SYSTEMATIC REVIEW OF THE IMPACT OF NUTRITION AND PHYSICAL ACTIVITY ON CARDIOVASCULAR DISEASE RISK AMONG FIREFIGHTERS

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Abstract: **Background:** Fatal heart attacks account for 45-60% of all line of duty firefighter deaths, making cardiovascular disease (CVD) the primary cause of line of duty deaths in the fire service. Firefighters experience numerous occupational risk factors contributing to CVD, however research shows underlying CVD from lifestyle is the major contributing factor. Thus, the purpose of this study was to review and summarize the literature on non-occupational risk factors experienced by firefighters, nutrition and physical activity in particular. **Methods:** The current systematic review searched PubMed and Scopus databases using search terms related to CVD, nutrition, and physical activity in firefighters. The PRISMA checklist was followed to ensure a rigorous review. The Academy of Nutrition and Dietetics Quality Criteria Checklist for Primary Research was used for critical appraisal of included studies. The review process was performed by one researcher with plans for an additional reviewer in the near future. **Results:** 26 articles were included in the qualitative synthesis (4 nutrition, 4 nutrition and physical activity, and18 physical activity). Included studies indicate that firefighters do not engage in regular physical activity, tend to poor dietary habits, and work in a poor food environment, which is associated with higher prevalence of CVD and its indicators. They also indicate that firefighters want information, programs, and resources related to improving nutrition and physical activity. **Discussion & Conclusions:** Numerous studies exist regarding increased CVD risk related to inadequate physical activity levels, however, few studies address the role of a healthy diet in the development of CVD risk among firefighters. This review is beneficial for practitioners and fire service leaders as it provides insight into the need for initiatives to increase physical activity levels and into the need to further investigate how diet affects CVD risk among the firefighting population.

TABLE OF CONTENTS

Chapter Page

LIST OF FIGURES

Figure Page

CHAPTER I

INTRODUCTION

One of the most important health concerns within the firefighting profession is cardiovascular disease (CVD). It has been reported that CVD and fatal cardiovascular events account for 45-60% of all line of duty firefighter deaths, thus making CVD the primary cause of line of duty deaths in the fire service.[1] Likewise, investigators have found that sudden cardiac death (SCD) was responsible for 50% of on duty deaths of volunteer firefighters and for 39% of on duty deaths of career firefighters.[2]

According to the Centers for Disease Control, heart disease is the leading cause of death for the general population in the United States for men, women, and people of most ethnic groups.[3] Additionally, CVD has remained among the top two leading causes of death in the U.S. since 1975, with 633,842 deaths, which equates to one in every four deaths in the general U.S. population.[4] For firefighters, the percentage of deaths from CVD is 45-60%, compared to 25% for the general population. For these reasons, CVD is a leading health concern among firefighters.

What is causing the higher rates of CVD among firefighters compared to than the general population? Part of the equation is that firefighters experience additional risk from occupational factors contributing to the development of CVD. Several occupational risk factors that have been

mentioned in the research have been dehydration, heavy equipment/PPE, heat, unreliable meal times, and short bursts of physical activity as well as sleep disruption and deprivation. In fact, one study found that sleep deprivation and sleep disturbances contributed to insulin resistance, increased rates of hypertension, cardiovascular disease, (CVD), and weight gain.[1] An additional contributor to CVD that was mentioned in the literature was that firefighters typically lead lives in which there are periods of strenuous activity and long periods of physical inactivity.[5] Long periods of physical inactivity or sedentary lifestyles can contribute to obesity and thus to cardiovascular disease development. Decreasing occupational risk factors is beyond the scope of practice for most public health practitioners. But what about modifiable CVD risk factors?

For the general U.S. population, major modifiable CVD risk factors include high rates of overweight and obesity, physical inactivity, high cholesterol, smoking, alcohol consumption, and high blood pressure, as well as poor diet and development of diabetes.[6] Do firefighters experience the same non-occupational, modifiable CVD risk factors as the general population? This information would be of great use to public health practitioners working to improve the health of firefighters.

There is a growing body of literature related to non-occupational, modifiable CVD risk factors among firefighters. In a study conducted by Sotos et al., it was concluded that one of the most modifiable risk factors and biggest contributors, including those from the occupation itself, to the development of CVD was poor diet.[19] In fact, another study, which surveyed 154 firefighters about their dietary and lifestyle factors, stated that 86% of respondents ate red meat 1–5 times a week, while another 90% of participants indicated they relied on fast food choices 1–3 times per week.[2] This study also identified that fish was eaten less than once a week by most participants (57%).[2] Physical inactivity is another non-occupational risk factor that may contribute to CVD and obesity among firefighters.[2] Lack of medical exams, perceptions of

obesity, and access to medical professionals providing health classification advice are other non-occupational risk factors that have been cited in the research to contribute to CVD.[7-9] These non-occupational CVD risk factors, specific to firefighters, are similar to that of the general population in many ways, but also differ in several regards.

Reviewing and summarizing the non-occupational risk factors experienced by firefighters is of great importance, so that public health practitioners can appropriately target CVD risk factors in this occupational group. There has been extensive research on CVD risk factors among the firefighting population, however a summary of non-occupational risk factors is needed. Therefore, the purpose of the systematic review was to summarize non occupational CVD risk factors related to nutrition and physical activity among firefighters.

CHAPTER II

REVIEW OF LITERATURE

The Obesity Epidemic Among Firefighters

The Centers for Disease Control and Prevention defined the prevalence of adult overweight and obesity in the United States as 63.4% in 2012.[10-11] The prevalence of overweight and obesity among career firefighters is very close to the national average. A cohort study, looking at the prevalence of health care providers providing weight advice among career male firefighters from 2011 to 2012, found that over 82.5% of firefighters in the United States were overweight or obese.[8] Additionally, a case control study, investigating the occupational and personal risk factors associated with Coronary Heart Disease and on duty death amongst firefighters, found a 33% prevalence of obesity among firefighters. Most alarmingly, this prevalence of obesity increased to 40% over four years.[8] Smith (2012) examined both standard risk factors and new measures for cardiovascular health in 116 male career firefighters. They found that 51.7% of male firefighters were classified as obese based on BMI, while only 5.2% were classified as normal weight. Additionally, 3.4% of firefighters were classified as having extreme obesity. In addition to weight concerns, 45.9% of the firefighters examined in this study

were considered at high risk for cardiovascular disease based on waist circumference measures.[5] Despite concerns regarding accuracy of BMI, this measure appears to be an accurate assessment of obesity among firefighters for assessing disease risk. This topic of BMI accuracy will be further addressed later in this chapter.

In a self-report survey study by Eastlake, researchers examined occupational exposures, lifestyle factors and demographics of firefighters in Midwest fire departments. These investigators found that 12.4% of surveyed firefighters were normal weight, while 50.8% of firefighters were overweight, and 36.8% of firefighters were obese. Additionally, this study found that for every time unit increase in BMI, there was a 5% increase in job disability.[2] Other studies have found obesity rates to be high ranging from 32 – 40 % for obesity and between 77% and 90% for combined overweight and obesity amongst firefighters.[5,12-14] More alarming than the obesity rates in firefighters is the fact that studies are continuing to find younger firefighters to be obese upon admission to the fire service rather than becoming obese and overweight after entering the fire service.[5]

There are serious health implications for firefighters directly related to high prevalence of unhealthy weight status. A retrospective case control study conducted by Yang investigated the causes of on duty sudden cardiac death (SCD) by comparing SCD fatalities from 1996 to two control groups comprised of age-matched non-cardiac traumatic fatalities from 2007–2009, as well as age-matched non-cardiac traumatic fatalities from 2004–2010.[16] The results of this study showed that on-duty SCD was prevalent in younger firefighters less than 35 years of age. They also concluded that SCD was primarily related to preventable factors that coincide with obesity. This study also found that 63% of those with SCD were obese when compared to controls (36%). Additionally, 28% of firefighters with SCD had class 2 or 3 obesity compared to only 10% among controls.[16]

Based on the studies reviewed in this section, obesity is a major concern among the firefighting population which, when present, may lead to significant job disability. Additionally, not only are firefighters becoming obese throughout their service years, but one of the emerging problems appears to be firefighting recruits entering the service already classified as overweight or obese, placing them at further risk of developing CVD. Health care providers may not be providing adequate knowledge or classification of weight status which may increase firefighters' chances of preventing modifiable factors that occur in conjunction with obesity.

Accuracy of Body Mass Index (BMI) as a Weight Status Indicator among Firefighters

Several sources in the literature have expressed concern regarding BMI as an accurate measure of firefighter obesity.[17-18] A few sources have speculated that individuals who have low body fat and high muscle mass may be misclassified as overweight or obese, when in fact they are really normal weight. One study suggested that a BMI greater than or equal to 25 was not an accurate indicator of overweight and misclassified nearly 80% of firefighters as overweight due to high lean body mass. This study also found that BMI > 30 was more accurate, but also misclassified some normal fat firefighters.[17] Another study found that BMI misclassified firefighters 28-38% of the time.[18] However, this same study found that the prevalence of obesity in firefighters using body fat percentage analyzed by bioelectric impedance (BIA) was higher than that estimated by BMI and waist circumference (WC) methods and concluded that BMI was thus indeed more accurate than BIA or WC.[18] Similarly, supporting use of BMI with firefighters, another study conducted by Smith showed that misclassification of muscular firefighters as obese using BMI has been infrequent at best.[5] One additional study showed that high obesity prevalence in firefighters using BMI was not in fact due to misclassification of muscular firefighters as obese. Instead, this study found that obesity was even more prevalent in firefighters when assessed by other methods, such as body fat percentage, rather than BMI, and additionally that misclassification of muscular firefighters by BMI was infrequent.[9] Despite conflicting evidence,

the majority of evidence points to BMI as an appropriate assessment of weight status for the firefighting population.

Firefighters and Cardiovascular Disease

Cardiovascular disease (CVD) is the leading cause of on duty death in the fire service, accounting for approximately 45% of on duty fatalities and 30% of deaths overall.[19] Likewise, another study found that SCD was responsible for 50% of on duty deaths of volunteer firefighters and for 39% of on duty deaths of career firefighters.[5] A third study found that cardiovascular disease mortality was highest amongst the fire service than any similar occupational group.[5] Further research has stated that construction workers and police officers have CVD fatality incidents of 13 and 22%, while the average fatality rate due to cardiovascular disease among all occupations is 15%.[1] Another source found that SCD was the leading cause of death in firefighters in the United States accounting for 50% and that of these deaths 90% were CHD-related. This study additionally found that SCD cases were more likely to be obese.[16] A different study, which looked at C-reactive protein (CRP), central blood measures, arterial stiffness, and myocardial blood supply found that obese firefighters had higher levels of CRP, and thus increased risk of a CVD event.[5] Lastly, a study, which looked at personal health issues, found that the most common personal health issues among firefighters were high cholesterol and high blood pressure, which are indicators of CVD.[2]

Possible Occupational Causes of Cardiovascular Disease among Firefighters

There are many occupational contributors that have been cited in the research that can contribute to the development of cardiovascular disease among firefighters. The first of these occupational factors is due to heavy personal protective equipment (PPE) firefighters use to insulate themselves from flames and hazardous material that occur when responding to a fire. According to a recent systematic review, firefighting PPE adds an extra 25 kilograms and adds to

metabolic and thermal demands of firefighting.[20] A second occupational risk factor that has been shown to contribute to cardiovascular disease is the high temperatures and heat that firefighters encounter when performing their duties. Due to metabolic heat that firefighters produce from their own bodies as well as their PPE which limits firefighters' abilities to disperse or get rid of heat, one source states that core temperatures can increase at a rate of 0.05 degrees Celsius per minute or one degree Celsius over twenty minutes of firefighting activity which can lead to an increase in cardiovascular strain.[20] Another occupational cause of cardiovascular disease among firefighters which may often be overlooked is dehydration during fire suppression. Dehydration often occurs alongside heat related illnesses. One source stated that dehydration can decrease plasma volume and impair thermoregulation and increase the concentration of cellular elements in the blood leading to increased coagulator variables and prothrombotic activity.[20] Another occupational risk factor that is worth noting in its ability to contribute to the development of cardiovascular disease is firefighting profession's short bursts of vigorous physical activity required for suppression or containment of fires. Another study, which investigated physical activity among firefighters, stated that lack of physical activity may lead to metabolic syndrome and that irregular episodes of intense physical activities among previously sedentary firefighters can trigger cardiovascular events.[1] One last occupational risk factor which may contribute to firefighter CVD prevalence may be unreliable meal patterns and sleep schedules, which occur due to shift work.[18] A previously mentioned study found that sleep deprivation and sleep disturbances contributed to insulin resistance, increased rates of hypertension, cardiovascular disease, (CVD), and weight gain.[1] In addition, another study investigated sleep disturbances in firefighter and firefighter mortality and found that a difference in circadian rhythm patterns was associated with coronary heart disease (CHD) deaths in firefighters when compared to the general population.[8]

Possible Non-Occupational Causes of Overweight, Obesity, and Cardiovascular Disease among Firefighters

Several causes of overweight, obesity, and CVD within the fire service have been noted in the literature. These causes are often due to a mixture of lifestyle and occupational risk factors. One of the most considerable causes of obesity according to literature is poor dietary habits. In one article, factors such as poor diet and a high emphasis on fast food and sugar sweetened beverages were highlighted as potential contributors to obesity prevalence in the fire service.[19] Another study, which surveyed 154 firefighters about their dietary and lifestyle factors, stated that 86% of respondents ate red meat 1–5 times a week, while another 90% of participants indicated they relied on fast food choices 1–3 times a week.[2] This study also identified that fish was eaten less than once a week by most firefighters in the survey (57%).[2] Another study conducted an extensive literature review and found that firehouse meals were often high in unhealthy fats and in refined carbohydrates, both of which have the potential to contribute to obesity.[1]

Another contributor to overweight, obesity, and CVD mentioned in the literature was that firefighters lead lives in which there are periods of strenuous activity and long periods of physical inactivity.[5] Long periods of physical inactivity or sedentary lifestyles can contribute to obesity. In this study, researchers compared traditional and novel cardiovascular disease risk factors between obese and non-obese career firefighters. They found that 65% of a firefighter's time was spent doing nonemergency duties, while only 1–5% of time was spent in fire suppression.[5] Another thing that is important to note is that some firefighters may not have access to fitness equipment and may additionally not have any health or wellness policies in place. One study found that less than 30% of fire departments surveyed had any health or wellness programs initiated within the service.[1] This same study found that only 39% of departments reported having a voluntary fitness program and of those only 8% set mandatory fitness standards.[1]

Another potential contributor to unhealthy weight status and ultimately to the development of CVD within the fire service may be individuals are not receiving weight advice and, when they do, are not told they are overweight or obese by their healthcare provider. One

study which investigated this found that 82.5% of firefighters were overweight or obese and that most (69.2%) firefighters reported receiving no weight advice in the past year.[7] Fewer than half of overweight and obese firefighters reported that their healthcare provider advised them to lose weight. In the overweight category, only 12% of individuals received advice by their healthcare provider to lose weight.[7] Likewise, this same study found that younger overweight and class 1 obese firefighters were less likely to receive advice to lose weight than older groups.[7]

One last contributor to firefighter overweight and obesity and CVD within the firefighting population is that firefighters may not perceive themselves to be overweight or obese. One study found that fewer overweight or obese firefighters correctly perceived themselves as their correct weight category.[9] In fact, when investigating this phenomenon, researchers found that two-thirds of firefighters who were obese did not recognize that they were obese and believed they were at low risk of developing obesity.[9] This study also found that 68% of overweight and obese career firefighters underestimated their weight classification. Additionally, likelihood of underestimating one's weight increased with age.[9] Lastly, this study found that while 89% of those with a normal BMI perceived themselves correctly, only 32.4% of those who were overweight correctly perceived themselves as overweight, and those that perceived themselves as obese were close to morbid obesity on average.[9]

One of the last contributors to firefighter overweight, obesity, and CVD mentioned in the literature was lack of medical exams among firefighters. One study found that although CVD factors were detectible in routine medical screenings, medical exams were lacking in 75% of firefighters who eventually died from CHD.[5] Another study also found that 75% of firefighters who died of CHD had not had a medical examination and concluded that over 25% of CHD deaths had major CVD risk factors that would have been detected and modified at a regular health screening.[8] Possibilities as to why individuals fail to have health exams include being reluctant to report problems and being considered incompetent.[1] Likewise, this article stated that firefighters'

reluctance to leave the fire line can cause firefighters to ignore early symptoms like chest pain.[1] Firefighters may also not want to have medical screenings because they may have difficulty asking for help losing weight or initiating a fitness plan.[1]

CVD Among the General Population Compared to Firefighter

For the general population lifestyle-related risk factors for cardiovascular disease include being overweight or obese, having diabetes, stress, high blood pressure and high cholesterol, eating an unhealthy diet, being physically inactive, smoking, and having excessive alcohol intake.[3,6] This gives practitioners an idea of possible risk factors for the firefighting population, however, firefighters are quite different from the general population in many ways, including nature of their work and how it impacts their lifestyle. There is quite a bit of research on non-occupational, modifiable CVD risk factors among firefighters, but the literature has yet to summarize all of the non-occupational risk factors in one place. This information may be valuable for public health professionals working to improve firefighter health and performance. As such, the purpose of this study was to determine and summarize the non-occupational CVD risk factors among firefighters.

