting profession that must be completed without failure. This was of importance because an individual cannot become a firefighter until he/she passes the CPAT. The CPAT is an excellent analysis in determining if an individual is physically fit enough to become a firefighter. However, the problem within the institution of the CPAT is that once an individual passes it to become a firefighter, the individual is not required to take it ever again throughout their firefighting career. It was proposed that the CPAT should be required annually to ensure that firefighters remain physically fit. The last focus of this paper was on possible prevention programs and/or protocols that can be implemented that target firefighters' cardiovascular health. Educational programs on proper cardiovascular health were identified as a simple and effective method of treatment. One interesting piece of information that came from this section was the comparison of fire departments who required their firefighters to participate in health programs and those who did not. It was found the firefighters that were required to participate in such programs were less likely to be obese and demonstrated a higher VO2 max when compared to firefighters who were not required to participate in any health program. The hydration status of firefighters and the use of aspirin as a means of primary or secondary prevention to CVD was also discussed.

Methodology

The study's topic was addressed using a non-experimental, quantitative research design. The researched methodology used in this study was a survey by a specific research approach. The study's sample was accessed through a non-probability, convenient sampling technique.

The methodology of this thesis consisted of surveying firefighters of Hernando County Fire Department. The survey was composed of 33 questions. The questions consisted of open-ended, Likert scale, and yes or no questions. The questionnaire can be found in Appendix C. The main focus of the survey was to obtain demographic information relating to the surveyed firefighters and the state of the firefighters' cardiovascular health. The only criteria for this study was the individual answering the survey must be an active duty firefighter. With the answers from this survey, the cardiovascular health of the surveyed firefighters was assessed.

The researcher chose to conduct a survey to make it convenient and easy for the firefighters to participate. The survey was created by the researcher to collect qualitative and quantitative data on firefighters. After gaining IRB approval, the firefighters were contacted through the Fire Chief of Hernando County who then sent out the survey to all of the firefighters of each station. The survey was expected to take no more than fifteen minutes to complete. Out of the 296 firefighters of Hernando County, 25 responses were received.

The study's data were analyzed and reported using descriptive and inferential statistical techniques. Although study data were originally recorded and coded through Excel spreadsheet format, the analysis and reporting of study data were conducted using the 28th version of IBM's Statistical Package for the Social Sciences (SPSS).

Data

Introduction

The study was conducted to evaluate factors associated with fatal cardiovascular events and CVD in professional firefighters. A non-experimental, quantitative research design (Edmonds & Kennedy, 2017) was used to address the study's topic. A survey research methodology represented the specific research approach adopted to address the study's problem statement. The study's sample of participants, 25, was accessed on a non-probability basis, and was convenient and purposive by definition (Fraenkel, Wallen, & Hyun, 2019). The study's data were analyzed and reported using the 28th version of IBM's Statistical Package for the Social Sciences (SPSS).

Preliminary Findings

Foundational analyses of a preliminary nature were conducted in advance of the formal analysis and reporting of findings associated with the study's research questions. Descriptive statistical techniques were used in the preliminary, foundational analyses for comparative and illustrative purposes. The following represents findings for the descriptive statistical analyses conducted on the study's data in advance of the analyses associated with the research questions:

Descriptive Statistics; Demography & Nominal Level Data

Descriptive statistical techniques were used to assess the study's primary demographic identifying information and additional nominal level variables. Frequencies (n) and percentages (%) represented the descriptive statistical techniques used to address the study's demography and other nominal level variables.

Table 1 contains a summary of finding for the descriptive statistical findings for the study's demography and other nominal-level variables featured in the study:

Table 1

Descriptive Statistics: Demography and Nominal-Level Variables

Variable	*n*	%	Cumulative %
Gender			
Male	24	96.00	96.00
Female	1	4.00	100.00
Missing	0	0.00	100.00
Ethnicity			
White/Caucasian	23	92.00	92.00
Hispanic	1	4.00	96.00
Asian	1	4.00	100.00
Missing	0	0.00	100.00
Perceptions of Cardiovascular Risk			
No	23	92.00	92.00
Yes	2	8.00	100.00
Missing	0	0.00	100.00
Perceptions as Healthy and Fit			
No	7	28.00	28.00
Yes	18	72.00	100.00
Missing	0	0.00	100.00
Dehydration During Service			
No	15	60.00	60.00
Yes	10	40.00	100.00
Missing	0	0.00	100.00

Dehydration After Service			
No	9	36.00	36.00
Yes	16	64.00	100.00
Missing	0	0.00	100.00
Heat Exhaustion			
No	16	64.00	64.00
Yes	9	36.00	100.00
Missing	0	0.00	100.00

Descriptive Statistics; Demography & Scale-Level Data

Descriptive statistical techniques were used to assess a segment of the study's demographic identifying information and additional scale-level variables. Frequencies (n), measures of typicality (mean), variability (minimum/maximum; standard deviations), standard errors of the mean, and data normality (skew; kurtosis) represented the descriptive statistical techniques used to address a segment of the study's demography and other scale-level variables.

