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Faculty of Health Sciences

Doctoral Dissertation

The impact of Dietary Choices on Cardiometabolic Outcomes Among US Firefighters: A Comprehensive Study

Andria Christodoulou

Limassol, July 2025

CYPRUS UNIVERSITY OF TECHNOLOGY

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Approval Form

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To my family, thank you for your unconditional love and support. Your constant encouragement and understanding provided the foundation I needed to persevere.

To my friends, thank you for being a steady source of motivation, laughter, and perspective. Whether it was a kind word, a much-needed break, or just being there when I needed you most, your support made a world of difference.

ABSTRACT

This dissertation examines the relationship between dietary patterns - particularly adherence to the Mediterranean Diet - and cardiometabolic outcomes among U.S. firefighters. Drawing on data from the Feeding America's Bravest (FAB) study, it explores the role of diet in a high-risk occupational group through cross-sectional analysis and a six-month longitudinal intervention. The study identified two dominant dietary patterns; Mediterranean and Standard American; and found that higher adherence to the Mediterranean Diet and lower Dietary Inflammatory Index (DII) scores were associated with improved lipid profiles, lower body fat, and reduced systemic inflammation. The intervention, tailored to the firefighting context and including family engagement, proved both feasible and effective in promoting healthier eating behaviors. Key strengths include the real-world application and use of multiple dietary assessment tools. Limitations include reliance on self-reported data and a predominantly male sample. The findings support scalable, nutrition-based strategies to improve firefighter health and inform future research and occupational wellness programs.

Keywords: Mediterranean diet, Standard American diet, DII, PREDIMED, firefighters

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LIST OF ABBREVIATIONS

Important abbreviations that have been used in the text and need explanation are briefly presented

MD:	Mediterranean Diet
CVD:	Cardiovascular disease
PREDIMED:	Prevention with Mediterranean Diet
USFA:	US Fire Administration
DII:	Dietary Inflammatory Index
MEDAS:	Mediterranean Adherence Score
FAB:	Feeding America's Bravest
MedDiet:	Mediterranean Diet
MDNI:	Mediterranean Diet Nutritional Intervention
RCT:	Randomized control trial
IFD:	Indianapolis Fire Department
mMDs :	Modified Mediterranean diet score
PSM:	Public Safety Medical
BMI:	Body Mass Index
METs:	Metabolic Equivalent of Tasks
FFQ:	Food Frequency Questionnaire
PCA:	Principal Component Analysis
SCD:	Sudden Cardiac Death
E-DII:	Energy adjusted Dietary Inflammatory Index
CRP:	C-reactive Protein
RR:	Relative Risk

1 Introduction

1.1 Mediterranean Diet and Cardiometabolic outcomes

In today's fast-paced, rapidly changing world, nutrition plays an important role in the overall health of individuals. The Mediterranean diet (MD), the origin of which can be traced to the traditional dietary habits of people living in countries bordering the Mediterranean Sea, has gained worldwide recognition for its notable health benefits[1,2]. This overview aims to provide a comprehensive understanding of the Mediterranean diet's impact on various aspects of human health, with a particular focus on its role in the prevention and management of cardiometabolic diseases.

As mentioned above, the Mediterranean diet stems from the dietary patterns and traditional practices of the people living in the Mediterranean region[3,4]. The diet is characterized by a high consumption of olive oil, unrefined cereals, fruits, and vegetables; a moderate to high consumption of fish; a moderate consumption of dairy products; moderate consumption of wine; and a low consumption of red meat products[2,5,6]. The combination of the so-called "healthy" foods provides a rich source of nutrients, such as antioxidants, fiber, and healthy fats, that contribute to the health benefits of the diet[7]. The Mediterranean diet follows a general food pyramid guideline that does not include specific quantities while at the same time encourages communal eating and an active lifestyle[8]. Every meal is centered around vegetables and fruit (with the darker colored fruit and vegetables containing more antioxidants), whole grains, legumes, beans, and nuts, and olive oil is the main source of fat. Seafood is consumed at least twice a week, whereas red meat, saturated fat, and sweets should be eaten less often than other foods. It is further recommended that females drink 1 glass of wine per day typically with meals, whereas for males 2 glasses of wine are recommended daily with meals (Figure 1).

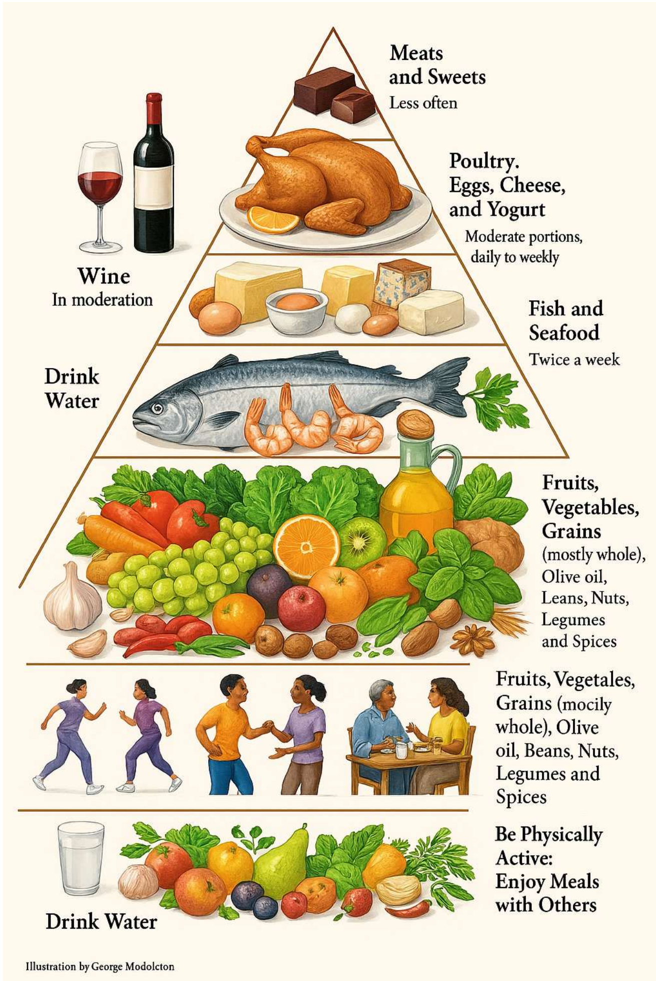

Figure 1. Mediterranean Diet pyramid

In recent years, the Mediterranean diet has gained widespread attention due to its health benefits and potential in preventing several chronic diseases. Research has shown that the Mediterranean diet is associated with a reduced risk of heart disease, stroke, and certain cancers[9]. The benefits of the Mediterranean diet in reducing mortality rates from heart conditions were highlighted by the Seven Countries Study, conducted by Ancel Keys[10–12]. In addition, adherence to this diet is also associated with improved cognitive function and lower risk of developing neurogenerative disease, such as Alzheimer's and Parkinson's[13–15]. Essential vitamins and minerals can be found in fruit and vegetables, while the intake of olive oil and fish contributes to the high levels of omega-3 fatty acids[13,16].