CHAPTER III

METHODOLOGY

Methods

A systematic literature review of current evidence was performed to systematically review the literature to determine the non-occupational or lifestyle factors contributing to CVD among career and volunteer firefighters. The review was conducted and reported following to the Preferred Reporting Systems for Systematic reviews and Meta-Analysis.[21]

Search Strategy

The search strategy was determined a priori. Published studies were searched using the electronic databases PubMed and Scopus. Variables of interest included diet, physical activity, and weight related CVD risk of firefighters. Thus, the search strategy was conducted using the following keywords: cardiovascular disease, (heart disease, stroke, aneurysm, cardiac arrest, heart attack, ischemia, myocardial infarction, heart failure, hypertension, angina), diet (diet* habits, diet patterns, eating patterns, nutrition), and physical activity, (exercise and physical fitness), as well as weight status (overweight and obesity).

Inclusion criteria for types of participants were limited to adults 18 years of age or older who were current career or volunteer firefighters during the time of the study. Studies were

included if they involved diet, physical activity, or weight-related CVD risk factors; studies were also included if they involved other risk factors, however, this review only reported on diet, physical activity, or weight-related CVD risk factors. Additionally, studies were also included if cancer risk factors were reported along with CVD risk factors, however only factors relating to CVD were reported on in this review. Studies involving CVD mortality rates while retired were included if the risk factor was surveyed or assessed while performing as an active firefighter. Types of study designs were limited to cross-sectional, case control, prospective cohort/ longitudinal, or experimental studies. Lastly, all studies included were those conducted among firefighters in the United States. Abstracts and full texts were considered and studies were included only if they met inclusion criteria.

Exclusion criteria included studies which reported only on occupational and other non-occupational, lifestyle CVD risk factors aside from diet, physical activity, and weight, studies that included cancer risk only, studies that were limited to firefighter retirees, and studies that were conducted with firefighters that did not reside within the United States. Additionally, studies were also excluded if types of studies were not cross-sectional, case control, prospective cohort, or experimental study designs. Finally, studies were excluded if there was no English translation available or if it was from a non-peer-reviewed journal source.

Selection of Studies and Data Synthesis

A two-step screening process was employed. In step one, one author scanned the title and abstracts of the studies identified in the search for their eligibility and duplicates were removed. In step two, full text articles were screened by the first author for eligibility. Two independent reviewers conducted the search strategy to decrease bias. Any disagreement in study inclusion was discussed and resolved. Data was extracted from published papers into a standardized table

by two authors. Extracted data included authors, year, study design, sample size & characteristics, exposure & follow-up period, outcome measures and results.

Review of Study Quality

Study methodological quality was assessed using a standardized critical appraisal instrument, the Quality Criteria Checklist for Primary Research from the Academy of Nutrition and Dietetics Evidence Analysis Library.[22] This checklist appraises the quality of a study by determining the presence and rigor of important aspects of a scientific study, such as research question, selection of study patients and bias, methods of handling withdrawals, whether blinding was used, therapeutic targets that were used, outcomes that were reliable and valid, and study funding, as well as limitations that may or may not have been considered. A rating is assigned to each of these components and include yes, no, not applicable, or unclear. Ratings of yes for individual checklist criteria mean that the study in question does address the component of interest, while ratings of no for individual criteria mean that the study did not address the component of interest. In terms of overall study quality ratings, a positive quality rating indicates that the study has addressed inclusion and exclusion bias generalizability, as well as data collection and analysis protocols. A study gets a positive rating if validity/ criteria questions 2, 3, 6, and 7 all rated as yes and one additional question is rated as a yes. A negative overall quality rating indicates that the study has not addressed issues of inclusion, exclusion, generalizability, data collection, and analysis protocols. A study receives a negative overall quality rating if six or more of the validity/ criteria questions are rated as no's. A neutral overall quality rating indicates that the study is neither extremely weak nor extremely strong. A study gets rated as a neutral overall quality rating if the answers to validity/ criteria questions 2, 3, 6, and 7 are a mixture of yes and no ratings.[22]

CHAPTER IV

RESULTS

An initial search of the literature revealed 519 total search results. After screening by title, 264 articles remained from the initial search. Furthermore, after removing duplicates, 68 articles remained. After screening by abstract, 45 full text articles were assessed for eligibility. Finally, 26 articles were included in the qualitative synthesis. A flow diagram of the literature search and filtering process for this systematic review can be found in figure 1. A summary of included studies and extracted data can be found in Appendix 1. Quality ratings of included articles can be found in Appendix 2.

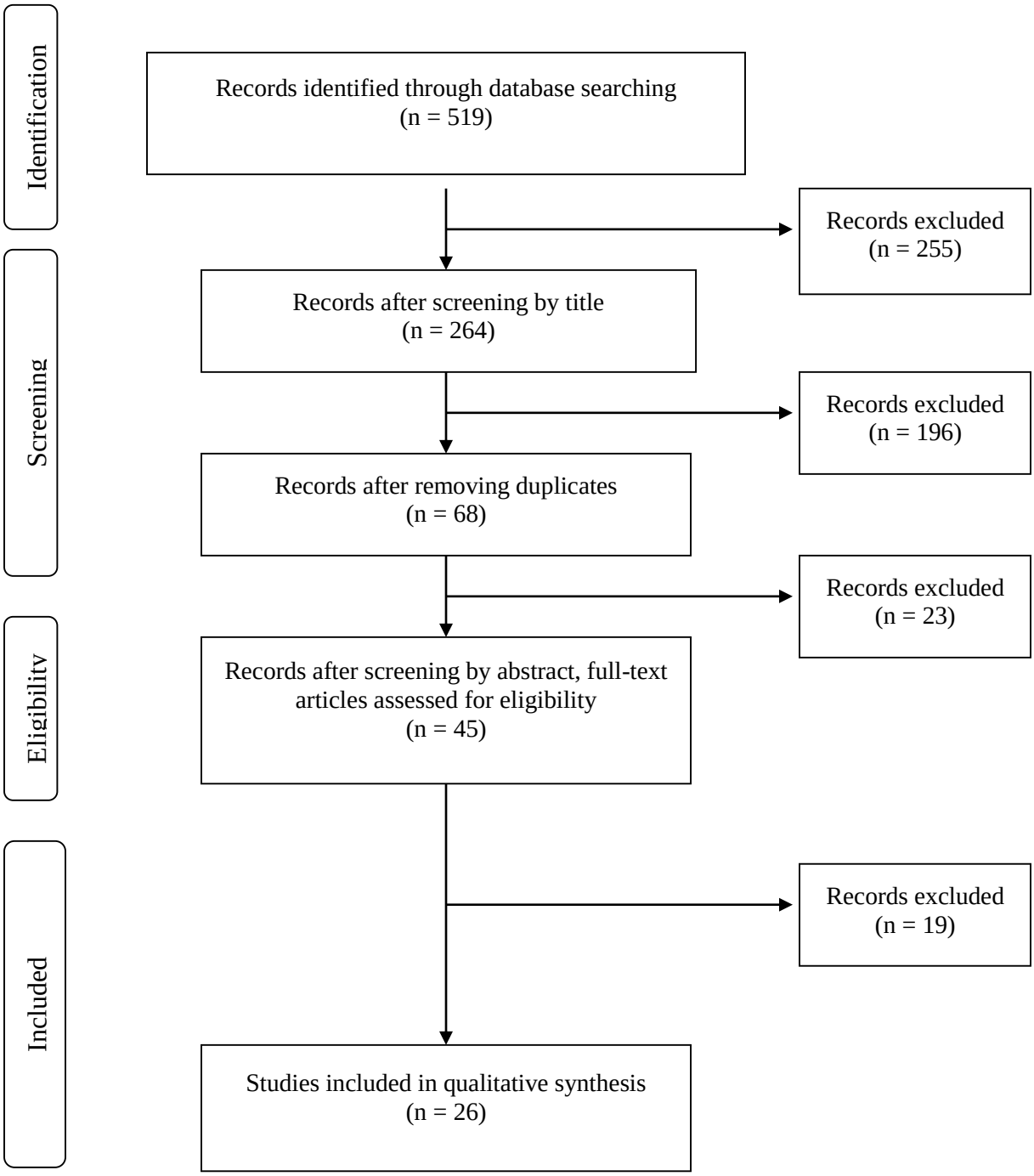
Identification
Screening
Eligibility
Included
Records identified through database searching
(n = 519)
Records excluded
(n = 255)
Records after screening by title
(n = 264)
Records excluded
(n = 196)
Records after removing duplicates
(n = 68)
Records excluded
(n = 23)
Records after screening by abstract, full-text
articles assessed for eligibility
(n = 45)
Records excluded
(n = 19)
Studies included in qualitative synthesis
(n = 26)

Figure 1. Flow diagram of the literature search and filtering process for the current systematic review investigating non-occupational CVD risk factors among firefighters

Range of sample sizes varied between studies with 29 being the smallest number of participants to the largest being 3172 participants. The majority of studies involved primarily Caucasian male populations, and many studies excluded female participants due to females making up very small percentages of the firefighting population. Less than half of the studies involved only volunteer firefighters or a combination of career and volunteer firefighters. Thus, the majority of studies involved career firefighters. The majority of samples included in this review resided within the US, however location within the US varied greatly.

Nutrition-related Risk Factors for CVD among Firefighters

Four studies were included in the final review regarding nutrition. Of these four studies, three studies were composed of career firefighters only and one study was composed of both volunteer and career firefighters. All four studies were of cross-sectional design with one including focus groups. Exposures that were addressed in these studies included demographic characteristics, awareness of risk factors for CVD, modified Mediterranean diet score, as well as focus group information examining firefighters' suggestions to design CVD prevention programs. Outcome assessments of the studies included favorability ratings of diet descriptions as well as information regarding diet and diet advice received from the fire service. Other outcome assessments included self-reported prevalence/presence of risk indicators for CVD, as well as BMI, body fat %, weight change, and metabolic syndrome scores. Specific outcome assessments for CVD risk included BMI, body fat %, weight change, metabolic syndrome scores, and self-reported risk factors of CVD including cholesterol levels, high blood pressure, food choices. Quality Control Checklist ratings for these four studies included two positive and two neutral ratings.[5]

Regarding dietary intake and habits of firefighters, a cross sectional study by Yang et al.,[23] reported that 71% of career firefighters in their sample population failed to follow any specific dietary plan. When presented with a description of diets, participants ranked the Mediterranean diet as the more favorable diet ($p<0.001$) over other comparable low-fat, plant-based diets, including Paleo, therapeutic lifestyle change (TLC), Atkins, or Esselsteyn Engine 2 diets. In a cross-sectional study by Kay et al., researchers found that 37% of career firefighters did not want to change anything about what they ate. Focus groups conducted by Frattaroli et al.,[24] found that firefighters reported not consuming a well-balanced, nutritious diet or engaging in regular physical activity because of the fire service lifestyle. Furthermore, this study indicated that often, the fire culture encourages snacks and sugar-sweetened beverages through use of vending machines and that this often leads to high consumptions of sugar, fat, and salt. Thus, the majority of firefighters are not following a specific diet and tend to not be eating healthfully. Some firefighters do not wish to change their eating habits, but if they did, the Mediterranean Diet would be favorable.

As for nutrition knowledge and interest in learning about nutrition, a cross-sectional study by Yang et al. reported that 85% of firefighters in the study believed they didn't receive sufficient nutrition information, and 75% of firefighters were interested in learning about healthy eating.[23] Firefighters also expressed great interest in topics regarding nutrition in a cross-sectional study conducted by Kay et al.[25] When assessing firefighters' knowledge regarding major health issues, investigators found that 90% and 78% of firefighters had read/heard that their food choices can cause/prevent heart disease and obesity, respectively, as well as 69% for hypertension, 64% for cancer, and 48% for diabetes. A cross-sectional focus group performed by Fratteroli et al.[24] found that firefighters suggested individually-focused interventions supplying firefighters with knowledge and skills that are required to maneuver past convenient, quick, and cheap food choices in their communities and firehouses. These firefighters also suggested

minimizing community risks, including minimizing fast food restaurant consumption and unhealthy vending machine choices. In summary, firefighters do not feel that they are receiving enough nutrition information and would like more on topics such as general healthy eating, nutrition to prevent obesity and chronic disease, and ways to decrease or make healthier choices related to fast food and vending machine/ convenience food consumption while on duty.

Regarding nutrition and weight status, one study by Kay et al.,[25] revealed that 79 out of 96 (82%) career firefighters were classified as overweight. Of these 79 individuals in the overweight category, 13 (16%) were classified as obese based on BMI. When investigators looked at personal weight perceptions, the majority of firefighters with an overweight BMI did not perceive themselves as being classified as overweight. Data indicated that 44% of these firefighters considered themselves to be overweight, while 53% considered their weight to be about right. Another cross-sectional study investigating modified Mediterranean diet scores (mMDS)[26] found that obese participants exhibited significantly lower mMDS and exhibited greater fast/take-out food and sweetened drink intake ($p=0.002$) compared to normal weight participants. These researchers also found that higher mMDS were inversely related to risk of gaining weight over the past five years [Odds ratio (OR) = 0.57, 95% confidence interval (95% CI) = 0.39–0.84, p for trend across score quartiles = 0.01] and risk of metabolic syndrome (OR = 0.65, 95% CI = 0.44–0.94, p for trend across score quartiles = 0.04), even after adjusting for multiple confounding variables (age, BMI, and physical activity). Thus, many firefighters appear to be unaware of their unhealthy weight status, and those that are of a higher BMI have less healthful eating habits (i.e., higher fast food and sweetened beverage intake, lower mMDS).