Table 2 contains a summary of finding for the descriptive statistical findings for the study's demography and other scale-level variables featured in the study:

Table 2

Descriptive Statistics: Demography and Scale-level Variables

Variable	M	SD	n	SE_M	Min	Max	Skewness	Kurtosis
Age	39.96	7.36	25	1.47	23.00	50.00	-0.63	-0.10
Years of Experience	14.92	8.58	25	1.72	1.00	30.00	-0.15	-1.01
On-Duty Sleep (Hours)	4.11	1.31	23	0.27	2.00	7.00	0.20	-0.30

Off-Duty Sleep (Hours)	7.16	0.90	25	0.18	6.00	10.00	1.14	2.06
Mandatory Exercise	4.36	0.86	25	0.17	2.00	5.00	-1.16	0.47
Non-Mandatory Exercise	3.60	1.32	25	0.26	1.00	5.00	-0.33	-1.30

Descriptive Statistics; Primary Cardiovascular Risk Factors

Descriptive statistical techniques were used to assess a segment of the study's scale-level cardiovascular risk factor variables. Frequencies (n), measures of typicality (mean), variability (minimum/maximum; standard deviations), standard errors of the mean, and data normality (skew; kurtosis) represented the descriptive statistical techniques used to assess the study's scale-level cardiovascular risk factor variables.

Table 3 contains a summary of finding for the descriptive statistical findings for the study's scale-level cardiovascular risk factor variables featured in the study:

Table 3

Descriptive Statistics: Primary Cardiovascular Risk Factors

Variable	*M*	*SD*	*n*	SE_M	Min	Max	Skewness	Kurtosis
Heart Rate	72.06	9.81	24	2.00	50.00	90.00	-0.07	-0.30
Systolic BP	123.04	8.45	25	1.69	105.00	140.00	0.04	-0.35
Diastolic BP	74.76	7.29	25	1.46	60.00	88.00	-0.34	-0.84
Weight Gain (Pounds)	19.00	20.72	25	4.14	0.00	80.00	1.47	2.14
Weight Gain (Kg)	8.64	9.42	25	1.88	0.00	36.36	1.47	2.14
Weight Gain CHD Risk	12.95	14.12	25	2.82	0.00	54.55	1.47	2.14
BMI	29.05	3.95	25	0.79	24.21	39.87	1.32	1.66

Findings by Research Question

The study's research questions were addressed using descriptive and inferential statistical techniques. A statistically significant finding was defined as a probability level of $p \leq .05$. Effect sizes achieved in respective analyses were interpreted using the conventions of Cohen (1988) and Sawilowsky (2009).

The following represents the reporting of finding by research question stated in the study:

Research Question #1

Considering the study's sample of participants, to what degree were they officially informed that they were at-risk for cardiovascular disease?

A minority of study participants (8.0%; n = 2) stated that they were considered at-risk for cardiovascular disease. The statistical significance of the finding in research question one was addressed using the non-parametric binomial statistical technique. As a result, the proportion of study participants self-identifying as at-risk for cardiovascular disease was statistically significant ($p < .001$) using the test proportion of .50.

Table 4 contains a summary of finding for the statistical significance of finding for study participants self-identifying as at-risk for cardiovascular disease:

Table 4

Cardiovascular Risk Summary

Cardiovascular Risk	*n*	Observed Proportion	Test Proportion	*p*
Yes	2	.08	.50	< .001
No	23	.92		
Total	25	1.00		

Research Question #2

Using respective BMI values of study participants, was the mean BMI within the normal range?

The one sample *t* test was used to assess the statistical significance of finding in the comparison of BMI values for study participants and the general population. The normal range of BMI for health and cardiovascular at-risk purposes is 18.5 to 24.9. The mean BMI value for study participants was 29.05. Using the upper range value for normal BMI of 24.9, the mean value of BMI for study participants was statistically significantly higher than what is considered normal ($t_{(24)} = 5.26$, $p < .001$).