A systematic review by Widmer et al. demonstrated that adherence to the Mediterranean diet was associated with a lower risk for cardiovascular disease (CVD) and improved the overall health of individuals with existing cardiometabolic problems[17]. Participants following a Mediterranean diet had 10% lower risk of cardiovascular disease incidence and 13% lower risk of cardiovascular disease mortality. The review also reported that individuals with existing cardiovascular disease who followed a Mediterranean diet had a 37% lower risk of all-cause mortality and a 31% lower risk of cardiovascular disease mortality compared to those who did not adhere to the Mediterranean diet[17].

Another meta-analysis by Swingshackl and Hoffman reported that the Mediterranean diet is associated with a reduction in the levels of several cardiometabolic risk factors, including blood pressure, cholesterol, and markers of inflammation[18]. A Mediterranean dietary pattern was associated with a significant reduction in C-reactive protein, a marker of systemic inflammation, as well as improvement in endothelial function, which is crucial for cardiovascular health. The authors claimed that the Mediterranean diet led to a 0.85 mg/L decrease in C-reactive protein levels compared to control diets. Additionally, the Mediterranean diet was found to improve flow-mediated dilation, a measure of endothelial function, by 1.98% compared to control diets[18].

The Mediterranean diet has been linked with improved glycemic levels and reduced risk of type 2 diabetes[19,20]. Salas-Salvadó et al. reported that individuals who followed a Mediterranean-style diet had a lower risk of developing type 2 diabetes compared to those individuals who followed a low-fat diet [21]. Moreover, adherence to the Mediterranean diet was shown to be associated with a reduced risk of obesity, a known risk factor of cardiometabolic outcomes[20]. In the PREDIMED-Reus nutrition intervention randomized trial, Salas-Salvadó et al. found that individuals following a Mediterranean diet had a 49% lower incidence of new-onset type 2 diabetes compared to those on a low-fat diet [21]. Specifically, the study reported that the Mediterranean diet group had a 4.8% incidence of type 2 diabetes over a 4-year period, while the low-fat diet group had an incidence of 9.6%, demonstrating a substantial reduction in the risk of developing type 2 diabetes for those adhering to the Mediterranean dietary pattern[21].

Further evidence of the beneficial properties of the Mediterranean diet is provided by the PREDIMED study, a large, randomized control trial, conducted in Spain between 2003-2011, where 7,447 participants were randomized to either a Mediterranean diet supplemented with extra virgin olive oil, a Mediterranean diet supplemented with nuts, or a low-fat control diet[22]. The authors argued that participants at high risk of cardiovascular events who followed a Mediterranean diet supplemented with extra-virgin olive oil or nuts, had a lower risk of a cardiovascular event compared to those individuals who followed a low-fat diet without the supplementation of olive oil or nuts. The study also showed that the Mediterranean diet played a very crucial role in preventing and managing cardiovascular conditions. Furthermore, individuals at high cardiovascular risk who followed a Mediterranean diet supplemented with extra-virgin olive oil or nuts had a 30% lower incidence of major cardiovascular events, such as heart attack, stroke, and cardiovascular death, compared to those following a low-fat diet[20,23]. More specifically, the PREDIMED study demonstrated that the Mediterranean diet led to a 35% lower risk of stroke, a 28% reduction in the risk of heart attack, a 32% lower risk of cardiovascular mortality, a decrease of 49% in the incidence of new-onset type 2 diabetes, and a 18% reduction in the risk of all-cause mortality, compared to the low-fat diet group[20,23,24].

Generally, the scientific evidence from several studies points out that the Mediterranean diet plays an important beneficial role in cardiometabolic outcome prognosis and prevention[25]. As research continues to evolve, there is a need to investigate further the underlying mechanisms of the beneficial effects of the Mediterranean diet[26,27]. Understanding how specific diet components interact with physiological processes and how these influence cardiometabolic outcomes can help individuals shape their nutritional habits and create interventions that can target varying risk profiles[28,29]. The current knowledge on the topic supports the conclusion that the Mediterranean diet has positive effects on cardiovascular outcomes, being associated with an overall improvement of cardiometabolic risk factors[30,31].

In recent years, the Mediterranean diet has gained popularity not just in the Mediterranean region. Many people around the world have recognized the potential benefits of the Mediterranean diet to the overall health and well-being of individuals[32]. Additionally, the Mediterranean diet has been associated with improved weight management and control, especially since within the Mediterranean diet there is a strong emphasis on the consumption of unprocessed foods and of olive oil and nuts as healthy fats, resulting to the feeling of fullness and helping in controlling a person's caloric intake, thus promoting weight loss[33,34].

Firefighters, who are often required to perform physically demanding tasks, are not exempt from the rise in obesity rates seen in the general population[35–37]. For example, a study by Munir (2012) found that the prevalence of overweight and obesity among UK firefighters was 73.1% and 26.1%, respectively[38]. This trend has raised concerns about the potential impact on the firefighters' ability to effectively carry out their duties and maintain their overall health and fitness. Recent studies have explored the potential role of the Mediterranean diet in addressing the issue of obesity among firefighters[39]. According to Torre and colleagues, firefighters in the UK often consume diets that do not align with national dietary guidelines[40]. The researchers found that only 23% of the firefighters in the study met the recommended intake of fruits and vegetables, and only 27% consumed the recommended amount of whole grains. Additionally, 35% of the firefighters exceeded the recommended intake of saturated fats[40]. These findings suggest that there is significant room for improvement in the dietary habits of firefighters. Promoting healthier eating through tailored nutrition education and intervention programs could help address the high rates of overweight and obesity observed in this population. Similar results were observed in studies elsewhere. For instance, Swiss firefighters have shown low intakes of fiber and micronutrients compared to the national Swiss guidelines[41]. The paper by Gendron and colleagues examined cardiovascular disease risk factors among male firefighters in Québec[42]. The authors found that 36% of the firefighters in the study were overweight, and another 21% were obese. Additionally, 42% had elevated blood pressure and 27% had high cholesterol levels. These findings underscore the need for targeted interventions to address the cardiometabolic health of this population[42]. Implementing targeted nutrition education and dietary intervention programs based on the principles of the Mediterranean diet, such as emphasizing plant-based foods, healthy fats, and limiting processed meats and sweets, could help improve the overall diet quality and weight status of this high-risk population[43].

Firefighting is a physically demanding profession that requires a high level of endurance, strength, and agility. Studies have found that firefighters often have diets high in saturated fat, sodium, and calories, with one survey reporting over 75% of firefighters being overweight or obese, with 34% being obese[44]. It was further reported that 46% of firefighters had high blood pressure and 38% had high cholesterol levels[44].