In regards to cardiovascular disease indicators noted in the nutrition-related studies, one cross sectional study conducted by Kay et al.,[25] indicated that 28% of firefighters in their sample had been informed of having high cholesterol and that 94% of the sample indicated the best way to lower cholesterol was eating foods low in cholesterol. Additionally, 22% of firefighters stated

that their blood pressure was high, 86% of whom were also considered to be overweight. Yang et al.[26] revealed that in their sample, an increased mMDS was associated with increased HDL cholesterol ($p=0.008$) and decreased LDL cholesterol ($p=0.04$), even after controlling for confounding variables indicating that Mediterranean diet adherence might be a way to improve CVD indices among firefighters.

As for stress and nutrition, one study regarding both volunteer and career firefighters by Frattaroli et al.[24] found that the most important issue firefighters expressed in regards to fire service lifestyle was stress. Participants felt stress makes engaging in healthy behaviors difficult to manage and noted stressful lifestyles in combination with unhealthy food options in the community as a particular obstacle that should be considered when intervening to promote healthier eating.

As for the fire service's role in encouragement of nutrition and health principles, a study by Kay et al.[25] found that 79% of firefighters in their sample did not think general health habits and principles were being assessed to an appropriate level by their employers. However, individuals in a cross-sectional study by Frattaroli et al.[24] stated that mandating a health and wellness initiative would not be a wise decision due to firefighters' resistance to change. They expressed that individuals need to be willing to commit to healthy eating. Firefighters also suggested that helpful strategies to tackle barriers to healthy eating should occur through implementation of strategies at the individual, worksite, and community levels and that including a competition and prizes would increase participation in interventions.

In relation to the food environment, a study by Frattaroli et al.[24] found that firefighters reported sharing most regular meals cooked at the firehouse. They report that this was common across the fire culture and that they may also eat at home, bring take out from restaurants to the fire house, or go to fast food places or rely on snacks from the vending machines. The latter was

more typical of volunteer fire departments. Firefighters in this study also discussed challenging food environments, including vast community options (i.e., fast food restaurants providing convenient access and sometimes representing the only hot food option in the area) and the firehouse where vending machines often are filled with non-nutritious food options and resources for healthy cooking are in short supply. Snacking was also discussed as a hurdle to healthy eating. Fire staff mentioned donuts, buns, and pizza as being accessible, free, and difficult to turn down. They also mention unhealthy foods being much more available than healthy foods. As for resources in the environment, some firefighters mentioned sporadic healthy eating classes offered at stations regarding diet and nutrition. However, they also discussed that these classes provided little benefit to offset the never-ending supply of non-nutritional options in the area. Another barrier that was brought up by volunteer firefighters was the struggle to manage live fire service obligations and day jobs, which results in going for food options that are readily available, simple, and quick. They also mentioned that firefighter lifestyle influences food choices, such that they need to be fast, tasty, cheap, and filling.

Looking at cost of healthy food, the cross sectional study conducted by Frattaroli et. al[24] found that many firefighters perceive healthy eating to be limited or nonexistent due to a small budget allotted for food. Likewise, focus groups of this study revealed that firefighters are very sensitive to cost. Many arrangements about what kinds of foods to cook or what to eat were often described to researchers as being primarily motivated by what items are on sale due to the need to feed a large quantity of people on a restricted budget. Healthy foods were generally perceived as costly, more complex, and less satisfying/filling to firefighters.

Nutrition- & Physical Activity-related Risk Factors for CVD among Firefighters

Four studies included in the final review involved both nutrition and physical activity. Among these four studies, two studies were conducted with career firefighters only, while the

other two studies consisted of career and volunteer firefighters. Three of the four studies were composed of cross-sectional designs, while the last study was quasi-experimental in nature. As for exposures, one study which involved a focus group focused primarily on the perspectives fire service personnel had regarding lifestyle related CVD risk factors. Other study exposures included a comprehensive wellness program, demographic characteristics, nutrition and physical activity habits, and knowledge of CVD risk factors. Outcome assessments for indicators of CVD included resting heart rate, blood pressure, percent body fat, BMI, cholesterol, and glucose. For the quality control checklists, two studies received neutral ratings, while the other two studies received positive ratings.

In terms of knowledge and interest in learning about healthy lifestyle behaviors, one cross-sectional study published by Jahnke et al.[27] reported that firefighters were primarily concerned with cancer and heart disease, as well as their respective contributing factors including fitness, nutrition, and sleep, mental health, and injury. Participants in this study were most concerned with risk of cancer and exposure to carcinogenic agents. Firefighters additionally were knowledgeable about CVD, and many referenced the statistic that more than half of line-of-duty deaths each year are CVD related. One cross-sectional study conducted by Eastlake et al.[28] found that a majority of firefighters were able to identify risk factors for cardiovascular disease, including 69% of participants recognizing family history as a risk factor and 82% recognizing obesity and hypertension as risks factors. Of those who recognized hypertension or inactive lifestyle as risks for CVD, 52-54% did not have HTN and were not sedentary. On the other hand, 46-64% of those who understood the risk factors for CVD were sedentary, obese, or exhibited hypertension. Thus, there is concern and awareness of CVD and cancer as health issues in the fire service, and there is also awareness that having a healthy lifestyle decreases risk of these health issues, including physical activity and nutrition, as well as sleep and mental health.

Regarding barriers to healthy eating and diet, one cross-sectional study[27] found that many firefighters communicated challenges regarding cardiovascular health included factors such as intense physical demands, emotional stress, shift structure, and high physical fitness. Many firefighters in this study also recognized the negative consequences of a poor diet and reported that barriers in maintaining a healthy diet included social norms around eating, traditions around meals, and social expectations to conform to the preferences and expectations of the crew. Reliance on energy drinks and caffeine for energy may also be a barrier to healthy eating, as one other study conducted by Eastlake et al.[28] revealed that 87% of firefighters reported consuming energy drinks < 1 time per week. In regards to the food environment, a focus group conducted by Jahnke et al.[27] found that firefighters felt the food environment within the firehouse is of particular importance in influencing firefighter health, despite resistance to change as a strongly built upon tradition, including unhealthy food and large portion sizes in the fire station. Thus, barriers to healthy eating may include job stressors, social norms and expectations, traditions, and the fire station food environment. In a quasi-experimental study by McDonough et al.,[29] researchers found that having weigh-ins and measurements made firefighters more conscious of eating behavior patterns.

In regards to frequency of physical activity, a cross-sectional study conducted by Eastlake et al.[28] found that 46% of firefighters reported exercising 1-3 times per week, with 16% exercising < 1 time per week. Another study conducted by Risavi et al.[30] revealed that in their sample of firefighters 58% of respondents reported regular exercise. On the other hand, looking at sedentary time as video game use, a cross-sectional study by Eastlake et al.[28] revealed that 79% of firefighters reported playing video games < 1 time per week/never. It appears that around half of firefighters are exercising regularly, and that the majority do not have high levels of screen/ sedentary time from video game playing.

As for beliefs and barriers to physical activity, one cross-sectional study by Jahnke et. al.[27] found that firefighters felt like they should display better fitness levels than the general public due to the unique nature of their job duties. They also found that these firefighters admitted there are unique challenges of maintaining physical fitness, particularly being aware of what types of exercise are best to perform their job. In this study, firefighters believed that initiating programs that focus on improving firefighter health/fitness levels were important. In another quasi-experimental study by McDonough et al.,[29] researchers found that many firefighters reported that having weigh-ins and measurements made them more conscious of exercise behavior patterns over the 8-week period.

Looking at a CVD prevention program involving nutrition and physical activity, the previously mentioned quasi-experimental study conducted by McDonough et al.[29] involved an 8-week Fit Firefighter intervention to prevent CVD, including health education seminars, nutrition information sharing, exercise demonstrations, and hands-on healthy snack preparation, and health coaching (optional). Following the 8-week program, both blood pressure and resting heart rate decreased 3%. Aerobic fitness improved 1.6%, while BMI increased 1%. Body fat percent change was reported as -8%, indicating the increase in BMI was likely due to gain in lean mass. There was an 18% improvement in flexibility and 5% improvement in bicep strength, while waist circumference decreased 8.3% (all differences noted as significant, but no p value reported). This study also found that with additional but optional health coaching (utilized by 48% of participants), significant differences in systolic/diastolic blood pressure, % body fat, BMI and back flexibility ($ps<0.05$) were revealed between the coached vs. non-coached groups, favoring improved health and fitness in the coached group. Thus, culturally-appropriate CVD prevention programs including both nutrition and physical activity are acceptable and can be effective among firefighters in improving nutrition and physical activity behaviors and reducing CVD risk factors.

Physical Activity-related Risk Factors for CVD among Firefighters

Eighteen studies were included in the review regarding physical activity. Of the eighteen studies, ten studies were composed of career firefighters only, while four studies were composed of volunteer firefighters only, and four studies were composed of both career and volunteer firefighters combined. Sixteen of the studies were of cross-sectional design. One study was a prospective cohort study, and another study was a cost-effectiveness analysis. Regarding exposures, a majority of studies involved cardiorespiratory fitness, assessed via exercise treadmill test. Other exposures include demographic information and motivation to exercise, as well as physical fitness beliefs and attitudes, and usefulness of initiating a physical fitness program. Other physical fitness assessments included muscular strength VO2 max, push-ups, curl ups, grip strength. Regarding outcome assessments for CVD risk, most studies included BMI, electrocardiogram (ECG), metabolic syndrome, weight, blood pressure, %body fat, VO2 max, HDL and LDL cholesterol, and triglycerides. Of the studies included, seven articles received positive ratings, while eleven articles received neutral ratings on the quality control checklist.

Cardiorespiratory Fitness (CRF) Levels of Firefighters in Included Studies.

Cardiorespiratory fitness refers to the ability to transport oxygen from the atmosphere to the mitochondria in order to perform work.[51] It is related to integrated functions of various bodily systems and can be considered to be reflective of total body health. Cardiorespiratory fitness is usually assessed using VO2max (mL/kg/min) or metabolic equivalents (METs), which define cardiorespiratory fitness by the volume of oxygen consumed doing a given activity.[52] In terms of METs, one MET is defined as the amount of oxygen consumed while sitting at rest. In relation, one MET is equivalent to a VO2max of 3.5mL/kg/min.[52] Types of tests that are used to determine CRF include exercise tolerance tests or maximal treadmill tests which measure VO2max.[51]

CRF is important among the fire service for two reasons. First, it can be used to set a standard of fitness when entering the profession. Second, considering the high prevalence of CVD among firefighters, it is a strong predictor of risk for adverse cardiovascular outcomes, even stronger than traditional risk factors, including lipid abnormalities, hypertension, insulin resistance, obesity, and smoking.[51]

In terms of cardiorespiratory fitness standards, the National Fire Protection Association recommends firefighters maintain a minimum fitness standard of 12 METs.[31] They also have proposed for firefighting to have a VO2max range of 33.6 ml/kg/min to 49 ml/kg/min.[31] To put these values into perspective, according to data from NHANES 1999–2004, the estimated cardiorespiratory fitness level, as mean VO2max, was 43.2 mL/kg/minute for men aged 20-49 years old in the general US population (i.e., similar demographic group to the majority of firefighters).[53] Additionally, MET values for common activities include 3.3 METs for sweeping the carpet, 4.5 METs for mowing the lawn, 6.0 METs for leisurely swimming, and 11.0 METs for running a 9-minute mile.[54]

A cross-sectional study by Baur et al.[31] found that 44% of firefighters had cardiorespiratory fitness that exceeded the National Fire Protection Association's (NFPA) minimum fitness standard of 12 metabolic equivalents (METs). This same study found that 10% of firefighters revealed a CRF greater than or equal to 14 METs. On the contrary, only 10% of firefighters in this study were in the high fitness group.

Additionally, one cross-sectional study by Peate et al.[32] found that mean VO2 max was 41.8 ± 8.8 mL/kg/min. Researchers of this study also examined quintiles of aerobic capacity in which they discovered statistically similar proportions of firefighters per activity level (self-rated activity levels = 0-4, increasing level indicates higher activity). In comparing aerobic capacity of those within each activity level, 33% of the firefighters in the second activity level exhibited

aerobic capacities of 22-37 ml/kg/min, similar to 21% of firefighters in the fourth level (p=0.60). Lastly, 20% of firefighters in the third activity level had VO2 max of <33.5 ml/kg/min, similar to 16% of firefighters in the fourth activity level as well (p=0.74).

A prospective cohort study by Martin et al.[33] revealed that for measures of cardiorespiratory fitness, participants on average had very poor recovery heart rate (HR) after completing the YMCA step test; average heart rate for the YMCA test was 160.2 ± 14.6 bpm. Participants of this study however on average scored in the very good category for push-ups. The average number of sit ups performed by participants in this study was 27.3 ± 10.5, which ranked in the 25th percentile.

Finally, one cross-sectional study by Hammer et al.,[34] which looked at certified vs. noncertified firefighters, found that there were no significant differences (p=0.431) in predicted VO2 max between certified (39.9 ± 8.4 ml/kg/min) and uncertified (37.8 ± 8.5 ml/kg/min) firefighters. This study additionally found that 30% of volunteer firefighters had predicted aerobic capacities, which were below the recommended minimum VO2 max level of 33.5 ml/kg/min.

In summary, a majority of studies regarding cardiorespiratory fitness found firefighters to have low to average cardiorespiratory fitness levels compared to recommendations for their profession. One study however, revealed that on some areas of cardiorespiratory fitness, particularly those that require upper body strength like push-ups, firefighters scored well. Overall, most studies demonstrated that there is a slightly larger proportion of firefighters meeting minimum fitness requirements than those not meeting requirements.

Obesity, Metabolic Syndrome, and Cardiorespiratory Fitness Levels of Firefighters

A cross sectional study by Bauer et al.,[31] revealed that 90% of their study participants were classified as overweight and obese, while 40% of study participants were classified as being strictly obese. This study also found that obese firefighters were more likely to be in the very low

or low fitness groups. Another cross-sectional study by Amodeo[35] found that 35.9% of participants were overweight, while 44.4% of participants in their study were obese. Likewise, one study by Scanlon et al.[36] found that 18.6% of participants classified as healthy BMI range, while 41.2% of participants were classified as overweight based on BMI and 35.5% of participants were classified as obese based on BMI.

In regards to metabolic syndrome, a study by Leiba et al.[37] found that 28.3% of study participants met the standard criteria for metabolic syndrome. Of their population 21.7% didn't meet any criteria for metabolic syndrome while 28.2% met a single criterion and 21.7% met two criteria for metabolic syndrome. They additionally found that 51.2% of participants in the lowest fitness group had metabolic syndrome, while 5.2% of participants in the highest fitness group had metabolic syndrome. They also found that 37.9% of participants in the group with METS < 12 had metabolic syndrome, while 15.9% of participants in the group with METS > 12 had metabolic syndrome. Additionally, the mean cardiorespiratory fitness in METS decreased in a dose respondent way, which was significant even after adjusting for age ($p<0.001$). This same study found that the odds of having metabolic syndrome were 3.24 higher in those with fitness levels < 12 METS compared to those with fitness levels > 12 METS [OR = 3.24 (95% CI = 2.4-4.4)]. This study also found that a 1-unit increase in METS resulted in 31% decreased odds of having metabolic syndrome [OR = 0.69 (95% CI = 0.63-0.76)].