Table 5 contains a summary of finding for the comparison of study participant BMI values against the customary upper range value for normal BMI:

Table 5

BMI Comparison: Study Participant Mean and Upper Normal Value

Variable	*M*	*SD*	μ	*t*	*p*	*d*
BMI	29.05	3.95	24.9	5.26	< .001	1.05

Note. Degrees of Freedom for the *t*-statistic = 24. *d* represents Cohen's *d.*

Research Question #3

Was the degree of study participant classification of overweight and obese significantly different than the observed value in the general population?

A majority of study participants (88.0%; n = 22) were considered overweight/obese using respective BMI values within known parameters for overweight and obesity. The statistical significance of the finding for the comparison in research question three was addressed using the non-parametric binomial statistical technique. As a result, the proportion of study participants identified as overweight/obese was statistically significant ($p = .04$) using the test proportion of .702 (national norm of 70.2%).

Table 6 contains a summary of finding for the statistical significance of finding for study participant overweight/obesity value compared to the national norm:

Table 6

Overweight/Obesity Comparison: Study Sample and national Norm

Overweight/Obese	*n*	Observed Proportion	Test Proportion	*p*
Yes	22	.88	.702	.04*
No	3	.12		
Total	25	1.00		

*$p < .05$

Research Question #4

Considering the risk associated with weight gain and cardiovascular disease, what was the mean percentage of risk reflected in study participants' mean weight gain over the course of their professional careers as professional firefighters?

Study participant risk of cardiovascular disease (CHD) was established using JAMA's rule of thumb (1.0% increase of risk for CHD for every 2.2 pounds or 1.0 kilogram of weight gain). As a result, study participants' average increase of CHD risk over their careers as professional firefighters in light of weight gain was 12.95% (range: 0% to 54.55). Using the one sample chi square test for statistical significance testing purposes, the finding for the study's sample increased risk of CHD was statistically significant (x^2 (8) = 17.12; $p = .03$).

Research Question #5

Was the mean value for study participant diastolic blood pressure significantly different from the mean value within the population?

The one sample *t* test was used to assess the statistical significance of difference in study participant diastolic blood pressure and the median diastolic blood pressure value within the normal range of 60 to 80. Although the mean diastolic blood pressure value for study participants was below the upper limit for normal of 80, this was statistically significantly higher than the median value of 70 within the normal range ($t_{(24)} = 3.27$, $p = .003$). The magnitude of effect in the comparison was considered medium to large ($d = .65$).

Table 7 contains a summary of finding for the comparison of diastolic blood pressure values between study participants and the median value of 70 within the normal range:

Table 7

Diastolic Blood Pressure Comparison Summary

Variable	*M*	*SD*	μ	*t*	*p*	*d*
Diastolic BP	74.76	7.29	70	3.27	.003	0.65

Note. Degrees of Freedom for the *t*-statistic = 24. *d* represents Cohen's *d.*

Research Question #6

Was the mean value for study participant systolic blood pressure significantly different from the normal range upper value within the population?

The one sample *t* test was used to assess the statistical significance of difference in study participant systolic blood pressure and the upper normal range systolic blood pressure value of 120. As a result, the mean systolic blood pressure value for study participants was statistically significantly higher than the upper range value of 120 within the normal range ($t_{(24)} = 1.80$, $p = .09$). The magnitude of effect in the comparison was considered small to medium ($d = .36$).

Table 8 contains a summary of finding for the comparison of diastolic blood pressure values between study participants and the upper range value of 120 within the normal range:

Table 8

Systolic BP Comparison: Study Participant Systolic Blood Pressure and Upper Normal Range Value

Variable	*M*	*SD*	μ	*t*	*p*	*d*
Systolic BP	123.04	8.45	120	1.80	.09	0.36

Note. Degrees of Freedom for the *t*-statistic = 24. *d* represents Cohen's *d.*

Research Question #7

Was there a statistically significant difference in study participant perceptions of willingness to participate in mandated and non-mandated exercise programs?

The *t* test of Independent Means was used to assess the mean difference in study participant perceptions of willingness to participate in mandated and non-mandated exercise programs. The assumption of data normality was satisfied for the data arrays associated with mandated exercise programming and non-mandated exercise programs as skew values were well-within -/+2.0 and kurtosis values were well-within -7/+7.0 (George & Mallery, 2018).

The comparison favoring the mean perceptions of study participant willingness to participate in mandated exercise programming was statistically significant ($t_{(41.22)} = 2.41$; $p = .02$). The magnitude of effect in the comparison was considered medium to large ($d = .68$).