Irregular meal schedules and limited access to healthy food options during emergency calls can contribute to poor nutritional habits, leading to an increased risk of chronic health conditions, such as heart disease, diabetes, and obesity. Implementing strategies to improve the dietary choices and overall wellness of firefighters is crucial for their long-term health and job performance[45]. A theoretical framework proposed by Choi et al., suggests that the high physical and mental demands of firefighting, combined with irregular work schedules and limited control over work conditions, can increase the risk of obesity among firefighters[46].

Firefighters with higher cardiovascular fitness complete simulated firefighting tasks quicker than those with lower fitness, highlighting the importance of physical fitness for this occupation. A study conducted by Elsner and Kolkhorst, reported that firefighters in the top 25% of cardiovascular fitness were able to complete the simulated tasks 30% faster, on average, compared to those in the bottom 25% of fitness[47]. This underscores the critical importance for firefighters to maintain a high level of physical fitness in order to effectively perform their duties, especially during emergency situations[48].

1.2 Firefighters and Cardiometabolic outcomes

According to the US Fire Administration (USFA) there are 1,208,800 active firefighters, serving in 27,228 fire departments across the US, responding to emergencies from 58,150 fire stations. Of the active firefighting personnel, 35% are career firefighters, 53% are volunteer firefighters, and 13% are paid-per-call firefighters. Most of the registered departments are in the Southern (36%) and Midwestern (31%) states (Figure 2). There is no age limit for the Fire Fighter Academy, however, candidates need to be able to perform their duties safely and meet the physical requirements of the position and pass the state examination[49].

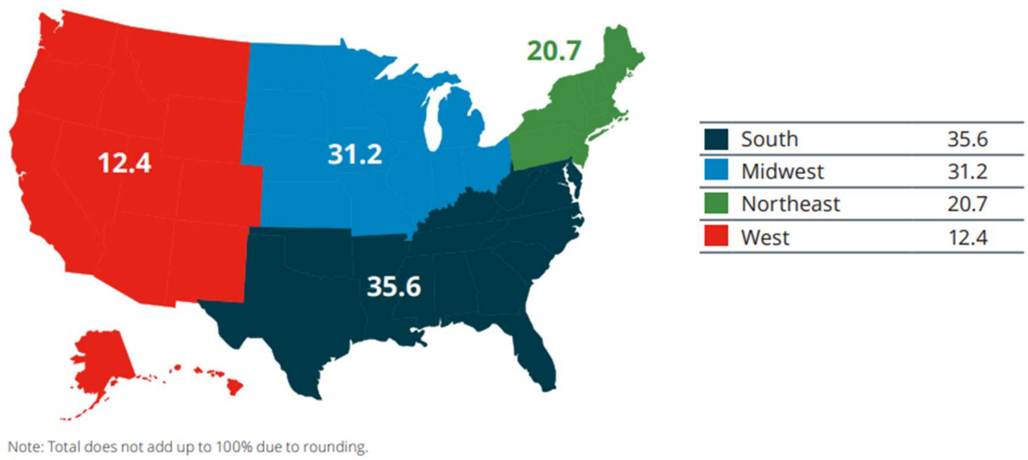

Figure 2.Percent of registered fire departments by census region (January 2023)

Obesity and cardiovascular diseases are significant health concerns in the fire service, affecting firefighters both on and off duty. Firefighters are at a high risk of cardiovascular disease due to the physical demands of their job, including the high levels of stress, smoke, and toxic fumes they often have to encounter[50]. Additionally, long work hours and irregular schedules can lead to poor eating habits and lack of physical activity, contributing to obesity and other related health issues[51]. In addition to physical health, mental health also plays a crucial role in the overall well-being of firefighters.

It is imperative for fire departments to prioritize regular medical screenings, promote healthy lifestyle choices, and provide resources for proper nutrition and fitness programs to mitigate the impact of obesity and cardiovascular disease on their personnel. Fire departments should also incorporate mental health awareness and support within their wellness programs - this could potentially include providing counselling services, creating a safe space for open discussions about mental health, and implementing strategies to reduce the stigma surrounding seeking help for mental health issues. Encouraging a culture of wellness and prioritizing mental and physical health can lead to a healthier and more resilient firefighting force[52,53]. Creating a holistic approach to health and wellness within the fire service will not only benefit the firefighters themselves but also improve overall operational readiness and community safety. It is also important to consider the role of leadership in promoting and sustaining a culture of wellness initiatives and demonstrating a commitment to prioritizing the health and well-being of their personnel[54,55].

Firefighting is a demanding occupation that entails engaging in physically challenging tasks within high-pressure environments. Approximately fifty percent of all on-duty fatalities were linked to sudden cardiac death, with a significant portion of these deaths being associated with cardiovascular disease while performing emergency duties[56]. Strokes, aneurysms, and other CVD-related conditions accounted for an additional five percent of on-duty fatalities. It has been further reported that for each fatal cardiovascular disease incident that occurs while on duty, an additional 17 non-fatal CVD incidents take place in the fire department. This indicates that CVD not only significantly contributes to mortality among firefighters but also serves as a major cause of morbidity and disability. According to Soteriades et al. (2011), these CVD events do not occur randomly in the fire service; rather, they tend to be more common at specific times of the day and periods of the year, concentrating during strenuous duties compared to non-emergency situations[57].

On-duty cardiovascular events typically occur primarily among vulnerable firefighters with pre-existing CVD. Therefore, it is recommended that preventive measures that have been shown to be effective are vigorously implemented among firefighters. Furthermore, it has been proposed that individuals with substantial clinical coronary heart disease are limited from engaging in demanding emergency duties[50]. Studies have shown that firefighting leads to a rapid increase in the heart rate, initiated by sympathetic physiologic arousal from the fire alarm. This can result in maximal or near-maximal heart rates taking place during physically strenuous firefighting activities. Additionally, there is evidence of a 35% reduction in blood flow volume following firefighting activity as reported by Smith et al. (2013) using Doppler echocardiography[58,59]. Following 18 minutes of firefighting, a 14.8% decrease in plasma volume was also observed. Hypovolemia has negative effects on the functioning of the heart and leads to an increase in blood viscosity. Finally, it has been shown that after brief periods of firefighting there is an elevated platelet number and activity, as well as changes in partial thromboplastin time and fibrinogen levels. These alterations point to a pro-coagulatory state that could increase the risk of thrombus formation[60].

Arterial stiffness is a critical parameter in the assessment of cardiovascular health, as it provides invaluable insights into the structural and functional integrity of the arterial system[61]. Arterial stiffness is typically measured through pulse wave velocity, which quantifies the speed at which blood flows through the arteries and it has been identified as a strong predictor of cardiovascular morbidity and mortality[62]. Increased pulse wave velocity indicates greater arterial stiffness, which can lead to higher blood pressure and increased strain on the heart. This shows the significance of central aortic stiffness, its implications for various cardiovascular diseases, and the advancements in methodologies for measuring and managing arterial stiffness[63,64].