Another cross-sectional study which focused on metabolic syndrome abnormalities by Baur et al.[38] found that as the number of metabolic abnormalities in the firefighting population increased, the mean CRF in METS decreased. They highlighted that this occurred in a dose response fashion and appeared to be significant after adjustment for age ($p<0.0001$). Regarding cardiorespiratory fitness, this study also found the mean CRF level of the population to be 12.0 METS. When comparing firefighters who had metabolic syndrome with those who did not meet criteria, researchers found that firefighters who had metabolic syndrome had a mean maximal

METS of 11.1 (SD 1.8) compared to 12.8 (SD 1.7) in participants who met none of the criteria ($p<0.0001$, adjusted for age). These investigators also found that 51.2% of participants in the lowest fitness group had metabolic syndrome compared to 5.2% of participants in highest fitness group ($p<0.0001$, adjusted for age). They also found that 37.9% of participants had metabolic syndrome in group with METS less than or equal to 12, while 15.9% of participants had metabolic syndrome in group achieving greater than 12 METS ($p<0.0001$, adjusted for age). Lastly, those with fitness levels less than or equal to 12 METS compared with those greater than 12 METS had 3.24 times the odds of metabolic syndrome (95% CI = 2.4–4.4) unadjusted and 2.93 times the odds (95% CI = 2.1–4.1) adjusted for age. One of the more important things that researchers found was that regression analysis showed a one-unit increase in METS resulted in 31% decreased odds of having metabolic syndrome (OR=0.69 [95% CI = 0.63–0.76]) after adjusting for age.

Another study published by Donovan et al.[39] found that 25% of firefighters failed to achieve the minimum cardiorespiratory fitness level as VO2 max of 42.0 ml/kg/min, which is the minimum level of cardiorespiratory fitness needed to perform the duties of the job. These researchers also found that the mean cardiorespiratory fitness level was 46.6 ml/kg/min, which was higher than that expected for the age- and sex-matched population, indicating a higher fitness level. Likewise, authors of this study additionally found that subjects with two or three or more metabolic abnormalities had significantly lower estimations for VO2 max compared to participants with zero or one metabolic abnormalities, indicating a significant inverse trend between cardiorespiratory fitness and metabolic abnormalities ($p< 0.001$). Additionally, a cross-sectional study by Li et al.[40] revealed that mean VO2 max was 46.9 ml/kg/min (SD = 6.8 ml/kg/min) and that 49% of participants did not meet the minimum cardiorespiratory fitness level set at 42 ml/kg/min by the NFPA. They additionally found that VO2max was negatively associated with number of metabolic syndrome components (incident rate ratios (IRRs) = 0.95,

95% CI = 0.93–0.96, p<0.001), when controlling for age, group, smoking and alcohol among males.

A cross-sectional study by Baur et al.[41] looking at stress test abnormalities in relation to CRF and metabolic syndrome reported that 64% of participants revealed one or more abnormal exercise stress test criteria in the lowest fitness group of less than or equal to 10 METS. In addition, 23% of participants revealed one or more abnormal exercise stress test criteria in the highest fitness group. Researchers additionally found the incidence of abnormalities in the lowest fitness group was 47% as compared to 7% in the highest fitness group (p<0.001 after adjustment for age and metabolic syndrome). Lastly, they found that for each additional MET achieved, odds of abnormalities decreased by 29-31%, in the adjusted model for age, body mass index and metabolic syndrome.

In summary, the vast majority of firefighters in these studies would be classified as having metabolic syndrome. Likewise, the majority of firefighters were also classified as being overweight or obese. Lastly, firefighters classified as being obese or having metabolic syndrome exhibited lower fitness levels and higher CVD indicators.

Presence of CVD Risk Indicators and Cardiorespiratory Fitness Levels of Firefighters

As for indicators for CVD, one cross-sectional study published by Donovan et al.[39] found that high blood pressure was the most prevalent health abnormality and that 55% of the study population had high blood pressure. Additionally, they also found that 10% of firefighters had a resting blood pressure of greater than or equal to 140/90 mmHg. Likewise, 14% of firefighters reported currently taking antihypertensive medication. Another cross-sectional study by Baur et al. found strong significant associations between cardiorespiratory fitness (CRF) and CVD risk factors including total cholesterol, HDL, TC/HDL ratio and blood glucose, after adjusting for age and BMI. They additionally found that for every one-unit increase in METS, the average increase

in HDL was 1.91 mg/dL. Investigators of this study found that the average HDL was 53.8 mg/dL in the highest CRF category, while average HDL was 38.6 mg/dL in the very low CRF category. As for fasting blood glucose, this study showed a decrease of 1.5 mg/dL for every one-unit increase in METS (beta = -0.65, p = 0.0343). Investigators found that an average obese firefighter who increased their physical fitness to greater than 12 METS could see a BMI decrease by 1.6 units, HDL increase by 5 mg/dL., TG decrease by > 30 mg/dL and blood glucose to about 9 mg/dL on average. This study also found that for every one-unit increase in METS, resting diastolic BP decreased by 0.71 mm Hg, which could decrease risk for CHD by 6% and stroke by 16%. They also found that higher CRF categories were significantly associated with lower diastolic BP, body fat, triglycerides, LDL, total/HDL ratio, and higher HDL (ps < 0.05, age and BMI adjusted).

An additional cross-sectional study by Leiba et al.[37] found that 40.8% of participants in their study had HDL < 40 mg/dL, while 39.8% had elevated BP or were taking antihypertensive medications. This study found that firefighters who were less fit had almost twice the risk of exercise-induced hypertension [OR = 1.8 (95%CI = 1.3-2.47)]. Another study by Durand et al.[43] found that higher BMI was negatively associated across all dimensions of physical activity for CRF and CVD risk factors. Likewise, they found HDL (p=0.02) and TG (p=0.04) were significantly improved in individuals who exercised at least 30 minutes per session as compared to those who exercised less than 30 minutes per session. They also found that the frequency physical activity dimension was significantly and positively associated with HDL (p=0.001) and negatively with TG (p=0.02), TC/HDL, (p=0.003) and fasting glucose (p=0.005). As for other dimensions of physical activity, such as duration and intensity, these did not show significant associations with CVD risk factors (ps>0.05). Individuals who acknowledged moderately sweating showed significantly lower mean values of TG (p=0.03) compared to individuals who reported sweating lightly or who did not exercise often. Lastly, total weekly exercise was

positively associated with HDL (p=0.003) and negatively associated with TG (p=0.03), TC/HDL (p=0.01) and hs-CRP (p=0.03).

A prospective cohort study by Martin et al.[43] analyzed eight CVD risk factors in their sample including age, history of CVD, history of smoking, sedentary lifestyle, obesity, hypertension, dyslipidemia and prediabetes. Researchers found that 27% of participants were hypertensive, 30% of participants had hypercholesterolemia, and 9% of participants were at risk for diabetes. They also found that 68% of participants had two or more CVD risk factors and also that most of the firefighters in this sample had inadequate physical fitness. One cross sectional study by Scanlon et al.[36] revealed that 19.9% of their study population reported high blood pressure, 18.5% reported high cholesterol levels, and 8.5% reported high cholesterol in addition to high blood pressure. Investigators found that 30.8% of participants indicated that they were currently taking medications, with 15.6% for high blood pressure and 11.0% for high cholesterol.

An additional study by Li et al.[44] looking at atherosclerotic cardiovascular disease (ASCVD) risk found that %BF (OR = 1.24, p<0.01), VO2max (OR = 0.90, p<0.05), MetS (OR = 2.66, p<0.05) and age group (OR = 5.62 for 55+ versus 39–44 years, p<0.001) were significantly related to 10-year ASCVD risk. They also found that after controlling for age, %BF (OR = 1.13, p<0.01) and MetS (OR = 2.87, p<0.05) remained significantly associated with 10-year ASCVD risk. Furthermore, after controlling for all independent variables including age, only %BF (OR = 1.17, p<0.01) was significantly associated with 10-year ASCVD risk.

Finally, a study by Dzikowicz et al.[45] found that 73.3% of the sample were hypertensive while 30.2% of the sample had myocardial ischemia. This study also found that the incidence of myocardial ischemia was 30%. When assessing cardiorespiratory fitness, 80.2% of participants had at least one exercise-induced premature ventricular contraction (EI-PVC) during their 24-hour recording session. Likewise, 3.5% of study subjects had more than 10 EI-PVCs per hour for

at least 20 hours. Additionally, the risk of myocardial ischemia with presence of EI-PVCs was 1.54 (95% CI = 1.22, 1.95). They also found that age was the only variable that differed between those that had EI-PVCs and those that did not have EI-PVCs. Males with EI-PVCs were more likely to be older (44.6 ± 7.3 years vs. 39.7 ± 8.0 years, p = 0.007). Investigators found no statistically significant results in differences in heart rate before exercise, (EI-PVC 76.0 ± 9.7 bpm, no EI-PVC 78.6 ± 7.3 bpm, p = 0.22), maximum obtained heart rate (EI-PVC 166.6 ± 18.5 bpm, no EI-PVC 171.1 ± 15.8 bpm, p = 0.28), or 1-min post-exercise heart rate (EI-PVC 136.6 ± 20.1 bpm, no EI-PVC 140.0 ± 15.8 bpm, p = 0.45) between those with and without EI-PVC's. They additionally found that at a univariate level using logistic regression models EI-PVCs were shown to be a significant predictor of myocardial ischemia (OR = 5.11, p = 0.015, 95% CI [1.38, 18.9]; Cox & Snell r2 = 0.085; Nagelkerke r2 = 0.121) and that after adjusting the model for age, race, BMI, resting SBP, resting DBP, resting mean 24-hr heart rate, and current smoking, EI-PVCs remained a statistically significant predictor of myocardial ischemia (OR = 4.281, p = 0.038, 95% CI [1.087, 16.862]; B = 1.454; Cox & Snell r2 = 0.140; Nagelkerke r2 = 0.198). Also looking at ECG/ stress test abnormalities, a cross-sectional study by Baur et al. found significant associations between CRF categories and max METS, total treadmill time, % max HR, HRR, RHR/HRR, exaggerated BP, and ECG abnormalities, after adjusting for BMI, age, and metabolic syndrome (ps<0.05).

In summary, these studies indicate that increasing fitness levels were associated with improved CVD indicators, specifically total cholesterol, HDL, TC/HDL ratio, LDL, triglycerides, blood glucose, and fewer ECG abnormalities. An additional point worth noting is that the majority of firefighters in these studies exhibited high blood pressure and high cholesterol.

Dimensions of Physical Activity and Cardiorespiratory Fitness Levels of Firefighters

A cross-sectional study by Storer et al.[46] found that 36% of participants in their study completed aerobic exercise three days per week and 30 minutes per day, while 50% of participants completed resistance training two days per week. This same study assessed cardiorespiratory fitness and found that mean (SD) for VO2 max test duration, maximum heart rate, and respiratory exchange ratio were 11.2 (2.1) min, 175 bpm, and 1.16 (0.03), respectively. They also found that a plateau of VO2 max occurred in participants despite increasing work rate seen in 59% of tests at end of exercise, with values at the 44th percentile on average. These researchers also found that relative to body weight, this sample had a VO2 max of 39.6 ml/kg/min on average, or 11 METS, which is 6% below recommended value of 42ml/kg/min for firefighters. Other results indicated that 33% of participants had VO2 max greater than the recommended value and 30% had VO2 max scores below minimal value for firefighters of 33 ml/kg/min. Researchers also assessed handgrip strength and abdominal endurance scores, which appeared to be similar to previously reported data for firefighters. Lastly, investigators of this study assessed pulmonary function as part of cardiorespiratory fitness and found that pulmonary function (FVC/FEV1 ratio) was normal and represented 94%, 96% and 101% of predicted values for age, height, and sex, respectively.

As for frequency of physical activity, one cross-sectional study by Amodeo[35] found that 14.4% of participants did not participate in any moderate-intensity cardiovascular exercise in the prior seven days. They also found that 16% of firefighters met American Heart Association/ American College of Sports Medicine 10 (AHA/ACSM10) requirements for physical activity for moderate-intensity cardiovascular exercise and that 40.8% of firefighters did not participate in any vigorous-intensity exercise in the past seven days. Researchers of this study also found that 32% of firefighters met the requirements for vigorous-intensity cardiovascular exercise in the prior seven days and that 53.3% of firefighters met physical activity requirements through a combination of moderate- and vigorous-intensity cardiovascular exercise. Lastly, researchers of

this study revealed that 45.2% of firefighters did not participate in any strength training exercise in the prior seven days and 29% of firefighters met the guidelines for strength training. Another cross-sectional study by Scanlon et al.,[36] found that 44% of participants revealed participating in an exercise program on average 5.92 (SD = 4.12) hours each week, however, they also found that 6% of participants in the 17–29-year age group, 10% of the 30–39-year age group, and 12% of the group > 40 years of age were found to not be in compliance with NFPA guidelines.

A study by Long et al.[47] found that out of the range of responses recorded, mild aerobic training was one of the most common type of training, ranging from 0-10 sessions a week, with a mean number of sessions of 2.47 (SD = 2.27) per week. Additionally, this study found that the least common form of exercise recorded was moderate aerobic, which ranged from 0-7 sessions per week, with a mean of 2.04 (SD = 1.65) sessions per week. Strenuous aerobic exercise responses ranged from 0-8 sessions per week, with a mean of 3.25 (SD = 1.52) sessions per week. Lastly, study researchers found that the highest average reported exercise category was strength training, which ranged from 0-8 sessions per week, with a mean of 3.31 (SD = 1.688) sessions per week.

In a cross-sectional study by Durand et al.[42] found that the frequency of physical activity in their sample included 47% of participants exceeding 90 minutes per week of moderate/vigorous physical activity. Likewise, they found that 20% of participants were estimated to be exceeding 150 minutes weekly. Regarding cardiorespiratory fitness, 37% of firefighters in this study had CRF less than or equal to 12 METs. After adjustment for age BMI and smoking status, the CRF outcome variables total treadmill time and max METs were shown to have significant differences along the 3 dimensions of physical activity ($p<0.001$). This study additionally assessed heart rate recovery at 1 minute (HRR), and resting heart rate (RHR). They found that HRR was associated with significant differences in duration ($p<0.001$) and intensity physical activity dimensions ($p=0.005$), while the RHR/HRR index was significantly associated

(p=0.02) with duration physical activity dimension. They additionally found that positive effects were demonstrated and most apparent when comparing those who reported their exercise duration was greater than or equal to 30 minutes with those who exercised less than 30 minutes (p=0.003) per session.

In summary, frequency of physical activity was variable among firefighters. The majority of studies found firefighters to be lacking in engagement in regular physical activity thus resulting in lower cardiorespiratory fitness levels than is recommended for firefighters. As for types of physical activity, many firefighters seemed to prefer strength training exercises.

Perceived Definition of Fitness.

One cross-sectional study by Staley et al.,[48] which was composed of focus groups, found that firefighters often use the words physical fitness or fitness to refer to the formal department policy or organization's allotted physical training, or PT, period for exercise, thus relating fitness with exercise. They also found that fitness was also generally framed by organizational fitness readiness, such as annual physical fitness exams, measures of flexibility, aerobic endurance, strength, height, weight, or blood pressure. Researchers of this study concluded that the cultural meaning of fitness appears to be intricate and could be expressed more around language describing fitness for the job at hand, such as finishing a response event task like pulling a victim from a fire, hauling a water hose, or "humping gear" up flights of steps. Researchers also found that firefighters used language regarding fitness to refer to the individual's or crew's readiness/preparedness for the job. "Good" fitness means being able to support one's crew effectively throughout an event using adequate levels of stamina and strength.