Table 9 contains a summary of finding for the comparison of the mean perceptions of study participant willingness to participate in mandated versus non-mandated exercise programming:

Table 9

Comparison of Willingness to engage in Exercise Programming: Mandated versus Non-Mandated

Category	n	Mean	SD	*t*	*d*
Mandatory	25	4.36	0.86	2.41*	.68
Non-Mandatory	25	3.60	1.32		

*p = .02

Discussion

Introduction

The purpose of this study was to evaluate the cardiovascular health of the surveyed firefighters as well as propose interventional programs that will improve the cardiovascular health of firefighters. The design of this study was a non-experimental, quantitative research approach. The study's sample size was 25 firefighters from the southeastern region of the United States. Descriptive and inferential statistical techniques were used to assess the collected data. The following section is a discussion of the results.

Descriptive Statistical Findings

A total of 25 participants who completed the study's survey comprised the study's sample. Study participants were defined as active-duty firefighters from Hernando County. It is not known how many different fire departments of Hernando County participated in this survey as the survey was conducted to ensure participant anonymity. However, this survey was sent to all firefighters in Hernando County, so it is reasonable to assume that the participants of this survey were not all included in one fire department. Since the goal of this research is to explore a correlation between firefighters and poor cardiovascular health, it was necessary to survey firefighters from different fire departments. The ages of the surveyed firefighters varied from 23 to 50 years of age, and all but one of the firefighters that participated in this study were male. The length that these participants have been active-duty firefighters varied from one to thirty years. As a result, research data has provided a multitude of different perspectives in regard to this study.

BMI had been identified as an indicator of cardiovascular disease during the review of the literature. An optimal BMI would be under or at 25 as this is the BMI range for a normal healthy person. Based on the results from the questionnaire, it can be concluded that a number of firefighters display a BMI that falls out of the normal BMI range. In fact, the overall BMI for firefighters participating in the study was reflected at the upper end of the “overweight” category, bordering on the “obese” category.

Four firefighters responded that they have not gained any weight since becoming a firefighter. One firefighter had only gained five pounds, with 12 firefighters experiencing a weight gain between 15 to 35 pounds. Two firefighters had gained 70 and 80 pounds respectively. A total of 19 of the 25 firefighters (76%) had answered this question.

Other risk factors of CVD are an abnormal heart rate and blood pressure. From the results of the study’s survey, all study participants had heartbeat rhythms that were well within the normal range of 60-100 beats per minute. A survey question related to heart rate and rhythm was represented later on in the survey. The question was stated as, “how likely are you to wear an Apple Watch that tracked your heart rate and rhythm while on duty?” This question was answered based on a Likert scale that ranged from one to five, with one as not likely and five being most likely. Ten study participants (40%) answered with a response of most likely. Six study participants (24%) answered as not likely.

In regard to a normal blood pressure of 120/80 mmHg, only 13 of 25 (52%) of study participants surveyed displayed normal blood pressure. The other 12 (48%) firefighters displayed blood pressures that can be categorized as elevated, hypertension stage one, and hypertension stage two. Elevated blood pressure is 120-129 systolic and below 80 diastolic. Hypertension stage one is 130-139 systolic and 80-89 diastolic. Hypertension stage two is 140 or higher systolic and 90 or higher diastolic. Responses of four study participants (16%) indicated they had blood pressures described as elevated. Responses of six study participants (24%) indicated they had blood pressures values that were categorized at the hypertension stage one level. One study participant (4%) indicated a blood pressure level that was consistent with hypertension stage two.

The exercise habits of study participants were examined. All study participants surveyed perceived that they needed to participate in regular exercise. Eighteen out of the 25 study participants (72%) also perceived that they can be described as healthy and fit, while the seven (28%) did not perceive they could be described as healthy and fit. An additional survey question related to the availability of exercise equipment at respective fire stations. Twenty-one (84%) responded to the question. All 21 study participants responded that there was some sort of exercise equipment available at their fire station. Some responses included comments such as old trashy equipment, a full array of equipment, random weights, free weights, treadmill, pull-up bar, large tires, row machine, weight bench, etc.

The question of how many days a week do you exercise and for how long was also posed in this study. Twenty out of the 25 (84%) firefighters responded to this question. Nineteen firefighters (76%) responded that they participate in weekly exercise, while the remaining 24% said they do not exercise weekly. The responses of the 19 who responded that they participated in weekly exercise varied. Fourteen firefighters (56%) responded that they exercise at least three times a week. Ten of those (71.4%), who exercise at least three times a week, exercise for at least an hour. The other four of those 14 (28.6%), who exercise at least three times a week, exercise for less than an hour. Two of the 14 (14.3%), who exercise at least three times a week, exercised an additional fourth day. Three of the 14 (21.4%), who exercise at least three times a week, exercised an additional fourth and fifth day. One of the 14 (7.1%), who exercise at least three times a week, exercised an additional fourth, fifth, and sixth day. One of the 14 (7.1%) who exercise at least three times a week, exercised an additional fourth, fifth, sixth, and seventh day.