The significance of central aortic stiffness cannot be overstated, as it is directly linked to the development and progression of numerous cardiovascular diseases[65]. For example, studies have shown that adherence to a Mediterranean-style diet can help improve arterial stiffness and potentially reduce the risk of cardiovascular events. One such study found that individuals who closely followed a Mediterranean diet had a 25% lower aortic pulse wave velocity compared to those with lower adherence, highlighting the beneficial effects of this dietary pattern on arterial health[66].

It has been documented that engaging in firefighting can cause a rise in arterial stiffness[61]. Additionally, overweight firefighters experience higher levels of arterial stiffness while at rest compared to their non-overweight counterparts[67,68]. A study which included 3-4 training drills lasting around 20 minutes each, over a span of 2.5 to 3 hours, revealed signs of diastolic dysfunction (a reduction of 19% in lateral wall E-wave) following firefighting training[69,60]. Furthermore, a study of over 500 firefighters found that those with higher aortic pulse wave velocity had a 35% increased risk of cardiovascular events compared to their peers with more compliant arteries. Another study of 400 firefighters reported that a 1 m/s increase in aortic pulse wave velocity was associated with a 40% higher risk of developing hypertension over a 5-year period. Stiffening of the larger central arterial system, such as the aortic tree, significantly contributes to the development of cardiovascular diseases in older individuals[70].

It has been suggested that the sympathetic response plays a significant role in sudden cardiac events among firefighters. This is emphasized by the fact that alarm responses have been linked to a five-to seven-fold increase in the risk of sudden cardiac death compared to non-emergency situations[58]. Similarly, a review by Kales and Smith reported that the physiological stress of firefighting, which activates the sympathetic nervous system, can trigger cardiac arrhythmia and other acute cardiovascular events[59]. These findings highlight the critical importance of understanding and mitigating the impact of psychological stress on the cardiovascular health of emergency responders. The heightened sympathetic activation experienced by firefighters during emergency calls and hazardous incidents can have profound physiological effects, such as increased heart rate, blood pressure, and contractility, which can contribute to the development of sudden cardiac events. Effectively managing the psychological and physiological stressors inherent to the firefighting profession is essential for promoting long-term cardiovascular health and wellness among this high-risk population[71].

During structural firefighting, firefighters frequently engage in tasks that combine static and aerobic exertion, including climbing stairs and ladders while carrying heavy equipment, performing forcible entry, conducting victim search and rescue operations, ventilating buildings, as well as attacking and suppressing fires. These essential activities are carried out while wearing multi-layered protective clothing weighing over 25 kilograms, which adds to the physical demands of firefighting[72]. For instance, von Heimburg and colleagues found that moving equipment up to a six-story building while wearing firefighting personal protective gear (such as self-contained breathing apparatus) utilized 88% of a firefighter's maximum oxygen intake. While it is commonly accepted that various firefighting activities demand different levels of physical effort, a number of research studies and expert agreement have determined that firefighting constitutes demanding work, necessitating at least 42 $ml.kg^{-1}min^{-1}$ (or 12 METs) to safely carry-out essential duties. Firefighting demands high levels of strength and endurance, thus overweight or obese firefighters find it challenging to execute the physical demanding duties required[73,74]. Occupational factors that are likely to contribute to an elevated risk of cardiovascular disease among emergency responders include inadequate physical activity, suboptimal dietary habits (potentially due to limited access to healthy food options during duty hours), irregular shift schedules leading to sleep disturbances and deprivation, exposure to high levels of noise, post-traumatic stress disorder, and lack of equilibrium between the requirements of the job and control in decision-making[75]. In particular, irregular shift schedules and sleep disturbances could lead to increased fatigue, decreased cognitive performance, and impaired decision-making abilities, which can endanger the safety of both firefighters and the public they serve. Firefighters who experience sleep disturbances and deprivation due to irregular shift work are at heightened risk of making critical errors or misjudgements during emergency response, which can have severe consequences for their own safety as well as that of their colleagues and the community[75].

In addition to the physical demands of firefighting, psychological factors can also place significant strain on emergency responders. Firefighters are frequently exposed to traumatic events and highly stressful situations, which can lead to the development of post-traumatic stress disorder. The exposure to psychological trauma, combined with the lack of equilibrium between the high demands of the job and the level of control firefighters have in decision-making, can create a challenging work environment that exacerbates mental health issues. Firefighters may struggle to cope with the emotional and psychological toll of their duties, which can further impact their overall well-being and job performance.

Similar to firefighters, all first responder occupations are physically and mentally demanding. Police officers, rescue workers, and emergency personnel are frequently required to perform strenuous tasks in high-pressure situations, often under unpredictable and hazardous conditions. To that extent, a 12-month nutrition program was conducted for the Austin Police Department under a project called Wellness Department[76]. Out of forty participants initially enrolled in the program, twenty-four completed the dietary segment of the study. The comparison of 7-day dietary intakes before and after the program revealed a significant decrease in energy intake from an average of 2,273 kcal/day to an average of 1,379 kcal/day ($p<0.001$). There was also an increase in the percentage of energy from protein, from 16% to 21% ($p<0.001$), while energy from fat decreased from 42% to 36% ($p<0.05$)[76]. These changes align with dietary recommendations aimed at reducing the intake of unhealthy fats and increasing lean protein sources, which are beneficial for maintaining muscle mass, supporting metabolic health, and reducing inflammation. The implications of these findings in firefighters would be profound. A diet high in protein and low in unhealthy fats can help manage body composition, improve physical performance, and support cardiovascular health. Protein, for example, plays a key role in muscle recovery and repair[77], which is critical given the physically demanding nature of firefighting. Moreover, reducing fat intake, particularly saturated and trans fats, can lower LDL cholesterol levels, a primary risk factor for atherosclerosis and coronary artery disease[78]. Increasing the intake of heart-healthy fats, such as omega-3 fatty acids, can further support cardiovascular health by reducing inflammation and improving lipid profiles[79].