From a younger firefighter perspective, the definition of fitness surrounds appearance (i.e., wanting to look good) and to avoid gaining weight/ "gutting out." From an older firefighter perspective, the definition of fitness is more around concern about fitness and viewing fitness

within the context of physical health on and off the job, specifically regarding coronary health. Older firefighters in this focus group discussed how fitness was a long-term commitment and how they needed to "start early" in order to prevent heart-related problems later on in life.

Physical Training Adherence.

Firefighters in the Staley, et al. study[48] also described adherence behavior and descriptors as walking, lifting weights, riding the bike, or treadmill. Unconventional descriptors were also common and included training or doing the job, as these activities do increase heart rate and cardiovascular endurance. Reasons for adhering to PT that was discussed included reliance on a firefighter's personal motivation. Firefighters discussed how personal motivation is reinforced by strong interpersonal influences, such as their crew or management. Firefighters of this study stated that the most significant motivator that improves group PT adherence is crew cohesion and productivity. They state that fire department management can significantly impact PT adherence by putting in place fit captains and battalion chiefs, which may act as strong interpersonal influences. However, these firefighters also highlighted that it does become confusing and variable when management attempts to influence adherence in contradictory ways (e.g., establishing opposing expectations within a same shift, station, or department; lack of sanctions for firefighters which don't adhere to PT). Other factors or barriers to adherence to PT within the organization that were mentioned included immediacy for emergency responses or nonresponse activities, training activities, and in-station duties. Environmental factors within the station included physical space and equipment to exercise, quality and type of equipment, and the temperature.

Motivation to Improve and Adhere to Physical Fitness Training.

Staley at al.[48] reported that an intervention that is designed to improve fitness by focusing on CVD prevention is challenging with younger firefighters who primarily view PT and

participation in fitness as a way to improve their physical appearance. Younger, more fit firefighters also can influence older firefighters; however, they also talk about how these influences are often overpowered by the captain who is the officer in charge. Firefighters in this study discussed how "no man left behind" mindset is a strong motivator for encouragement of physical activity. Focus groups also discussed how a bigger motivator may be to have physical training programs patterned after real-life events, while also encouraging physical fitness.

Barriers to Physical Fitness Training.

One study by Long et al.[47] found that 92.7% of participants in their study reported strength-training equipment was available at their workplace. Additionally, 94.8% of participants stated they had access to equipment to exercise aerobically and a majority of firefighters expressed they had availability of equipment to exercise in different ways.

Attitude towards Physical Fitness Training.

One cross-sectional study by Amodeo et al.,[35] found that attitudes, perceived behavioral control, and past physical activity behavior accounted for 57.9% of the variance in physical activity intention ($r^2 = 0.579$, $p=0.031$). They also found positive significant associations with intention to be physically active included attitudes ($r=0.527$, $p<0.001$), perceived behavioral control ($r=0.494$, $p<0.001$), past physical activity ($r=0.618$, $p<0.001$), past physical activity moderate-intensity cardiovascular exercise ($r=0.556$, $p<0.001$), past physical activity vigorous-intensity cardiovascular exercise ($r=0.576$, $p<0.001$), past physical activity strength training ($r=0.514$, $p<0.001$), hours spent at the firehouse for service call activities ($r=0.268$, $p=0.004$). The only thing negatively associated with intention to be physically active included age ($r=-0.201$, $p=0.032$). Categories which were not associated at all with intention to be physically active included perceived risk of heart disease, subjective norm, hours spent at the firehouse for non-service call activities.

Knowledge and Interest in Learning about Physical Fitness to Prevent CVD.

One study by Scanlon et al.[36] revealed that when asked to select the major cause of line-of-duty death in US firefighters, 75.9% of participants selected heart attacks, 10.7% selected smoke inhalation, 9.6% selected auto accidents, and 2.5% selected burns. Additionally, 44.5% of participants were "definitely interested" and 45.6% of participants were "somewhat interested" in attending education sessions or lectures on proper diet and exercise and reducing heart attack risk if their fire department would provide it. Researchers also found that 56.8% of participants and 40% of participants were "definitely interested" and "somewhat interested," respectively, in being involved in a fitness program if their department provided it.

Physical Fitness Training Intervention Suggestions.

It is important to understand the experience and needs of the employer and the firefighter. One cross sectional study by Staley et al.[48] conducted focus groups, which discussed that fire service administrators should focus on creating fitness interventions which are culturally adapted to the unique nature of the fire service, emphasizing functional capacity, crew dependability, and fitness and well-being strategies. Fire service personnel included in this study stated that it would also be helpful for administration to focus on making physical training more normal and acceptable. They also recommended expanding policy on training programs to include physical fitness and broader well-being (i.e., healthy eating habits, proper hydration, better sleep habits, and stress management). In regards to cost, one cost-effectiveness analysis by Patterson et al.[49] found that having a wellness/fitness program prevented 10% of cardiovascular events and that physical activity monitors were shown to have the same effectiveness as but cost more than wellness/fitness programs.

CHAPTER V

DISCUSSION AND CONCLUSIONS

The purpose of this systematic review was to determine the non-occupational CVD risk factors among firefighters related to nutrition and physical activity. In the end, 26 articles were included in this qualitative synthesis – 4 nutrition, 4 both nutrition and physical activity, and 18 physical activity. Included studies indicate that firefighters do not engage in regular physical activity, have average fitness levels that often fall below minimum standards set forth for the fire service, tend to consume poor diets, and work in a poor food environment, all of which are associated with higher prevalence of CVD and its indicators. They also indicate that firefighters want information, programs, and resources related to improving nutrition and physical activity. Studies in this systematic review included both career and volunteer firefighters, as well as primarily male, Caucasian firefighters aged 18-70 years old residing in various states and regions across the United States. As such, results are broadly generalizable to the majority of the fire service, but may not be appropriate for more diverse departments.

This systematic review found very similar results to that of previous literature. Nutrition and physical activity in particular are non-occupational risk factors for CVD, which aligns with

previous studies. Many of the included studies highlight and indicate that firefighters do not engage in regular physical activity and have average cardiorespiratory fitness levels, as METs and VO2max, which are often below minimum fire service standards to perform physical duties of the job. This observation is in agreement with previous research by Smith et al., which concluded that firefighters lead lives in which there are short periods of strenuous activity and long periods of physical inactivity, which contribute to obesity.[5] Further, Smith et al. found that 65% of a firefighter's time was spent doing nonemergency duties, while only 1–5% of time was spent in fire suppression.[5] On the contrary, many firefighters perceive themselves to be physically active and fit despite their cardiorespiratory fitness levels are below recommended levels. This finding was parallel to previous research, which indicating overweight or obese firefighters often fail to correctly perceive themselves in their appropriate weight category.[9] In fact, researchers found that two-thirds of firefighters who were obese did not recognize they were obese and believed they were at low risk of developing obesity and that 68% of overweight and obese career firefighters underestimated their weight classification.[9] These studies emphasize the point that firefighters often have difficulties both in their perceptions regarding fitness levels and weight status. Furthermore, many of the participants in included studies were classified as overweight or obese based on BMI and as having metabolic syndrome, and numerous CVD indicators were highly prevalent (i.e., low HDL, high LDL and TG, high BP, ECG abnormalities). This observation is in agreement with previous research, which found that 51.7% of male firefighters were classified as obese based on BMI, while only 5.2% were classified as normal weight.[5]

Additionally, included studies highlighted that firefighters tend to have unhealthy dietary habits, which are often influenced by the firehouse culture, traditions, and food environment, as well as cost and convenience of foods. This is in agreement with previous research by Drew-Nord et al., which found that firehouse meals were often high in unhealthy fats and in refined carbohydrates, both of which have the potential to contribute to obesity.[1] Firefighters in included

studies also reported the lack of dedication by fire department administration in providing education, programming, and resources to improve diet and physical activity, including health and wellness screening/exams. This is in agreement with past research which found that medical exams were lacking in 75% of firefighters who eventually died from CHD.[5] However, studies which were included in the results have highlighted that firefighters are interested in learning more and participating in wellness programs, particularly regarding nutrition and physical activity.

Strengths

There were numerous strengths of studies included in this systematic review. Most of the interventions were thoroughly described in adequate detail. Another strength was that for a majority of studies exposure and outcome measures were valid and reliable, and statistical analyses were appropriate for the study design. Included studies were transparent about limitations, and in a majority of studies, funding sources were described and potential biases were disclosed. Another strength of the studies included in the systematic review was that there was a large body of consistent and cohesive evidence related to the impact of physical activity and fitness on the development of CVD among firefighters.

There were also numerous strengths of this systematic review. Multiple and appropriate databases (i.e., Scopus and PubMed) were used. Methods were established a priori, reducing the possibility for researcher bias on results, and followed the PRISMA checklist. A thorough, established quality criteria checklist was used to critically appraise studies included.

Limitations

One limitation of studies included in this systematic review was that numerous articles failed to address how the selection of participants occurred or if it was free from bias. Another limitation which occurred often was the lack of transparency in handling of withdrawals and

reporting of response rates. Many studies failed to mention if withdrawals occurred or how they handled them. Likewise, many studies failed to mention if blinding of researchers occurred, when possible, to prevent bias. Other limitations for included studies were the wide variety of exposures and outcomes assessments making it difficult to summarize conclusions cohesively and draw consistent conclusions. Likewise, many of the included studies with interventions were quasi-experimental and lacked stronger experimental study designs, such as a randomized controlled trial. Additionally, the majority of studies included in this systematic review were observational, specifically cross-sectional.

One limitation of this systematic review is that only two databases were searched in the identification of these studies. Ideally three or more would be used for a more complete search of the literature. Additionally, only one reviewer was involved in the identification of studies, and ideally two reviewers would be involved to ensure an unbiased search process.

Future Directions for Research

One direction for future research would be to conduct more studies regarding dietary habits and fire station food environment among fire personnel. While a few studies did include diet in relation to cardiovascular disease risk, the vast majority of the research focused on the physical activity and cardiorespiratory fitness in relation to CVD risk. Furthermore, more interventions need to be developed and tested aimed at improving nutrition and physical activity levels of firefighters. Finally, future studies should aim to include more diverse participants, as most studies involved primarily male, Caucasian, and general duty firefighters. More research is needed in relation to CVD prevention among females, ethnically-diverse groups, and specialty firefighters (e.g., wildland firefighters).

Conclusions

In summary, extensive evidence exists regarding increased CVD risk due to inadequate physical activity and low physical fitness levels among firefighters, however, very few studies address the role of firefighters' dietary habits in the development of CVD risk. This review is beneficial for practitioners and fire service leaders as it provides insight into the need for initiatives to increase physical activity levels and into the need to further investigate how diet affects CVD risk, as well as initiatives to improve dietary habits, among the firefighting population.

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APPENDICES

APPENDIX 1: Studies investigating non-occupational CVD risk factors among firefighters

Authors, year	Study design	Sample size & characteristics	Exposure & follow-up period (as appropriate)	Outcome measures	Results
Nutrition-related risk factors					
CAREER					
Yang et al., 2015	Cross-sectional	3172 career firefighters, average age 42yo, working in all 50 states + Canada, males 90% of survey respondents	Self-reported demographics, including height/weight for body composition	Survey: following a diet (yes/no), nutrition knowledge, favorability ratings of 5 diet descriptions, info on diet advice received from the fire service	- 71% of firefighters don't currently follow any specific dietary plan, 85% don't believe they receive sufficient nutrition information, and 75% are interested in learning about healthy eating - The Mediterranean diet was ranked as firefighters' favorite diet, receiving more favorable relative rankings ($p<0.001$) compared to Paleo, Atkins, TLC, or Esselsteyn Engine 2 (low fat, strictly plant based) diets - Participants who were obese revealed more limited nutritional knowledge ($p<0.001$) and were more likely to report lacking sufficient nutrition information ($p=0.021$) over participants within the normal body weight category
Kay et al., 2001	Cross-sectional	96 full-time male firefighters aged 20-56yrs, predominantly white working in a city in Northeastern Pennsylvania	Survey to determine awareness of risk factors for CVD (including sleep, CVD, diet, PA, medical diagnosis and stress), awareness	Self-reported prevalence/ presence of risk factors for and indicators of CVD	- 79, of firefighters were classified as overweight, 13 of which were considered obese, based on BMI - The majority of firefighters with an overweight BMI didn't perceive themselves as being overweight - 44% of firefighters considered themselves to be overweight, 53% considered their weight to be about right - 28% of firefighters had been informed of having high cholesterol and 94% indicated that eating foods low in cholesterol is the best way to lower cholesterol levels - 22% of firefighters stated their blood pressure is high; of firefighters diagnosed with hypertension, 86% were considered to be overweight - 79% of firefighters did not think general health habits were being assessed to an appropriate level by their employer - Firefighters expressed great interest in topics regarding nutrition, fitness, and stress management

			of need to modify dietary risk factors, actions to modify diet, and interest in worksite interventions		- 90% of firefighters heard/read that their food choices can cause/prevent heart disease, 78% obesity, 69% hypertension, 64% cancer, and 48% diabetes - 37% of firefighters reported they did not want to change what they ate
Yang et al., 2014	Cross-sectional	780 male career firefighters, aged 18-59yo, working in the Midwest	Modified Mediterranean diet score (mMDS)	BMI, body fat %, and weight change over past 5 years, metabolic syndrome score	- Obese participants exhibited significantly lower mMDS ($p<0.001$), they additionally exhibited greater fast/take-out food consumption and intake of sweetened drinks consumed during meals ($p=0.002$) compared to normal weight participants - Higher mMDS scores were inversely related to a risk of gaining weight over the past five years [Odds ratio (OR) = 0.57, 95% confidence interval (95% CI) = 0.39–0.84, p for trend across score quartiles = 0.01]; this was additionally true for metabolic syndrome components (OR = 0.65, 95% CI = 0.44–0.94, p for trend across score quartiles = 0.04), even after adjusting for multiple confounding variables (age, BMI, and physical activity) - Regression analysis also revealed that an increased mMDS score also was associated with increased HDL cholesterol ($p=0.008$) and decreased LDL cholesterol ($p=0.04$), even after controlling for confounding variables
BOTH CAREER AND VOLUNTEER					
Frattaroli et al., 2012	Cross-sectional (focus group)	37 selected fire stations, both volunteer and career	Firefighters' suggestions to design tailored and appropriate CVD prevention programs	N/A	- Options for healthy eating are perceived as limited or nonexistent due to a small budget allotted for food - Snacks and sweetened drinks that are readily available through vending machines contribute to a high supply of sugar, salt, and fat - Firefighters in this study recommended individually focused interventions that had a purpose of supplying firefighters with knowledge and skills that are required to maneuver past convenient, quick cheap food choices in their communities and firehouses. They also suggested minimizing community risks, including minimizing fast food restaurant consumption and unhealthy vending machine choices, as well. - Firefighters reported that they often were not consuming a well-balanced, nutritious diet or engaging in adequate physical activity, mainly due to the fire service lifestyle