Four of 20 (20%) who responded to the questionnaire exercised for at least one day a week. Two out of the four (50%) who exercise at least one day a week, exercise for only one day at a length of time between 30 and 45 minutes. The other two out of the four (50%) who exercise at least one day a week, exercise for an additional second day at a length of time of an hour.

When asked to list any barriers to exercise, 17 (68%) of study participants responded. Four (23.5%) responded that there is no barrier to exercising in their lives. Four (23.5%) responded that family responsibilities and childcare are a barrier to their participation in exercise. Seven (41.2%) study participants responded that poor time availability and their work schedule were barriers to their participation in exercise. Two (11.8%) study participants responded that their laziness is a barrier to their participation in exercise. One study participant (5.9%) responded that their lack of sleep is a barrier to their participation in exercise.

The willingness to be obedient to a mandatory exercise program was posed as a survey question on the survey. This question was based on a scale of one to five, with one being not likely to be obedient, and five being most likely to be obedient. All 25 study participants responded to this question. Fourteen (56%) responded with most likely to be obedient. Seven (28%) responded with a likelihood to be obedient. Three firefighters responded with three on the scale, and one responded with two on the scale. When asked about the likelihood of study participant obedience to a nonmandatory exercise program, the answers varied more than the previous question regarding mandatory exercise programming. Nine firefighters responded with a most likely response on the scale, with an additional five responding with Likely on the scale. Four study participants responded with a median response of three on the scale, and six selected two, and one study participant selected one on the scale.

The question of would participating in physical activity with fellow firefighters increase or decrease willingness to exercise was asked. Twenty-three (92%) of study participants responded that participating with fellow firefighters in exercise would increase their willingness to exercise, while the other two (8%) responded that their willingness to participate in exercise would not increase with exercising with fellow firefighters.

The question of fatigue after firefighting tasks was posed on the survey. Twenty-one study participants (84%) responded that they do often feel fatigued after firefighting tasks. Four (16%) responded that they do not feel fatigued after firefighting tasks. Hydration after firefighting tasks was represented on the study's survey. Twenty-two (88%) study participants responded that they do hydrate after every firefighting task. Three (6%) responded that they do not hydrate after every firefighting task. Dehydration before, during, and after firefighting tasks was also represented on the study's survey. Twenty-four (96%) responded that they did not feel dehydrated before firefighting tasks, while one (4%) study participant responded that they do feel dehydrated before firefighting tasks. Fifteen (60%) responded that they did not feel dehydrated during firefighting tasks, while 10 (40%) responded that they do feel dehydrated during firefighting tasks. Nine (36%) responded that they did not feel dehydrated after firefighting tasks, while 16 (64%) responded that they do feel dehydrated after firefighting tasks. Nine out of the 25 (36%) firefighters participating in the study had experienced heat exhaustion after a firefighting task, while the other sixteen firefighters had not.

No study participant surveyed indicated a need to go to the hospital within the past years due to high blood pressure. Due to the cardiovascular health of study participants being the main proponent of this study, the question of whether or not these firefighters have been identified as at risk for CVD was evaluated. Twenty-three (92%) of study participants responded that they had not ever been identified as at risk for CVD. Two (8%) indicated that they have been identified as at risk for CVD. When asked if they would attend an accessible program on the education of cardiovascular health, 20 (80%) indicated that they would attend such a program and five (20%) responded that they would not attend such a program.

Study participants were asked if fire stations required any participation in any health and wellness program. Only five (20%) responded to this question. Three responded that there was no required participation in any health and wellness program. One study participant responded there was training but did not elaborate any further. The remaining firefighter responded that there are annual physical exams and an annual air consumption test.

A question was posed regarding the role of aspirin consumption. Twenty-four (96%) responded that they do not consume aspirin after firefighting tasks. Only one firefighter responded that they consume aspirin after every firefighting task. The consumption of energy drinks was explored. Seven (28%) stated that they do consume energy drinks while on duty. Three of these seven firefighters drink one energy drink per shift. One of the seven drinks one to two energy drinks per shift. One of the seven firefighters' drinks one energy drink weekly. One of the seven firefighters' drinks one to two energy drinks weekly. One of the seven firefighters' drinks three energy drinks weekly. Only 12 study participants responded to this question. The other five responded they did not consume energy drinks while on duty.