Among firefighters, sleep deprivation resulting from demanding shift patterns and emergency duties is closely linked to increased fatigue, which negatively affects alertness, decision-making, and overall job performance[80]. Fatigue is commonly considered a factor that is directly linked to the amount of time spent on a task in the workplace and is primarily caused by physical exertion. However, scientists studying shift work have shown differences in factors, such as sleepiness and mood, depending on the time of day, thus raising questions about this traditional view of fatigue[81]. Several studies, conducted with a within-subjects design, aimed to explore variations in time-of-day effects on firefighters' sleep duration, levels of alertness, and mood ratings based on their shift schedules[82]. One study investigated the decrease in the length of sleep due to shift work and employed scales for assessing levels of drowsiness and mood.[83] In the study, participants completed surveys throughout a complete cycle of their shifts. The findings indicated that firefighters working rotating 5-hour shifts experience reduced sleep duration and reported lower scores for positive mood, alongside higher scores for negative mood and increased feelings of sleepiness during night shifts. Furthermore, the study revealed an inability among firefighters to adapt to changes in their sleep routines over the course of a shift[83]. These significant interactions observed challenge the more traditional views regarding fatigue[83]. Fatigue is further linked to burnout and is known to have a potentially detrimental effect on cardiovascular health[84]. Recent studies have focused on exploring the link between shift work and atherosclerosis as well as coronary heart disease. These indicate that shift work may elevate oxidative stress and inflammation levels, which are believed to be contributing factors to the onset of these conditions[85,86].

The Mediterranean diet and the Western diet are two distinct dietary patterns that have significant implications for human health and wellbeing. Extensive research has demonstrated the significant benefits of the Mediterranean dietary pattern on cardiovascular health and metabolic outcomes. According to the scientific evidence accumulated to this point, following a Mediterranean dietary pattern is associated with a reduced risk of cardiovascular disease, diabetes, and obesity[87,88]. These beneficial effects are attributed to the synergistic interactions among the various components of the Mediterranean diet, such as the high content of polyphenols, monounsaturated and polyunsaturated fatty acids, and fiber, which have been shown to favourably impact intermediate pathways of cardiometabolic risk, including lipid profiles, insulin sensitivity, oxidative stress, inflammation, and endothelial function[89]. In contrast, the Western dietary pattern has been linked to a range of negative health outcomes, including an increased risk of cardiovascular disease, metabolic disorders, and certain types of cancer[90]. The high intake of energy-dense, nutrient-poor foods characteristic of the Western diet is believed to contribute to these adverse health effects through various mechanisms, such as the promotion of inflammation, oxidative stress, and metabolic dysregulation[91]. Both the Mediterranean and Western dietary patterns have significant implications for public health, and understanding the nuances of these dietary patterns is crucial for developing effective dietary interventions and promoting healthier eating habits.

The dietary inflammatory index (DII) is a valuable tool used to address the overall inflammatory potential of an individual's diet[92–94]. A growing amount of evidence suggests that higher levels of the inflammatory index are associated with an increased risk of cardiovascular disease. For example, a large prospective study comprised of over 68,000 women, found that those in the highest quantile of the inflammatory index had almost double the risk of developing cardiovascular disease compared to those in the lowest quantile[95]. In addition, a meta-analysis with over 220,000 participants reported that a single unit increase in the dietary inflammatory index was linked to an 8% higher risk of coronary heart disease[96]. These associations could be driven by the inflammatory effect of specific dietary components, such as refined carbohydrates and trans fats, which could be promoting the development of atherosclerosis and other cardiovascular risk factors. Adopting a diet high in anti-inflammatory nutrients, like omega-3 fatty acids, fiber, and antioxidants, may help mitigate the risk of cardiovascular disease[97].

The dietary inflammatory index has been also shown to be associated with other chronic conditions, like type-2 diabetes and cancer. A higher dietary inflammatory index could triple the risk of developing type-2 diabetes, and, similarly, a large prospective study reported that a higher dietary inflammatory index was associated with an elevated risk of breast, colorectal, and prostate cancer[98]. The underlying mechanisms by which these are happening could include the pro-inflammatory effects of diet on insulin resistance, oxidative stress, and chronic inflammation[98,99].

While the dietary inflammatory index is a powerful and promising tool for assessing the inflammatory potential of a diet, it is important to consider potential limitations and counterarguments. A few studies have failed to find any significant association between dietary inflammation and chronic disease risk, mainly because other lifestyle factors may also play a crucial role[100]. Additionally, the dietary inflammatory index relies on the scoring system that assigns inflammatory values to individual foods, but the complex interactions between dietary components and their effects on inflammation are not fully captured by this index. It is also worth noting that inflammatory responses to diet can also vary among individuals due to different genetics, gut microbiome, and other factors[101].

Nonetheless, the Dietary Inflammatory Index (DII) has emerged as a valuable and widely used tool for assessing the inflammatory potential of individuals' diets. Its application has expanded across diverse populations and research contexts, consistently demonstrating its relevance in nutritional epidemiology and public health. Numerous studies, including large-scale cohort studies and meta-analyses, have confirmed the association between higher DII scores and increased risk of chronic diseases such as cardiovascular disease, type 2 diabetes, cancer, and all-cause mortality[97,99]. The robustness of the DII is further supported by its ability to predict inflammation-related biomarkers, such as C-reactive protein and interleukins, across various demographic groups. Collectively, the existing literature highlights the DII as a reliable and versatile instrument for investigating the relationship between diet, inflammation, and health outcomes.

Adherence to the Mediterranean diet is highly beneficial[102] and several prospective studies have examined its association with the onset of cardiometabolic morbidity. These studies have found that greater adherence to the Mediterranean diet at baseline is linked to a lower risk of experiencing the first cardiometabolic incident, as well as a reduced risk of cardiometabolic multimorbidity following the initial cardiovascular disease episode[103]. Using a modified Mediterranean diet score to measure adherence, a study found that higher scores were significantly associated with lower BMI, waist circumference, body fat percentage, and total cholesterol/HDL ratio, while being positively associated with higher HDL-cholesterol levels in a sample of US firefighters[98].

1.3 Research gaps

As previously mentioned, it would be important to understand the parameters that could potentially improve the wellbeing of firefighters, particularly in relation to the risk of cardiovascular disease, which is one of the main sources of morbidity and mortality in this population. Despite the growing recognition of the importance of nutrition in promoting health, significant research gaps exist in the areas of nutrition among firefighters and an individual diet's association with cardiometabolic outcomes.

Firstly, there is a need for more studies specifically focusing on firefighters and their unique working conditions, including shift work, and the impact on dietary habits, sleep, and overall health. The demanding and irregular working hours can predispose them to disrupted circadian rhythms, poor diet choices, and reduced sleep quality, all contributing to poor health outcomes. However, the extent by which these specific factors affect the health of this specific population remains unclear. Studies could further investigate how the adoption of a Mediterranean style diet may contribute to reducing the risk of cardiometabolic conditions, such as obesity, hypertension, and diabetes among firefighters. There is also a lack of studies exploring the effects of pro-inflammatory diets in this group of otherwise healthy and physically fit individuals. Given the physically demanding nature of firefighting and the potential for chronic low-grade inflammation due to occupational stressors, understanding the role of diet in modulating inflammation is particularly relevant.

The Mediterranean diet has demonstrated numerous health benefits in the general population, including reducing inflammation and improving cardiometabolic outcomes. However, there is limited research on the adherence to the MD among firefighters and how it might address their specific health challenges. Investigating the barriers and facilitators to adherence, as well as the potential benefits of the MD within the firefighting community, could offer valuable insights. Additionally, there is a need for studies evaluating the feasibility and effectiveness of tailored nutritional interventions based on the MD in improving health outcomes in this particular population.