					- The most important issue that firefighters expressed in this study in regards to fire service lifestyle was stress. Some firefighters communicated stress as needing to respond quickly as a result of an emergency. However, a majority of firefighters expressed stress in relation to the strenuous nature of modern lifestyles, which makes engaging in healthy behaviors difficult to manage. - Volunteer firefighters noted that they also have to balance their commitment to the fire service with their "day jobs" - Firehouses sharing regular meals, usually cooked at the firehouse, are common across the fire culture. Crew members may eat at home, bring takeout from restaurants to the firehouse, go to fast food places, or rely on snacks from vending machines (more typical of volunteer fire departments). - Challenging food environments which were mentioned included larger community options (i.e., fast food restaurants that provide convenient access and, in some places, represent the only hot food option in the regional area) and the firehouse where vending machines often include non-nutritious food choices and resources for healthy cooking are limited - Firefighters also communicated snacking as a hurdle. They mentioned that donuts, buns, and pizza are often accessible, free, and difficult to turn down and that unhealthy foods are much more available than healthy foods. - Several firefighter groups mentioned sporadic healthy eating classes offered at stations, which did contribute helpful information regarding diet and nutrition. However, they communicated that these classes were limited because they failed to take into consideration challenges of the food environment (i.e., these classes provided little benefit to offset the never-ending supply of non-nutritional options in the local and surrounding communities). - Many of the firefighters in this study highlighted stressful lifestyles in combination with unhealthy food options in the community as a particular obstacle and one that should be considered when intervening to promote healthy eating - Volunteer firefighters especially struggle to manage personal live, fire service obligation and day jobs, so they go for food options that are readily available, simple, and quick - Firefighters communicated that firefighter lifestyle influences food choices. As such these choices need to be fast, cheap, tasty and filling - Firefighters are sensitive to cost. Many arrangements about what kinds of foods to prepare or what to eat were often described to researchers as being primarily motivated by what items are on sale due to the need to feed a large quantity of people

					on a restricted budget. Healthy foods were generally perceived as costlier, more complex, and less satisfying/filling. - Suggestions by firefighters included tackling barriers to healthy eating previously mentioned through strategies at the individual, worksite, and community levels - Firefighters expressed hesitance regarding mandating health and wellness initiative out of concern that firefighters would resist this change. In order for success, it is important it is that individuals are willing to commit to healthy eating. - Individuals also recommend including a competition and prizes as an to increase participation in interventions
Nutrition and physical activity-related risk factors (studies including both factors as lifestyle)					
CAREER					
Jahnke et al., 2012	Cross-sectional (focus groups)	332 career firefighters, average age 41.7yo, 92.7% male, 67.6% Caucasian	Perspectives of fire service personnel towards life-style related CVD risk factors, including physical activity, nutrition, and stress	N/A	- 57.2% of participants at the firefighter rank, 23.4% held captain or lieutenant positions, and 15.4% were either fire chiefs or deputy/battalion chiefs - Average fire experience was 15.6 years with 57.2% of study participants had some college or technical school training and 28.3% were college graduates (7.8% with postgraduate degrees) - Top health concerns included cancer, heart disease and its contributing factors such as fitness, nutrition and sleep, mental health, and injury. One of the most prevalent concerns was risk of cancer and exposure to carcinogenic agents. - Firefighters frequently referenced the statistic that more than half of line-of duty deaths (LODDs) each year are cardiac related - Participants of the study communicated many challenges to cardiovascular health, including factors such as intense physical demands, emotional stress, shift structure, and high physical fitness - Firefighters raised concerns regarding sleeping difficulties, which often carries over to their home life - Participants of this study also mentioned mental health and its importance by itself, as well as its potential in playing a contributing role in other diseases, especially the emotional toll of repeated exposure to trauma emerged as a theme in focus groups in this study. Firefighters reported that much of their emotional trauma that played an impact on their mental health resulted from the totality of their exposures in particular on medical calls rather than over a single event. - Regarding physical fitness, firefighters expressed that they thought they should display better physical fitness than the general public, due to the nature of their job

					duties, but also that there are unique challenges of maintaining their physical fitness, specifically knowing what types of exercise are best to perform the job - Firefighters considered initiating programs, which focus on improving firefighter health/fitness levels, to be important - The food environment within the firehouse is of particular importance in influencing firefighter health, despite resistant to change in the food environment as a strongly built upon tradition (i.e., traditions of unhealthy food, large portion sizes) - Many firefighters recognized the negative consequences of a poor diet - Specific barriers to maintaining a healthy diet included social norms around eating, traditions around meals, and social expectations to conform to the preferences/expectations of the crew
McDonough et al., 2015	Quasi-experimental (pre-/post-test)	29 career firefighters, average age of 38yo, working in Mississippi, data not analyzed for gender	Comprehensive wellness programs (8-week, "Fit Firefighter"): The next 8 weeks included health education seminars, nutrition information sharing, exercise demonstrations, and hands-on healthy snack preparation, health coaching (optional).	Fitness and wellness assessments, resting heart rate and blood pressure, % body fat, BMI	- Changes following the 8-week Fit Firefighter intervention (% change pre- to post-intervention, no statistical significance or p-values reported): o Diastolic/systolic blood pressure = -3% o Resting heart rate = -3% o Aerobic fitness = +1.6% o BMI = +1% o Body fat = -8% o Flexibility = +18% o Bicep strength = +5% o Waist circumference = - 8.3% (noted as significant, but no p-value reported) - There were also differences from pre- to post-intervention in number of minutes of physical activity per week and in general nutrition knowledge related to recommended fruits and vegetables per day (no statistical significance or p-values reported) - Researchers stated many firefighters reported that having weigh ins and measurements made them more conscious of exercise and eating behavior patterns over the 8-week period - With additional health coaching optional (48% of participants utilized this option), significant differences in systolic/diastolic blood pressure, % body fat, BMI and back flexibility (ps<0.05) were revealed in the coached vs. non-coached group o Although not statistically different, researchers noted trends towards numerous other health improvements in the coached versus non-coached group (no p values recorded)

BOTH CAREER AND VOLUNTEER					
Eastlake et al., 2015	Cross-sectional	157 career and volunteer firefighters in a Midwestern town, 90% white, 91% male, working in Hamilton County, Ohio	Demographic characteristics, lifestyle factors (exercise, diet, smoking and alcohol consumption)	Indicators of CVD risk: blood pressure, blood cholesterol, blood glucose	- No firefighters were in the underweight BMI category, 13% were in normal BMI category, 53% were in overweight BMI category, and 33% were in obese BMI category - The most prevalent personal health issues included high cholesterol (35% of firefighters) and high blood pressure (18% of firefighters); 4% had high blood sugar and 3% had been diagnosed with heart disease - In terms of nutrition, 83% of firefighters reported consuming red meat 1-5 times, 90% reported consuming fast foods 1-3 times, 57% reported eating fish < 1 time, 73% reported eating vegetables 1-5 times, and 92% reported eating grains 1-7 times per week - Related to physical activity, 46% of firefighters reported exercising 1-3 times per week, with 16% exercising < 1 time per week - 79% of firefighters reported playing video games < 1 time per week/never - 87% of firefighters reported consuming energy drinks < 1 time per week - Age was shown to be the only significant factor contributing to risk of high blood sugar (OR 1.24 ± 0.17) or high blood pressure (OR = 1.06 ± 0.05) - Consumption of whole grains was the only significant factor that reduced risk for heart disease (OR = 0.27 ± 0.59) - Age and BMI were shown to significantly play a role in high cholesterol (OR for high cholesterol with increasing BMI = 1.09 ± 0.08, OR for participants with high cholesterol plus increasing age = 1.08 ± 0.04). Firefighters who had higher BMI's plus increasing age had the highest risk of high cholesterol. - Consumption of alcohol was shown to be associated with decreasing risk of high cholesterol (OR for high cholesterol with increased consumption of alcohol = 0.52 ± 0.41)
Risavi et al., 2015	Cross-sectional	160 volunteer and career, male and female firefighters, average age 36yo, average	Knowledge of CAD risk factors (biological and lifestyle)	Presence of CAD risk factors	- 58% of respondents reported regular exercise - 80.7% of participants were classified as overweight based on BMI - 39% were pre-hypertensive, while 45% had Stage I and Stage II hypertension (HTN); however only 26% were being treated currently for hypertension - 4% reported coronary artery disease (CAD) history, 5% had bypass surgery previously to their coronary arteries and 2% had stents - 11% of the population expressed a history of some type of heart condition - The majority of the study population identified several risks for CVD: o 69% of participants recognized family history as a risk factor

		BMI 31, primarily white and male population			○ 82% recognized obesity and hypertension as risks factors ○ 52-54% of the participants that recognized HTN or inactive lifestyle as risks for CVD did not have HTN and were not sedentary ○ 46-64% of those who understood the risk factors for CVD were sedentary, obese, or exhibited hypertension - 35% of firefighters were required by their department to undergo a medical evaluation (time period or frequency of evaluations not mentioned) - Having HTN in this study was significantly associated with age [OR = 1.035 (95% CI, 1.008-1.057)] and BMI [OR = 1.162 (95% CI, 1.097-1.237)], but not exercise
Physical activity-related risk factors					
CAREER					
Donovan et al., 2009-10	Cross-sectional	214 male career firefighters, average age 39yo, 95% white	Relationship between cardiorespiratory fitness (maximal graded exercise test), self-report data including demographics, personal and family history of chronic diseases	Metabolic syndrome, self-report data including height, weight, LDL, triglycerides, waist circumference, body composition, blood pressure, medication use	- 15% of firefighters in this study met criteria for metabolic syndrome (nearly double the prevalence in the age- and sex-matched population) ○ 14 % of 20–29 year olds met criteria ○ 9% of 30–39 year olds met criteria ○ 21% of 40–49 year olds met criteria ○ 18% of 50–59 year olds met criteria ○ The occurrence of metabolic syndrome was found to be lower among firefighters than what was observed in males in the general population of the US, which was 24% ○ However, the occurrence of metabolic syndrome was nearly double among the youngest firefighters in the study (20–29 years old) compared to age and sex-matched general population, which was 7% - 55% of the study population had high blood pressure ○ High blood pressure was the most prevalent abnormality ○ 10% of firefighters had a resting blood pressure of ≥140/90 mmHg ○ 14% of firefighters reported currently taking antihypertensive medication - 25% of firefighters in this study failed to achieve the minimum cardiorespiratory fitness level as VO2 max of 42.0 ml/kg/min, generally accepted as the minimum level of cardiorespiratory fitness needed to perform duties of the job ○ Mean cardiorespiratory fitness level was 46.6 ml/kg/min (higher than that expected for age-and sex-matched population, indicating higher fitness level)

					○ Subjects with two or three or more metabolic abnormalities had significantly lower estimations for VO2max compared to participants with zero or one metabolic abnormalities, indicating a significant inverse trend between increasing cardiorespiratory fitness with decreasing metabolic abnormalities ($p<0.001$)
Baur et al., 2011	Cross-sectional	968 male career firefighters, average age 39.5yo, average BMI 29.3, working in three US states	Cardiorespiratory fitness (maximal treadmill exercise test with EKG, METS)	CVD risk factors (height, weight, BMI, body fat, blood pressure, cholesterol, HDL and LDL cholesterol, triglycerides, glucose)	- 44% of firefighters had a CRF which exceeded National Fire Protection Association's minimum fitness standard of 12 METS ○ 10% of firefighters revealed a CRF > equal to 14 METS ○ This may be due to 90% of study subjects as overweight and almost 40% as obese ○ Obese firefighters in this study were more likely to be in very low or low fitness groups ○ Only 10% of firefighters were in the high fitness group - There were strong significant associations in regards to CRF and CVD risk factors, including total cholesterol, HDL, TC/HDL ratio, and blood glucose, even after stratification into categories by CRF and when adjusting for age and BMI - For every one-unit increase in METS, the average increase in HDL was 1.91 mg/dL ○ In the highest CRF category, average HDL was 53.8 mg/dL ○ In the very low CRF category average HDL was 38.6 mg/dL - In regards to fasting blood glucose, data showed a decrease of 1.5mg/dL for every one-unit increase in METS (beta = -0.65, $p=0.0343$) - An average obese firefighter who increases physical fitness to greater than 12 METS could see BMI decrease by 1.6 units, HDL increase by 5 mg/dL., TG decrease by > 30 mg/dL., and blood glucose to about 9 mg/dL on average. - For every one-unit increase in METS, resting diastolic BP decreased by 0.71 mm Hg, which could decrease risk for CHD by 6% and stroke by 16% ○ Higher CRF categories were significantly associated with lower diastolic BP, body fat, triglycerides, LDL, total/HDL ratio and higher HDL (ps<0.05, age/BMI adjusted)
Leiba et al., 2013	Cross-sectional	1030 male career firefighters, average age 37-39yo working in three	Cardiorespiratory fitness (maximal exercise test with EKG)	Metabolic syndrome, BP	- 28.3% of the study participants met criteria for Metabolic syndrome ○ 21.7% met no criteria ○ 28.2% met a single criterion ○ 21.7% met two criteria - 40.8% of participants had HDL < 40 mg/dL - 39.8% of participants had elevated BP or were taking antihypertensive medication

		Midwestern states			- As the number of metabolic abnormalities increased, the mean CRF in METS decreased in a dose respondent way, which was significant even after adjusting for age ($p<0.001$) o 51.2% of participants in the lowest fitness group had metabolic syndrome o 5.2% of participants in the highest fitness group had metabolic syndrome o 37.9% of participants in the group with METS < 12 had metabolic syndrome o 15.9% of participants in the group with METS >12 had metabolic syndrome - Prevalence of metabolic syndrome increased with age o Prevalence in the youngest group of firefighters (18-29 years) was 15.1% o Prevalence of in the oldest group of firefighters (50-62 years) was 34.9% - Logistic regression analysis regarding CRF acting as a continuous parameter (METS), adjusting for age o The odds of having metabolic syndrome were 3.24 higher in those with fitness levels < 12 METS compared to those with fitness levels > 12 METS [OR = 3.24 (95% CI = 2.4-4.4) and 2.93 (95% CI = 2.1-4.1] o 1 unit increase in METS resulted in 31% decreased odds of having metabolic syndrome [OR = 0.69 (95% CI = 0.63-0.76)] - This study found that firefighters who were less fit had almost twice the risk of exercise induced hypertension [OR = 1.8 (95%CI = 1.3-2.47)]
Dzikowicz et al., 2020`	Cross-sectional (secondary data analysis)	86 male professional firefighters, age range 39.7-44.6yo, primarily Caucasian working in western New York	Demographic data, height, weight, BMI, exercise treadmill testing (Bruce protocol)	Resting blood pressure, ECG's, heart rate, exercise-induced premature ventricular contraction (EI-PVC)'s,	- 90.7% of the sample were overweight/obese - 73.3% of the sample were hypertensive - 30.2% of the sample had myocardial ischemia - 80.2% of participants had at least 1 EI-PVC during 24-hour recording session - 3.5% of study subjects had more than 10 EI-PVC's per hour for at least 20 hours - The incidence of myocardial ischemia was 30% - EI-PVC's were significantly associated with myocardial ischemia ($p=0.003$). - Risk of myocardial ischemia with presence of EI-PVC was 1.54 (95% CI = 1.22, 1.95)