The amount of sleep while on shift was represented as a question on the survey. The answers to this question varied greatly. Three (12%) responded with two hours of sleep obtained. Three (12%) responded that they sleep three hours per night. Two (8%) responded with three to four hours of sleep obtained. Two (8%) responded with three to five hours of sleep each night. Three (12%) firefighters responded with three to six hours of sleep per night. Three (12%)

responded with four hours of sleep obtained per night. Two (8%) responded with four to five hours of sleep per night, with one (4%) responded with four to six hours of sleep obtained.

One (4%) responded with five hours of sleep obtained, with one (4%) responding with five to six hours of sleep per night. One (4%) study participant responded with six hours of sleep per night, with one (4%) responding with seven hours of sleep per night. Two responses (8%) were identified as “not applicable” to the question being asked.

The amount of sleep obtained while “off duty” was also represented on the study’s survey. Four (16%) of study participants responded with six hours of sleep per night. Three (12%) responded with six to seven hours of sleep per night. Seven (28%) responded with six to eight hours of sleep per night, while five (20%) responded with seven hours of sleep per night. One (4%) responded with seven hours of sleep per night, with one (4%) responding with seven to eight hours of sleep per night. Three (12%) responded with eight hours of sleep per night, with one (4%) responding with 10 hours of sleep per night.

The length of a typical shift was represented on the study’s survey. Twenty-four (96%) responded that their typical workday is 24 hours in length. One (4%) responded that their typical workday is eight hours five days per week.

Discussion of Findings

Perhaps the most salient finding achieved in the current study was reflected in the data supporting the cardiovascular fitness of study participants in contrast with data achieved that were not supportive of cardiovascular. Study participant heart rates and blood pressure (systolic and diastolic) were prominent indicators supportive of cardiovascular fitness, and similarly supportive of the fact that 92% of study participants received reports that they were not in danger of cardiovascular disease.

On the contrary, study data regarding BMI values, the statistically significant difference in decreased exercise probability for non-mandated exercise, and weight gain over the time of professional service appear not to be supportive of the overall optimal cardiovascular health of the study's sample. Study participants' mean BMI was manifested at the upper end of the scale for "overweight" and less than a unit (0.95) from an overall rating of obesity. Moreover, only 12% (n = 3) of study participants reflected BMI within the normal range, with the remaining 88% manifesting BMI values considered "overweight" and/or "obese", a value that well-exceeds at a statistically significant level the general percentage (70.2%) of Americans with overweight and/or obese BMI values. This fact coupled with the average weight gain manifested during study participant professional service (nearly 13%) would appear indicative of cardiovascular risk in the immediate and in the time ahead. The finding for study participant BMI values and mean weight gain values would appear all the more alarming in light of the predictive role that obesity represents in cardiovascular disease.

Another finding of importance that was reflected in the study's findings was that of the statistically significant difference in the likelihood of study participants engaging in exercise programming between mandatory and non-mandated programming. The predictive role of regular exercise (particularly cardiovascular exercise in the target heart rate zone) in reducing risk for cardiovascular disease is well-established in the professional literature. Study participants were far less likely to engage in regular exercise programming if non-mandated. This would appear alarming in that, generally speaking, organizations do not typically mandate exercise programs for employees. As such, the decrease in exercise likelihood predicted for non-mandatory exercise programs would appear to be an additional risk factor evident in the sample of study participants.

Proposed Interventional Programs

In order for the relationship between poor cardiovascular health and firefighters to be reduced, there needs to be mandated interventional programs on cardiovascular health in this population. A possible solution is the CPAT. As stated previously in the Review of Literature, the CPAT is a nationally required assessment for individuals wanting to become a firefighter. However, once the individual passes the CPAT and becomes a firefighter, the individual is not subjected to passing to CPAT throughout the entirety of their firefighter career. A simple proposal is that the CPAT be mandated to be passed annually by each firefighter across the nation. This would ensure that each firefighter is still in the necessary health to be a firefighter as they were when they first began. Another proposal is that each firefighter must go through an educational program on cardiovascular health as well as the risk factors for a fatal cardiovascular event. It was found through multiple studies that a firefighter's greater knowledge on cardiovascular health and the risk factors of a cardiovascular health is associated with a lesser mortality rate. The last proposal is that each firefighter undergoes a protocol named REHAB after each firefighting task. Each letter in REHAB stands for a precautionary measure that aims to reduce the likelihood of a fatal cardiovascular event. R stands for rest. E stands for EKG/ECG. H stands for hydration. A stands for aspirin. B stands for body temperature.