In summary, while the general health benefits of the Mediterranean diet and healthy eating practices are well-documented, their specific implications for firefighters, considering their unique occupational challenges and health risks, remain understudied. Addressing these issues will not only advance our understanding of the relationship between nutrition and firefighter health but also inform targeted strategies to improve their overall well-being and reduce the burden of cardiometabolic diseases in this crucial workforce.

1.4 Aims

Further investigation and awareness of the potential benefits of the Mediterranean diet for firefighters could provide valuable insights towards implementing targeted dietary interventions to support cardiovascular health in high-stress occupational settings. Overall, the Mediterranean diet has shown promise in improving cardiovascular outcomes for firefighters through its emphasis on nutrient-rich foods and anti-inflammatory properties. These findings highlight the potential benefits of incorporating Mediterranean-style eating patterns among firefighters to improve their cardiovascular health and mitigate the risks associated with their demanding and high-stress occupation.

The first aim of this dissertation work was to identify the dietary patterns of US firefighters and study how these patterns are associated with different cardiometabolic parameters. This would provide a better understanding of the differences in the overall diet among US firefighters as well as help comprehend the impact of dietary choices on the health of firefighters and potentially develop tailored interventions to improve their overall health.

The second aim was to compute the Dietary Inflammatory Index (DII) of the US firefighters' diet and further assess the relation of the index with cardiometabolic parameters. By estimating the Dietary Inflammatory Index and understanding its relationship with cardiometabolic parameters, we can gain insights into the inflammatory potential of firefighters' diets and how this pro- or anti-inflammatory diet would impact their health.

Finally, the third aim of this thesis was to estimate the association of Mediterranean Diet adherence evaluated with the use of the PREDIMED score as calculated at 2 different time points (baseline, and 6 months) with cardiometabolic parameters. This longitudinal analysis offers valuable insights into the relationship between adherence to the Mediterranean Diet and changes in cardiometabolic health markers over time, highlighting the potential benefits of the diet over a period of 6 months.

1.5 Outline

The rationale and the aims of this work are explained in Chapter 1. Furthermore, Chapter 1 provides background information on the Mediterranean Diet and the dietary inflammatory index. It outlines current epidemiological knowledge regarding the link between the Mediterranean Diet and specific cardiometabolic outcomes and it describes some of the challenges associated with the occupation of firefighting.

Chapter 2 discusses the research methodology and provides details of the "Feeding America's Bravest: Survival Mediterranean Style-Firefighters' Mediterranean Diet Intervention" (FAB) study, including information on the study participants, measures, exposures, and outcomes of interest. This chapter provides a detailed analysis of how adherence to the Mediterranean diet was assessed, as well as how the Dietary Inflammatory Index, and the energy adjusted DII, were computed.

Chapter 3 focuses on the dietary patterns among firefighters in the USA and the potential association with cardiometabolic outcomes. It provides a literature review on the topic, followed by the methods and results of the analysis performed, outlining the observed patterns and associations using data from the FAB study. It concludes with a discussion of these results and the implications for US firefighters.

Chapter 4 assesses the association of the Dietary Inflammatory Index and cardiometabolic outcomes. It provides a literature review on Dietary Inflammatory Index and outlines the calculation of the index for the study population, followed by the methodology, results, and discussion.

Chapter 5 deals with the adherence to the Mediterranean Diet among US firefighters as assessed by the PREDIMED score, derived from the FAB study. It begins with a literature review on the topic, followed by a detailed methodology and a presentation of the analysis results.

Chapter 6 summarizes the results of this work, highlights the significant contributions of the dissertation and its impact, its major limitations and strengths, and gives detailed suggestions for future research.

Finally in the Appendix several additional figures and tables, as well as additional measures used in this study are presented.

2 Research Methodology

2.1 Feeding America's Bravest

The *Feeding America's Bravest* study was designed by researchers at the Harvard T.H. Chan School of Public Health. In line with the established safety and benefits of the Mediterranean diet in preventing cardiovascular diseases, the study aimed to develop strategies for behavioral change within the fire service by integrating key elements of the Mediterranean diet in order to improve the current food culture among firefighters. Through educational initiatives, active involvement, and incentives provided, the intention was to encourage firefighters and their families to embrace Mediterranean diet principles both at work and at home. The research framework enabled the assessment of the efficacy of the proposed strategies in real-life settings within career and volunteer fire services in terms of changing dietary habits and reducing cardiovascular disease risk.

The study's goals included the development of a Mediterranean Diet Nutritional Intervention (MDNI), a comprehensive set of strategies to influence behavior, including educational initiatives on diet and lifestyle, discounts on essential Mediterranean diet foods, electronic tools (such as access to applications and web resources) so that individuals can access and enhance their understanding of nutrition, reminders about fitness goals, and other incentives targeting the family of the participants, given that the majority of the meals that the firefighters eat are at home. The components related to MDNI were developed based on feedback obtained through surveys, review of the literature, and input from local/national firefighters, including labor/management representatives and fire service focus groups. The process indicated that firefighters would like to have more information on nutrition and that they would like to learn more about healthy eating habits. In addition, the nutritional intervention proposed should be acceptable by firefighters in order to succeed. The Mediterranean diet does not require giving up any food items, therefore it is easier to adopt it for long-term adherence. Another very important component that was identified through the focus groups was the inclusion of the family. When firefighters are not in the fire house, they eat the majority of their meals at home, so any initiative should include the family and/or the person who prepares the food at home.

The study included a randomized controlled trial (RCT) with career firefighters and a demonstration project with volunteer firefighters and aimed to create affordable MDNIs for fire service personnel under both protocols. Phase I of the RCT involved more than 1,000 members of the Indianapolis Fire Department (IFD). The 45 firehouses were divided into two groups: Group 1 underwent a proactive 12-month Modified Dietary Nutrition Intervention, while Group 2 received standard care. In Phase II of the RCT, Group 1 participants transitioned to a "self-sustained continuation" for another year to assess whether there was a lasting impact on their behavior during this less intensive, self-directed maintenance intervention period. Meanwhile, Group 2 members switched to receiving the MDNI for six months before transitioning to six months of self-sustained continuation. Throughout both phases of the RCT, the modified Mediterranean diet score (mMDS) together with other validated scores and nutrition questionnaires, as well as clinical data, were collected/computed. Concurrently with Phases I and II, an MDNI demonstration project was carried out using web-based tools among several hundred volunteer firefighters who participated in the study. In this part of the study, participants were asked through an online survey repeatedly over time about their dietary habits as well as about their body weight.