				myocardial ischemia	- Age was the only variable that differed between individuals with and without EI-PVCs. Males with EI-PVC's were more likely to be older (44.6 ± 7.3 years vs. 39.7 ± 8.0 years, p = 0.007). - EI-PVC group had a lower mean total exercise time, exercise expenditure, and maximum exercise speed than those without EI-PVC's, however these differences were not statistically significant. - No statistically significant results were found in differences in heart rate before exercise (EI-PVC 76.0 ± 9.7 bpm, no EI-PVC 78.6 ± 7.3 bpm, p = 0.22), maximum obtained heart rate (EI-PVC 166.6 ± 18.5 bpm, no EI-PVC 171.1 ± 15.8 bpm, p = 0.28), or 1-min post-exercise heart rate (EI-PVC 136.6 ± 20.1 bpm, no EI-PVC 140.0 ± 15.8 bpm, p = 0.45) between those with and without EI-PVC's - Individuals with EI-PVCs had significantly lower post-exercise SBP, which was no longer significant after Bonferroni correction - At a univariate level using logistic regression models EI-PVCs were shown to be a significant predictor of myocardial ischemia (OR = 5.11; p = 0.015; 95% CI [1.38, 18.9]; Cox & Snell r^2 = 0.085; Nagelkerke r^2 = 0.121). After adjusting the model for age, race, BMI, resting SBP, resting DBP, resting mean 24-hr heart rate, and current smoking, EI-PVCs remained a statistically significant predictor of myocardial ischemia (95% CI [1.087, 16.862]; B = 1.454; Cox & Snell r^2 = 0.140; Nagelkerke r^2 = .198; OR = 4.281; p = 0.038).
Staley et al., 2011	Cross-sectional (focus group)	64 full time career firefighters, aged 20-47yo, 81% white, working in southeastern United States	Question areas included: 1) physical fitness meaning in general and in the fire service, 2) exercise meaning and if differs from physical fitness, 3) high rate of	N/A	- Firefighters use the words physical fitness or fitness to refer to the formal department policy or organization's allotted PT period for exercise, and thus relate fitness with exercise o Fitness is also generally framed in terms of organizational fitness readiness, such as annual physical fitness exams, measures of flexibility, aerobic endurance, strength, height, weight or blood pressure. o The cultural meaning of fitness appears to be more intricate and could be expressed in language which describes fitness for the job. - Fitness could also be described as finishing a response event task such as pulling a victim from a fire, hauling a water hose, or "humping gear" up flights of steps. o Language used to describe this relationship is often expressed as individual or crew's readiness/preparedness for the job o "Good" fitness typically means as being able to support one's crew effectively throughout an event using adequate levels of stamina and strength

			on-duty death rate from SCD and CHD, 4) creating a PT program as a para-military organizatio n.		- Fitness as it relates to firefighter age o From a younger firefighter perspective, the definition of fitness includes more appearance (i.e., wanting to look good) and to avoid gaining weight/gutting out o Older firefighters were also concerned about fitness and viewed fitness within the context of physical health on and off the job, specifically regarding coronary health. They also discussed how fitness was a long-term commitment and to "start early" in order to prevent heart related problems later in life. - PT adherence definition o Conventional descriptors regarding adherence behavior are generally evident and include things such as walking, lifting weights, riding the bike or treadmill o Unconventional descriptors of PT adherence are common and include training or doing the job, as these activities increase heart rate and cardiovascular endurance, thus implying adherence to PT - Reasons for adhering to PT o Reliant upon a firefighter's personal motivation o Personal motivation is reinforced when combined with strong interpersonal influences such as a crew or management o The most significant motivator that improves group PT adherence is crew cohesion and productivity o Fire management can significantly impact PT adherence by putting in place fit captains/battalion chiefs, which act as strong interpersonal influences o Becomes confusing and variable when management tries to influence adherence in contradictory ways (i.e., establishing opposing expectations within a same shift, station or department; the lack of sanctions for firefighters that don't adhere to PT) o Other organizational factors included immediacy needed for emergency responses or nonresponse activities, training activities, and in station duties o Station environmental factors included physical space/equipment to exercise, quality/type of equipment, and the temperature - Relevance of the word "heart attack" o Only notable (salient) among older aged firefighters

					o Younger firefighters (those in their 20s) reflected an "it can't happen to me" mind set in regards to CHD/SCD risk or any type of work-related injury, seeing these as things to "worry about when old" o All firefighters see the importance of being physically fit for health and for duties of the fire service o Older firefighters generally viewed younger firefighters as identifying as being immortal and as having low level of coronary risk awareness. o An intervention that is designed to improve fitness by focusing on CHD or SCD prevention is challenging with younger firefighters, who view PT and participation in fitness as a way to improve physical appearance - Younger/more fit firefighters can have the ability to influence older firefighters, however these expectations are overpowered by the captain oftentimes who is the officer in charge. - Fire service administrators should focus on creating fitness interventions that are culturally adapted to the unique nature of the fire service, emphasizing functional capacity, crew dependability, and fitness/well-being strategies. o The "no man left behind" mindset is a strong motivator for encouraging physical activity o It may be a bigger motivator to have physical training programs that are patterned after real life events, while also encouraging physical fitness o Would be helpful to focus on how to make physical training more normal and acceptable o Also recommend policy to expand training programs to include physical fitness and well-being (including healthy eating habits, proper hydration, better sleep habits, stress management).
Storer et al., 2014	Cross-sectional	46 male and 1 female career firefighters, average age 43.1yo, mean BMI 27.7; working in southern California	Fitness (muscular strength, VO2 max, push-ups, curl ups, grip strength, physical activity level),	CVD risk analysis - resting blood pressure, heart rate, fasting blood glucose, and HDL and total cholesterol, triglycerides	- 36% of participants completed aerobic exercise 3 days per week and 30 minutes per day - 50% of participants completed resistance training 2 days per week - 72% of participants were classified as overweight or obese o Relative body fat mean values were 20.9% for BIA and 19.6% for skinfold measurements and did not differ statistically (p=0.08) o 33% of participants were classified as having above average body fat o Mean waist circumference was 95.8 cm; 18% of sample exceeded WHO upper limit of 102 cm - 46% of participants were considered normotensive (BP 120/80)

			height, weight, age, smoking, body composition		○ 50% of participants were considered pre-hypertensive (BP 120-139/80-89) ○ 9% of participants were considered hypertensive (BP 140/90) - Mean (SD) for VO2 max test duration, maximum heart rate, and respiratory exchange ratio were 11.2 (2.1) min, 175 bpm, and 1.16 (0.03), respectively. ○ Plateau of VO2 max despite increasing work rate was seen in 59% of tests at end of exercise, with values at the 44th percentile on average ○ Relative to body weight, this sample had a VO2 max of 39.6 ml/kg/min on average, or 11 METS, which is 6% below recommended value of 42ml/kg/min for firefighters ○ 33% of participants had VO2 max greater than the recommended value and 30% had VO2 max scores below minimal value for firefighters of 33 ml/kg/min - Handgrip strength and abdominal endurance scores for this sample were similar to reported data for firefighters - Push up scores in current participants were more than twice scores of the reference population (age- and sex-matched healthy general population) - Sit and reach test was somewhat higher for participants than in other reports of firefighters - Pulmonary function (FVC/FEV1 ratio) was normal and represented 94%, 96% and 101% of predicted values for age, height, and sex, respectively
Durand et al., 2011	Cross-sectional	527 male career firefighters, average age 37.2yo, 35.7% obese, 51.2% overweight, working in Kansas and Missouri	Health/lifestyle questionnaire [eating, health, exercise (physical activity dimensions – frequency, duration, intensity), sleep, work habits],	Cardiorespiratory fitness (CRF, HRR = heart rate recovery at 1 minute, RHR = resting heart rate), ECG, HDL, LDL, TC, glucose, TG, hs-CRP	- 47% of participants were estimated to be exceeding the 90 minutes per week of moderate/vigorous PA ○ 20% of participants were estimated to be exceeding 150 min weekly - 37% of firefighters in this study had CRF less than or equal to 12 METs - After adjustment for age BMI and smoking status, the CRF outcome variables total treadmill time and max METs were shown to have significant differences along the 3 dimensions of PA ($p<0.001$) - Higher BMI was negatively associated across all dimensions of PA for CRF and CVD risk factors - HRR was associated with significant differences in duration ($p<0.001$) and intensity PA dimensions ($p=0.005$) - RHR/HRR index significantly associated ($p=0.02$) with duration PA dimension - Positive effects were demonstrated and most apparent when comparing those who reported their exercise duration was greater than or equal to 30 minutes with those who exercised less than 30 minutes ($p=0.003$)

			height, weight, BMI,		○ HDL (p=0.02) and TG (p=0.04) were significantly improved in individuals who exercised at least 30 minutes per session as compared to those who exercised less than 30 minutes per session - Frequency PA dimension revealed significant positive associations with HDL (p=0.001) and significant negative associations with TG (p=0.02), TC/HDL, (p=0.003) and fasting glucose (p=0.005) - Duration and intensity dimensions of PA did not show significant associations with CVD risk factors (ps>0.05) - Individuals who acknowledged moderately sweating showed significantly lower mean values of TG (p=0.03) compared to individuals who reported sweating lightly or who did not exercise often - Total weekly exercise was positively associated with HDL (p=0.003) and negatively associated with TG (p=0.03), TC/HDL (p=0.01) and hs-CRP (p=0.03)
Peate et al., 2002	Cross-sectional	101 male and female career firefighters average age 32, location not specified.	Aerobic capacity (5-minute step test, submaximal treadmill test using Bruce protocol, VO2 max), perceived physical fitness and activity survey	Health risk appraisal, ECG, blood pressure, heart rate	- Mean VO2 max was 41.8±8.8 mL/kg/min - Self-rated fitness level was not significantly associated with aerobic capacity by either submaximal treadmill test or 5-minute step test - Quartiles of aerobic capacity exhibited statistically similar proportions of firefighters per activity level (self-rated activity levels = 0-4, increasing level indicates higher activity) - 33% of the firefighters in the second activity level exhibited aerobic capacities of 22-37 ml/kg/min; this was also true for 21% of firefighters in the fourth level (p=0.60) - 20% of firefighters in the third activity level had VO2 max scores of <33.5 ml/kg/min; this was true for 16% of firefighters in the highest activity level as well (p=0.74) - There was no association between firefighters' self-perceived level of fitness and their aerobic capacity, as measured by either step test or submaximal treadmill
Baur et al., 2013	Cross-sectional	957 male career firefighters, average age 36.9yo, 29.3 average BMI, working in 3	Cardiorespiratory fitness (CRF)	ECG, metabolic syndrome (height, weight, BMI, blood pressure, HDL	- 28.3% of the population met criteria for metabolic syndrome ○ 21.7% of the population had none of defining criteria for metabolic syndrome ○ 28.2% met a single criterion for metabolic syndrome ○ 21.7% met two criteria for metabolic syndrome ○ The most occurring metabolic abnormality in this sample was HDL cholesterol < 40 mg/dl, which occurred in 40.8% of the population - 39.8% of the sample had high blood pressure or took antihypertensive medication

		Midwestern states		cholesterol, glucose, triglycerides)	- As the number of metabolic abnormalities in the firefighting population increased, the mean CRF in METS decreased. This occurred in a dose response fashion and appeared to be significant after adjustment for age ($p<0.0001$). - Results showed incidence of metabolic syndrome increased with age. In the youngest group of firefighters (18-29yo), 15.1% had metabolic syndrome, whereas the oldest age group of 50-62 had a prevalence of 34.9% ($p=0.012$). - Investigators found the prevalence of metabolic syndrome increased with decreasing fitness and that this had a stronger effect than age - Mean CRF level of the study population was 12.0 METS - Firefighters who had metabolic syndrome had a mean maximal METS of 11.1 (SD 1.8), compared to 12.8 (SD 1.7) in participants who met none of the criteria ($p<0.0001$, adjusted for age) - 51.2% of participants in the lowest fitness group had metabolic syndrome compared to 5.2% of participants in highest fitness group ($p<0.0001$, adjusted for age) - 37.9% of participants had metabolic syndrome in group with METS less than or equal to 12, while 15.9% of participants had metabolic syndrome in group achieving greater than 12 METS ($p<0.0001$, adjusted for age) - Those with fitness levels less than or equal to 12 METS compared with those greater than 12 METS had 3.24 times the odds of metabolic syndrome (95% CI = 2.4–4.4) unadjusted and 2.93 times the odds (95% CI = 2.1–4.1) adjusted for age. - Regression analysis of CRF as a continuous parameter (METS) showed that every one-unit increase in METS resulted in 31% decreased odds of having metabolic syndrome (OR=0.69 [95% CI = 0.63–0.76]) after adjusting for age
Long et al., 2014	Cross-sectional (mixed methods approach)	96 career firefighters, average age 36.3yo, 98% white, working in a state in the western portion of the US	Motivation to exercise and aerobic activity measures, interview responses	N/A	- 92.7% of participants responded that strength-training equipment was available at their workplace - 94.8% of participants stated they had access to exercise aerobically - A majority of firefighters expressed they had availability of different ways to exercise - Range of responses recorded for mild aerobic training was the largest and these ranged from 0-10 sessions per week, with mean number of sessions was 2.47 (SD = 2.27) per week - The lowest form of exercise recorded was moderate aerobic; number of responses ranged from 0-7 sessions per week, with a mean of 2.04 (SD = 1.65) sessions per week - Strenuous aerobic exercise responses ranged from 0-8 sessions per week, with a mean of 3.25 (SD = 1.52) sessions per week

					- The highest average reported exercise category came from strength training, which ranged from 0-8 sessions per week, with a mean of 3.31 (SD = 1.688) sessions per week
BOTH CAREER AND VOLUNTEER					
Li, et al. 2017	Cross-sectional	1099 career and volunteer firefighters, working in Colorado, both male and female included, average age 37.2yo,95% white	Cardiorespiratory fitness levels (VO2 max)	MetS, blood pressure, BMI, waist circumference, %body fat (underwater weighing and skinfold), glucose, triglycerides, HDL	- 4% of participants reported smoking at least one cigarette per day o 6% of female participants reported smoking at least one cigarette per day - 89% of participants reported drinking one or more drinks per week o 91% of female participants reported drinking one or more drinks per week - 9% of all participants, 9% of male participants, and 5% of female participants had metabolic syndrome o Metabolic syndrome incidence increased with age; 3% prevalence in those at or under 30 years old and 17% prevalence in those 50 or older - Mean VO2 max was 46.9 (SD = 6.8) ml/kg/min. o 49% of participants did not meet the minimum cardiorespiratory fitness level set at 42 ml/kg/min by the National Fire Protection Agency o VO2max was negatively associated with number of metabolic syndrome components (incident rate ratios (IRRs) = 0.95, 95% CI = 0.93–0.96, p<0.001), when controlling for age, group, smoking and alcohol among males - % body fat, measured using hydrostatic underwater weighing and skinfold test, were 21.1% (SD =7.9%) and 18.4% (SD = 6.7%), respectively o % body fat measured by hydrostatic underwater weighing (IRR = 1.04, 95% CI = 1.03-1.05, p<0.001) and % body fat measured by skinfold test (IRR = 1.06, 95% CI = 1.05-1.07, p<0.001) were positively associated with number of metabolic syndrome components, while controlling for age group, smoking and alcohol in male participants o % body fat value measured with hydrostatic underwater weighing (IRR = 1.08, 95% CI = 1.04-1.12, p<0.001) and % body fat measured with skinfold test (IRR = 1.09, 95% CI = 1.03-1.14, p<0.01) were positively associated with number of metabolic syndrome components, while controlling for age group, smoking and alcohol drinking in female participants