Study Limitations

Two primary limiting factors were noteworthy in the commission of the current study. First, the study was limited to participants employed in one county located in the state of Florida. As such, generalizations of study finding should not be made beyond the population from which the sample of study participants was accessed. The study's sampling technique, moreover, was non-probability in nature further limiting broad, sweeping generalizations of finding to firefighters representing jurisdictions outside the population from which the sample was conveniently accessed.

Second, findings achieved in the study were accomplished by virtue of self-reporting. Although self-reporting fulfills an important role in the research process, the study's findings represented study participant perceptions rather than actual measured data (blood pressure; heart rates, height/weight; etc.) at the time of the study.   Actual physical measurements of values of study importance would improve the validity of finding those variables in which numeric values represent critical markers for evaluative purposes.

Recommendations for Future Research

Several recommendations for future research would appear to be plausible in light of the findings achieved in the current study. First, a replication of the current study in a non-COVID19 era would appear warranted. Second, a study involving an increased population from which to access study participants would improve the generalizability of finding. Probability sampling could be used within a more protracted population in an effort to provide greater representation in the sample's construction. Third, representation of firefighting units in urban, rural, and suburban jurisdictions would provide a clearer picture of possible differences that geographic variables might exert on the nature and extent of cardiovascular risk. Fourth, the validity of study findings would appear to be greatly enhanced through the use of actual measurements where measurements are warranted. The current study was delimited by the use of study participant perceptions of measurable variables or data from measurable data that may no longer be relevant. Fifth, the study of the effectiveness of different interventional programs on cardiovascular health should be carried out.

Conclusion

This thesis proved that there is an association between poor cardiovascular health and firefighters. By the data gathered from the study, the most common risk factors of a fatal cardiovascular event and CVD were identified as obesity, weight gain, elevated BMI, sleep deprivation, and lack of health and wellness programs. Several interventional programs were proposed. Such programs were an annual CPAT, educational programs on cardiovascular health, and REHAB protocol. Only two out of the twenty-five firefighters identified themselves as at risk for CVD. Though, the collected data shows that much more of the surveyed firefighters are at risk for CVD. Now is the time to inform, educate, and put into action interventional programs that aim to improve the cardiovascular of firefighters, which will then reduce the number of firefighter deaths annually due to a fatal cardiovascular event.

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Appendix A
Study Approval from Firefighter Chief of Hernando County

Re: Firefighter Survey

MK Manuel, Kyle <ktmanuel@seu.edu>
To [redacted]

Reply | Reply All | Forward | ...
Sun 3/21/2021 12:45 PM

Great, thank you.

On Sun, Mar 21, 2021 at 12:43 PM [redacted]

Yes, I approve this survet

Get Outlook for Android

From: Manuel, Kyle <ktmanuel@seu.edu>
Sent: Sunday, March 21, 2021 12:42:18 PM
To: [redacted]
Subject: Re: Firefighter Survey

Hello,
I just need to get permission from you before I turn in my application for the study. Can you reply with "Yes, I approve this study" if that is true. Once I receive that, I will be able to get my study approved and I will be able to send over the questionnaire on google forms. Thank you.

On Sat, Feb 20, 2021 at 3:13 PM [redacted]

Ok. Send it when you are ready.

[redacted]

Get Outlook for Android

From: Manuel, Kyle <ktmanuel@seu.edu>
Sent: Saturday, February 20, 2021 2:50:55 PM
To: [redacted]
Subject: Re: Firefighter Survey

It will definitely be an online survey and it would most likely be on survey monkey, but I am not sure about that at the moment.

Re: Firefighter Survey

MK Manuel, Kyle <ktmanuel@seu.edu>
To [redacted]

Reply | Reply All | Forward | ...
Sun 3/21/2021 12:45 PM

From: Manuel, Kyle <ktmanuel@seu.edu>
Sent: Saturday, February 20, 2021 2:50:55 PM
To: [redacted]
Subject: Re: Firefighter Survey

It will definitely be an online survey and it would most likely be on survey monkey, but I am not sure about that at the moment.

On Fri, Feb 19, 2021 at 3:23 PM [redacted]

Sure. Will this be on hand delivered or on survey monkey?

[redacted]

From: Manuel, Kyle <ktmanuel@seu.edu>
Sent: Thursday, February 18, 2021 8:38 PM
To: [redacted]
Subject: Firefighter Survey

Hello,

I am not sure if you remember me, but my name is Kyle Manuel and I briefly talked to you at the fire station dedication ceremony for Steve Terry about my thesis for college. The goal of my thesis is to propose a possible exercise program and protocol for firefighters who are at risk for cardiovascular disease. Right now, I am in the process of gaining approval for my survey and I was wondering if I was still able to conduct the survey with the firefighters of Hernando County. It would be completely anonymous. I have attached a word document with a rough draft of the survey questions. If you have any questions or concerns please contact me either by phone at 3526131934 or by email. Hoping to hear from you soon. Thank you.