Information collected could help investigate how both lengths of MDNIs could improve mMDS scores; reduce weight; and enhance cardiovascular disease risk profiles among career firefighters involved in these studies. It was hypothesized that adhering to the diet longer, i.e., via a twelve-month program, would be linked with greater persistence to maintaining the intervention compared with following the shortened version, lasting only six months. It was also thought that a successful implementation of the program could lead not just towards enhancing one's diet but also affecting positively an individual's weight and cardiovascular health in more general.

The role of Mediterranean Diet Nutrition Interventions in reducing the risk of CVD is outlined in Figure 3. The figure shows the biological and physiological pathways of MDNI mechanisms. Insulin sensitivity, glucose metabolism, lipid metabolism, anti-oxidants, anti-inflammation, anti-thrombotic, vascular function, blood pressure regulation, and body composition are all influenced positively by the mediterranean diet and they collectively contribute to improved CVD risk profiles.

The progression of coronary heart disease is influenced by genetics, lifestyle habits, and body composition. However, there are also lifestyle factors that affect negatively the progression of the disease, such as poor diet, sleep deprivation, stress, and tobacco use. As the disease progresses it may lead to subclinical conditions, disability, as well as death.

The role of the mediterranean diet interventions emphasize the role of healthy diet and physical activity towards the improvement of health outcomes.

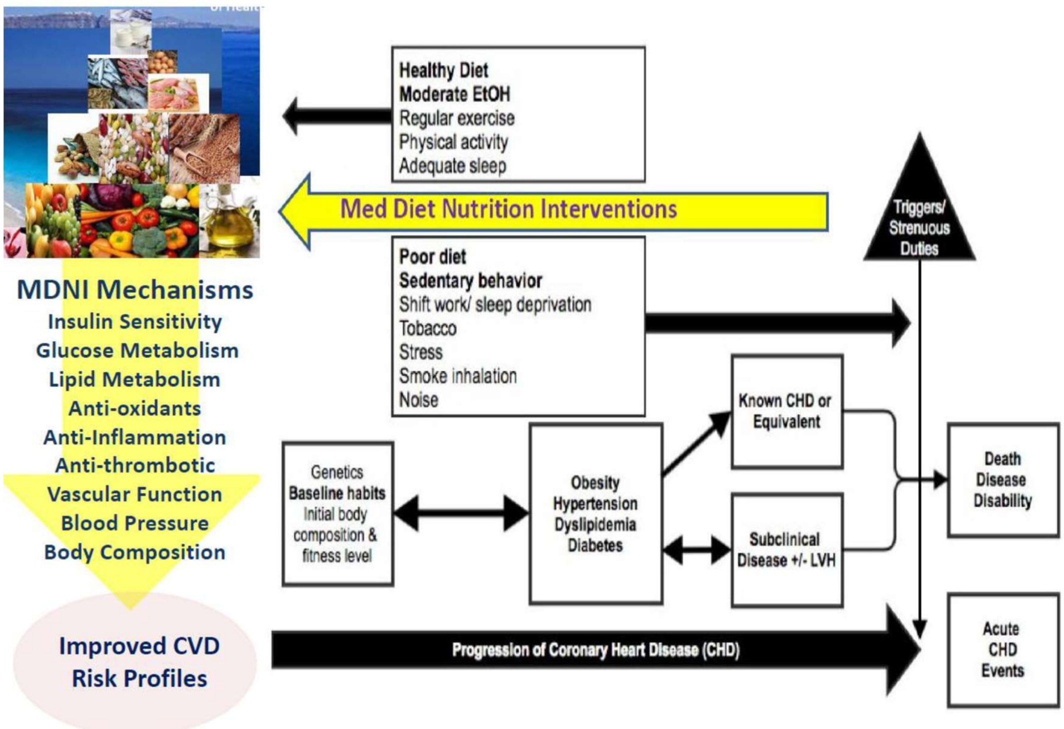

Figure 3 Overall proposal strategies

2.2 Study design

The study was a prospective, randomized control trial of MDNI versus usual care for 12 months, followed by a cross-over of interventions for an additional 6-12 months (Figure 4).

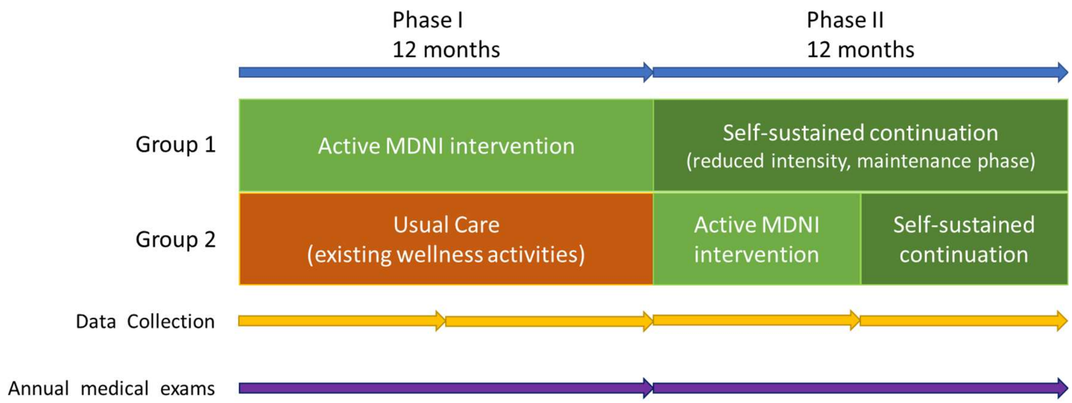

Figure 4 Timeline of MDNI Intervention, Usual Care, and Self-Sustained Continuation Phases

RCT-Phase I

Firehouses were randomized into one of two groups: Group 1 or Group 2. In phase I, Group 1 received the MDNI for 12-months. During this same time, Group 2 received usual care, consisting of existing Indianapolis Fire Department health and wellness activities, with no investigator-provided interventions.

The nutrition/lifestyle questionnaire, mMDS, a blood pressure check, weight-in, waist circumference, and body composition (impedance) were collected every six months during phase 1. A follow-up annual fire department medical exam ("second year") was done per the usual IFD/Public Safety Medical (PSM) protocol.

RCT-Phase II:

Group 1 firehouses crossed-over to "self-sustained continuation", a less intense, self-directed, maintenance phase for 12 months to examine longer-term persistence of behavior change after the active 12-month MDNI. During the self-sustained continuation firefighters had access to some environmental changes such as discounted food items, peer education/support, and online learning; however, the stations did not receive investigator-led educational sessions.

In Phase II, Group 2 firehouses crossed over to receive the full active MDNI for 6 months. This facilitated testing the efficacy of a shorter, but otherwise identical MDNI, followed by a final 6 months of "self-sustained continuation" (as described above) to examine the shorter MDNI's effect.