Li, et al., 2018	Cross-sectional	294 male and female firefighters, both career and volunteer, 11% age 55yo or older, 41% age 40–44yo, 26% age 45–49yo, 22% age 50–54yo, working in Colorado	MetS, % body fat (skinfold measurements), cardiorespiratory fitness (VO2 max)	Atherosclerotic cardiovascular disease (ASCVD)	- Using bivariate logistic regression, %BF (OR = 1.24, p<0.01), VO2max (OR = 0.90, p<0.05), MetS (OR = 2.66, p<0.05) and age group (OR = 5.62 for 55+ versus 39–44 years, p<0.001) were significantly related to 10-year ASCVD risk o After controlling for age, %BF (OR = 1.13, p<0.01) and MetS (OR = 2.87, p<0.05) were significantly associated with 10-year ASCVD risk o After controlling for all independent variables including age, only %BF (OR = 1.17, p<0.01) was significantly associated with 10-year ASCVD risk - BMI, VO2 max, and sex were not significantly associated with 10-year ASCVD risk (ps>0,05)
Patterson et al., 2016	Cost-effectiveness analysis	677 male career and volunteer firefighters, average age 33-39yo, 86-97% white, working in Colorado, Iowa, Kansas, Missouri, North Dakota, South Dakota, Nebraska, Wyoming	Comparing a wellness/fitness program, real-time monitoring, and no intervention	Cost effectiveness to guide management of CVD risk: Wellness fitness initiative costs, no preventative action costs, National Heart, Lung, and Blood Institute's Risk Assessment Tool for Estimating	- Having a wellness/fitness program prevented 10% of CVE - Physical activity monitors were shown to have the same effectiveness as but cost more than wellness/fitness programs

				Your 10-Year Risk of Having a Heart Attack	
Baur et al., 2012	Cross-sectional	1149 male career firefighters, average age 40-47.1yo, average BMI 30-32, working in 3 Midwestern States	CRF (maximal treadmill exercise test with ECG for METS), BMI, body fat %, MetS	Abnormal/ stress exercise test with ECG (for abnormalities)	- There were significant associations between CRF categories and all parameters including, max METS, total treadmill time, % max HR, HRR, RHR/HRR, exaggerated BP, and ECG abnormalities, after adjusting for BMI, age, and metabolic syndrome (ps<0.05) - 64% of participants revealed one or more abnormal exercise stress test criteria in the lowest fitness group of less than or equal to 10 METS - 23% of participants revealed one or more abnormal exercise stress test criteria in the highest fitness group - Incidence of abnormalities in the lowest fitness group was 47% as compared to 7% in the highest fitness group (p<0.001 after adjustment for age and metabolic syndrome) - For each additional MET achieved, odds of abnormalities decreased by 29-31%, in the adjusted model for age, body mass index and metabolic syndrome
VOLUNTEER					
Martin et al., 2019	Prospective cohort study	74 male volunteer firefighters, average age 40yo, average BMI 32.2, 59.4% of sample obese with BMI > 30, 47.3% very poor body fat % ranking, working in Michigan.	Height, weight, body fat %	CVD risk factors (self-reported including age, family history of CVD, smoking, sedentary lifestyle, obesity, hypertension, dyslipidemia, and prediabetes) and physical fitness capabilities	- Participants on average had very poor recovery HR after completing the YMCA step test; average heart rate for the YMCA test was 160.2±14.6 bpm - Participants on average scored in the very good category for push-ups - The average number of sit ups performed was 27.3±10.5, which ranked in the 25th percentile - Eight CVD risk factors were analyzed in the sample including age, family history of CVD, history of smoking, sedentary lifestyle, obesity, hypertension, dyslipidemia and prediabetes o 59.4% of participants were considered obese by both BMI (mean = 32.2) and body fat percentage (mean = 25.3±5.7%) o 27% of participants were hypertensive o 30% of participants had hypercholesterolemia o 9% of participants were at risk for diabetes o 68% of participants had two or more CVD risk factors - Most of the firefighters in this sample were at increased risk for CVD and had inadequate physical fitness

				(sit up testing, push up testing, 3-minute step test)	
Hammer et al., 2013	Cross-sectional	79 male Caucasian volunteer firefighters average age 38.5 yo, 93.8 mean kg, 7.6 mean years firefighting experience	Compare VO2 max levels in volunteer firefighters to determine if annual fitness testing is a potential factor leading to higher cardiorespiratory fitness	Demographic data, age, height, weight, blood pressure, waist circumference, VO2 max, heart rate	- No significant differences (p=0.431) in predicted VO2max between certified (39.9 ± 8.4 ml/kg/min) and uncertified (37.8 ± 8.5 ml/kg/min) firefighters - 30% of volunteer firefighters had predicted aerobic capacities, which were below the recommended minimum VO2max level of 33.5 ml/kg/min - Annual testing does not appear to be adequate motivation to maintain or improve cardiorespiratory fitness o Other suggested methods of motivation include specific testing of aerobic capacity, structural fire suppression activity testing, and education regarding the importance of aerobic capacity
Amodeo et al., 2020	Cross-sectional	123 male and female volunteer firefighters, 93.5% male, majority white working in North Carolina	Past physical activity levels, constructs of Theory of Planned Behavior, and perceived heart disease risk, demographics	Physical activity intention	- Most participants in the study didn't perceive themselves as being high or low risk for heart disease - 35.9% of participants were overweight - 44.4% of participants were obese - 14.4% did not participate in any moderate-intensity cardiovascular exercise in the prior 7 days o 16% of firefighters met AHA/ACSM10 requirements for physical activity for moderate-intensity cardiovascular exercise - 40.8% of firefighters did not participate in any vigorous-intensity exercise in the past 7 days o 32% of firefighters met the requirements for vigorous-intensity cardiovascular exercise in the prior 7 days

					○ 53.3% of firefighters met physical activity requirements through a combination of moderate- and vigorous-intensity cardiovascular exercise - 45.2% of firefighters did not participate in any strength training exercise in the prior 7 days ○ 29% of firefighters met the guidelines for strength training - Attitudes, perceived behavioral control, and past physical activity behavior accounted for 57.9% of the variance in physical activity intention (R^2 = 0.579, p=0.031) - Positively significantly associated with intention to be physically active: attitudes (r=0.527, p<0.001), perceived behavioral control (r=0.494, p<0.001), past physical activity (r=0.618, p<0.001), past physical activity moderate-intensity cardiovascular exercise (r=0.556, p<0.001), past physical activity vigorous-intensity cardiovascular exercise (r=0.576, p<0.001), past physical activity strength training (r=0.514, p<0.001), hours spent at the firehouse for service call activities (r=0.268, p=0.004) - Negatively significantly associated with intention to be physically active: age (r=-0.201, p=0.032) - Not associated with intention to be physically active: perceived risk of heart disease, subjective norm, hours spent at the firehouse for non-service call activities
Scanlon et al., 2008	Cross-sectional	730 volunteer firefighters, 87.8% men, 10.8% women working in Long Island, NY	Sex, age, weight, height, years in the fire service, and type of firefighter. Other items focused on medical history, current medications, physician follow-up, personal health insurance,	Survey of CVD risk factor awareness and attitudes: The firefighters were asked to express their level of interest (ie, "definitely interested," "somewhat interested," or "definitely not interested")	- 18.6% of participants classified as healthy BMI range - 41.2% of participants were classified as overweight based on BMI - 35.5% of participants were classified as obese based on BMI - 19.9% reported high blood pressure, 18.5% reported high cholesterol levels, 8.5% reported high cholesterol and high blood pressure - 53.4% of participants had received an echocardiogram or cardiac stress test at least one time - 30.8% of participants indicated that they were currently taking medications, 15.6% for high blood pressure and 11.0% for high cholesterol - 44% of participants revealed participating in an exercise program on average 5.92 (SD = 4.12) hours each week - 17.7% currently smoke, with mean packs smoked per day at 1.06 (SD = 0.364) - 61.9% consumption of alcoholic beverages, with mean number of drinks per week at 4.69 (SD = 4.66) - 87.3% of participants have their own health insurance and 82.5% received an annual physical from a physician - 51.4% of participants reported following up with a physician annually, 19.6% every 6 months, and 13.4% every 3 months or sooner

			cigarette use, alcohol consumption, and exercise.	and current behaviors regarding fitness programs, proper diet, and reduction of heart attack risk. They were also asked to identify from four choices the major cause of death among firefighters nationwide: automobile accidents, burns, heart attacks, or smoke inhalation.	- 6% of participants in the 17-29 year age group, 10% of the 30-39 year age group, and 12% of the group > 40 years were found to not be in compliance with NFPA guidelines - When asked to select the major cause of line of duty death in US firefighters, 75.9% of participants selected heart attacks, 10.7% selected smoke inhalation, 9.6% selected auto accidents, and 2.5% selected burns - 57.9% of participants "strongly agreed" and 34.9% of participants "somewhat agreed" fire departments needed to be more active in informing members about medical risks associated with their jobs - 44.5% of participants were "definitely interested" and 45.6% of participants were "somewhat interested" in attending education sessions or lectures on proper diet and exercise and reducing heart attack risk if their fire department would provide it - 56.8% of participants and 40% of participants were "definitely interested" and "somewhat interested," respectively, in being involved in a fitness program if their department provided it

APPENDIX 2: Quality assessment of studies investigating non-occupational CVD risk factors among firefighters using the Academy of Nutrition and Dietetics quality criteria checklist[28]

Authors, Year	Design	CVD Risk Factor	Q 1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q 9	Q1 0	QA
Nutrition-related risk factors													
Yang et al., 2015	Cross-sectional	*Self-reported demographics, including height/weight for body composition*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Pos
Kay et al., 2001	Cross-sectional	*Survey to determine awareness of risk factors for CVD (including sleep, CVD, diet, PA, medical diagnosis and stress), awareness of need to modify dietary risk factors, actions to modify diet, and interest in worksite interventions*	Y	Y	N/A	U	N	Y	N	N/A	Y	U	Neu
Yang et al., 2014	Cross-sectional	*Modified Mediterranean diet score (mMDS)*	Y	Y	Y	Y	N/A	N/A	Y	Y	Y	Y	Pos
Frattaroli et al., 2012	Cross-sectional (focus group)	*Firefighters' suggestions to design tailored and appropriate CVD prevention programs*	Y	U	N/A	N/A	N/A	U	N/A	N/A	Y	Y	Neu
Nutrition and physical activity-related risk factors (studies including both as lifestyle)													
Jahnke et al., 2012	Cross-sectional (focus groups)	*Perspectives of fire service personnel towards life-style related*	Y	U	N/A	U	N/A	Y	Y	U	Y	U	Neu

		CVD risk factors, including physical activity, nutrition, and stress											
McDonough et al., 2015	Quasi-experimental (pre-/post-test)	*Comprehensive wellness programs (8-week, "Fit Firefighter"): The next 8 weeks included health education seminars, nutrition information sharing, exercise demonstrations, and hands-on healthy snack preparation, health coaching (optional).*	Y	N	U	U	U	U	Y	Y	Y	U	Neu
Eastlake et al, 2015	Cross-sectional	*Demographic characteristics, lifestyle factors (exercise, diet, smoking and alcohol consumption*	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	Pos
Risavi et al., 2015	Cross-sectional	*Knowledge of CAD risk factors (biological and lifestyle)*	Y	Y	Y	U	Y	Y	Y	Y	Y	Y	Pos
Physical activity-related risk factors													
Donovan et al., 2009-2010	Cross-sectional	*Relationship between cardiorespiratory fitness (maximal graded*	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	Pos

		exercise test), self-report data including demographics, personal and family history of chronic diseases											
Baur et al., 2011	Cross-sectional	*Cardiorespiratory fitness (maximal treadmill exercise test with EKG)*	Y	Y	Y	N/A	U	Y	Y	Y	Y	Y	Pos
Leiba et al., 2013	Cross-sectional	*Cardiorespiratory fitness (maximal exercise test with EKG)*	Y	Y	Y	U	U	U	Y	Y	Y	U	Neu
Dzikowicz et al., 2020	Cross-sectional (secondary data analysis)	*Demographic data, height, weight, BMI, exercise treadmill testing (Bruce protocol)*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Pos
Staley et al., 2011	Cross-sectional (focus group)	*Question areas included: 1) physical fitness meaning in general and in the fire service, 2) exercise meaning and if differs from physical fitness, 3) high rate of on-duty death rate from SCD and CHD, 4) creating a PT program as a para-military organization.*	Y	U	N/A	N/A	U	U	Y	U	Y	Y	Neu

Storer et al., 2014	Cross-sectional	*Fitness (muscular strength, VO2 max, push-ups, curl ups, grip strength, physical activity level), height, weight, age, smoking, body composition*	Y	U	Y	Y	U	Y	Y	Y	Y	Y	Neu.
Durand et al., 2011	Cross-sectional	*Health/lifestyle questionnaire [eating, health, exercise (physical activity dimensions – frequency, duration, intensity), sleep, work habits], height, weight, BMI,*	Y	Y	U	U	U	U	Y	Y	Y	Y	Neu
Peate et al., 2002	Cross-sectional	*Aerobic capacity (5-minute step test, submaximal treadmill test using Bruce protocol, VO2 max), perceived physical fitness and activity survey*	Y	U	Y	U	U	U	Y	Y	Y	U	Neu
Baur et al., 2013	Cross-sectional	*Cardiorespiratory fitness (CRF)*	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	Pos
Long et al., 2014	Cross-sectional (mixed methods approach)	*Motivation to exercise and aerobic activity measures,*	Y	U	Y	Y	U	U	Y	Y	Y	U	Neu

		interview responses											
Li, et al. 2017	Cross-sectional	*Cardiorespiratory fitness levels (VO2 max)*	Y	U	Y	U	U	Y	Y	Y	Y	Y	Neu
Li, et al. 2018	Cross-sectional	*MetS, % body fat (skinfold measurements), cardiorespiratory fitness (VO2 max)*	Y	Y	Y	Y	U	Y	Y	Y	Y	U	Pos
Patterson et al., 2016	Cost-effectiveness analysis	*Comparing a wellness/fitness program, real-time monitoring, and no intervention*	Y	U	Y	U	U	Y	Y	Y	Y	Y	Neu
Baur et al., 2012	Cross-sectional	*CRF, total treadmill time; peak METS; peak HR and blood pressure (BP); HR recovery at 1min (HRR1 = peak HR − HR 1min into recovery)*	Y	Y	Y	U	U	U	Y	Y	Y	Y	Neu
Martin et al., 2019	Prospective cohort	*Height, weight, body fat %*	Y	Y	Y	Y	Y	Y	Y	U	Y	U	Pos
Hammer et al., 2013	Cross-sectional	*Compare VO2 max levels in volunteer firefighters to determine if annual fitness testing if a potential factor leading to higher cardiorespiratory fitness*	Y	Y	Y	Y	U	U	Y	Y	Y	U	Neu

Amodeo et al., 2020	Cross-sectional	*Physical activity measures/surveys*	Y	Y	N/A	Y	N/A	Y	Y	Y	Y	Y	Pos
Scanlon et al., 2008	Cross-sectional	*Sex, age, weight, height, years in the fire service, and type of firefighter. Other items focused on medical history, current medications, physician follow-up, personal health insurance, cigarette use, alcohol consumption, and exercise.*	Y	N/A	N/A	U	U	Y	Y	N/A	Y	Y	Neu

Q1 = Question 1:Was the research question clearly stated?
Q2 = Question 2: Was the selection of study subjects/patients free from bias?
Q3 = Were study groups comparable?

Q4 = Was method of handling withdrawals described?
Q5 = Was blinding used to prevent introduction of bias?
Q6 = Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were intervening factors described?
Q7 = Were outcomes clearly defined and the measurements valid and reliable?
Q8 = Was the statistical analysis appropriate for the study design and type of outcome indicators?
Q9 = Are conclusions supported by results with biases and limitations taken into consideration?
Q10 = Is bias due to study's funding or sponsorship unlikely?
Y = yes; N = no; N/A = not applicable; UC = unclear

Pos = positive; Neu = neutral; Neg = Negative
RCT = Randomized controlled trial

VITA

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