Appendix B
Consent Form

Title: Cardiovascular Intervention in Firefighters

Investigators: Kyle Manuel, Dominic Stross

Purpose: The purpose of the research study is to collect information regarding firefighters' physical health and lifestyle as well as information relating to their experiences as a firefighter.

What to Expect: This research study is administered online. Participation in this research will involve completing a single questionnaire which will consist of thirty-four questions. This questionnaire should take approximately between five to ten minutes to complete.

Risks: There are no risks associated with this research.

Benefits: There are no immediate benefits to your participation. However, your responses will provide greater insight to cardiovascular disease risk in firefighters as well as possible exercise programs and protocols that aim to minimize the risk factors associated with cardiovascular disease.

Compensation: There is no compensation for participating in this research.

Your Rights and Confidentiality: Your participation in this research is voluntary. There is no penalty for refusal to participate, and you are free to withdraw your consent and participation in this study at any time.

Confidentiality: The records of this study will be kept private. Any written results will discuss group findings and will not include information that will identify you. Research records will be stored on a password-protected computer in a locked office and only researchers and individuals responsible for research oversight will have access to the records. Data will be destroyed five years after the study has been completed.
Contacts: You may contact any of the researchers at the following emails, should you desire to discuss your participation in the study and/or request information about the results of the study: ktmanuel@seu.edu and/or ddstross@seu.edu. If you have questions about your rights as a research volunteer, you may contact the IRB Office IRB@seu.edu.

If you choose to participate: Please, click NEXT if you choose to participate. By clicking NEXT, you are indicating that you freely and voluntarily and agree to participate in this study and you also acknowledge that you are at least 18 years of age. You will be asked to answer questions in the following section. Most of these questions will be required for you to answer. However, questions that can be considered to be personal and/or sensitive have either been marked with an answer choice of "Preferred not to say" or are not required. It is up to you if you wish to answer these questions. As a reminder, this questionnaire is entirely anonymous and has no capability of being tracked to a specific participant. At the end of the questions, there will be a SUBMIT option. By clicking SUBMIT, this will signal the completion of this questionnaire. The completion of this questionnaire is considered to be consent.

Appendix C
Study Questionnaire

Demographic Information

1. What is your age?
2. What is your sex?
3. What is your ethnicity?
4. What is your height?
5. What is your weight?

Yes/No Questions

6. Do you believe you need to participate in regular exercise?
7. Do you often feel fatigued after tasks of firefighting?
8. Would you attend an educational program on cardiovascular health if made accessible to you?
9. Do you hydrate after every firefighting task?
10. Have you visited the hospital within the last two years due to high blood pressure?
11. Have you been identified as at risk for cardiovascular disease?
12. Would performing physical activity with your fellow firemen increase or decrease your willingness to participate?
13. Do you believe that you can be described as healthy and fit?
14. Do you often feel dehydrated before tasks of firefighting?
15. Do you often feel dehydrated during tasks of firefighting?
16. Do you often feel dehydrated after tasks of firefighting?
17. Have you ever experienced heat exhaustion after a task of firefighting?

Open-Ended Questions

18. How many years have you been a firefighter?
19. If known, what is your average heart rate?
20. If known, what is your average blood pressure?
21. Outside of your profession, how many days a week do you exercise? If so, then how long and often?
22. Are there any barriers that keep you from exercising? If yes, please list the barriers.
23. Do you consume aspirin during tasks of firefighting? If yes, how often?
24. On average, what amount of sleep do you achieve while on duty?
25. On average, what amount of sleep do you achieve while off duty?
26. Is there any exercise equipment available at your fire station? If yes, please describe the equipment.
27. On average, how long is your typical shift?
28. Do you ever consume energy drinks while on duty? If yes, how often and how many?
29. Does your fire station require you to participate in any health and wellness programs? If yes, please list and describe such programs.

30. Do you know if you have gained any weight since becoming a firefighter? If yes, please list the amount of weight gained.

Likert Scale Questions - 1 being not likely and 5 being most likely

31. How likely are you to be obedient to a mandatory exercise program?
32. How likely are you to be obedient to a nonmandatory exercise program?
33. How likely are you to wear an Apple Watch that tracked your heart rate and rhythm while on duty?