The nutrition/lifestyle questionnaire, mMDS, blood pressure check, body composition measures were collected every six months during phase 2. Another follow-up annual medical exam ("third year") was done per the IFD/PSM protocol (NCT02941757).

2.3 Study population

The study population consisted of individual participants selected from a cohort of 1,200 career firefighters in the Indianapolis Fire Department (IFD). To ensure consistency, inclusion was limited to about 1,000 members with permanent station assignments at one of the 45 fire houses within the IFD. The partnership with IFD was advantageous for several reasons, including the fact that there were minimal firefighter intervention assignment changes and that there are comprehensive annual health assessments by Public Safety Medical (PSM), including medical and occupational history, physical examinations, BMI measurements and body fat assessments that were available. PSM also provided access to baseline and follow-up medical data through electronic records. Additionally, there was a strong relationship between IFD and the collaborators at the Harvard a T.H.Chan School of Public Health, as further evidenced by high consent rates in previous collaborative studies.

The 45 fire houses were randomized into one of the two groups. They were either assigned to MDNI or "usual care". IFD members who were eligible for the study had to be permanently assigned to one of the 45 IFD stations, being over 18 years of age, have a fire department medical file at least 2 years prior to the study, and have full duty status.

Prior to the study, participants underwent a pre-RCT data collection using established coded, de-identified data transfer methods between PSM and HSPH and the results of the last fire department medical examination were imported from the existing database at Public Safety Medical. The medical exams were supplemented by a comprehensive nutritional and lifestyle questionnaire.

Although the original study population comprised 1,000 participants, the analyses for this dissertation utilized data from only 450 individuals. This was unavoidable because the specific variables required for the planned analyses were not available from all participants. Consequently, some fluctuations in sample size occurred across different analyses, reflecting variations in data completeness. Despite this limitation, the sample of 450 remains sufficiently robust to provide meaningful insights and support the study's objectives.

Data used for analysis in the current dissertation were obtained from the larger longitudinal study, with both cross-sectional and repeated measures components. For the analyses presented in Chapters 3 and 4, data collected exclusively at baseline - prior to the implementation of any intervention - were used. Specifically, dietary intake information obtained through the Food Frequency Questionnaire (FFQ) was used to characterize overall dietary patterns and to compute the Dietary Inflammatory Index (DII). These dietary exposures were then examined in relation to a range of cardiometabolic outcomes, thereby providing insights into potential associations between baseline diet quality, inflammatory potential of the diet, and metabolic risk markers.

In contrast, in Chapter 5 a longitudinal analytical approach, incorporating data collected at two distinct time points (baseline and 6 months) was utilized. This allowed for the assessment of changes in dietary behavior over time, with a particular focus on adherence to the Mediterranean dietary pattern.

2.4 Ethical Statement

The protocol for 'Feeding America's Bravest' was approved by the Harvard Institutional Review Board (IRB16-0170) and is registered at Clinical Trials (NCT02941757). All participants involved signed a consent and were informed that they could withdraw at any time as per the Declaration of Helsinki. Participants who decided to enrol provided an informed consent as per the protocol of the study.

2.5 Study outcomes

One of the primary objectives of this study was to identify the dietary patterns of firefighters and to evaluate the association of these patterns with cardiometabolic outcomes. Additionally, the study aimed to investigate the relationship between the Dietary Inflammatory Index (DII) scores and cardiovascular disease (CVD), as well as to assess the firefighters' adherence to the Mediterranean diet using the MEDAS score at baseline and at 6 months in the study. Changes in biomarkers over this period were also evaluated.

In order to meet the above objectives, we utilized the following variables as outcomes measures: body mass index (BMI), body fat percentage, HDL cholesterol, LDL cholesterol, cholesterol ratio, triglycerides, and glucose levels.

At the baseline visit, all participants underwent comprehensive blood pressure and anthropometric assessments. Resting blood pressure was measured using an appropriately sized cuff while participants were seated in a relaxed position. Body Mass Index (BMI) was recorded in kg/m^2, and body fat percentage was estimated using a Bioelectrical Impedance Analyzer (BIA). Biochemical indices were assessed during the medical examination, with samples being collected as close as possible to the date the participant provided informed consent and within a 12-month window. Blood samples were drawn following an overnight fast, with a total of 15 mL of blood collected into EDTA tubes. The blood plasma was then frozen at -80°C for storage and later analysis. Blood lipid profiles were determined through enzymatic analysis, which achieved a coefficient variation of $\leq 3\%$ for cholesterol and $\leq 5\%$ for triglycerides. This analysis was performed using the cholesterol assay kit and reagents (Ref: 7D62-21) and the triglycerides assay kit and reagents (Ref: 7D74-21) on the ARCHITECT c System, provided by Abbott Laboratories, IL, USA.

2.6 Covariates

We included gender, maximum metabolic equivalent of tasks (METs), maximum VO_2, age, BMI, and body fat percentage as covariates. All participants underwent the Public Safety Medical (PSM) examination, conducted under the supervision of a physician affiliated with the Indianapolis Fire Department (IFD).

The PSM examination is a comprehensive assessment that gathers detailed information on participants' occupational history, smoking status, and overall medical history. The examination also includes a thorough physical evaluation, with measurements of body mass index (BMI) and body fat percentage obtained through bioelectrical impedance analysis. Furthermore, routine laboratory tests are performed, alongside resting electrocardiograms to assess heart function. Additionally, maximal treadmill exercise testing is conducted to evaluate cardiovascular fitness and exercise capacity.

MET (Metabolic Equivalent of Task) is the score that represents the relative rate at which calories are burned during an activity. Sitting quietly has a MET value of 1. To calculate maximum METs the time spent on the treadmill is recorded, then multiplied by 4.38, with 3.9 subtracted from the result. This value is then divided by 3.5 to give the max METs.

VO_2 max represents the maximum or optimal rate at which the heart, lungs, and muscles can use oxygen during exercise, serving as an indicator of aerobic capacity. VO_2 max is calculated by multiplying the ratio of maximum heart rate to resting heart rate by 15.

2.7 Food Frequency questionnaire

The Food Frequency Questionnaire (FFQ) is often an extensive dietary assessment instrument specifically developed to evaluate the nutritional habits of individuals[104]. The specific FFQ used in the study was developed by researchers at Harvard T.H. Chan School of Public Health and it aims to gather detailed, structured data on food and beverage intake, cooking practices, and supplement use of firefighters. The FFQ was organized into multiple sections covering key dietary components, such as dairy products, fruits, vegetables, grains, proteins, snacks, sweets, and beverages. For each food item, participants indicated their frequency of consumption using a bubble-filling system with intervals ranging from "Never" to "6+ per day" or specific scales (e.g., "1–3 times per week" or "Daily"). Seasonal food consumption was addressed by instructing participants to calculate an average frequency over the year. Detailed examples and serving size specifications (e.g., cups, slices, ounces) were provided to standardize responses and improve accuracy.

The questionnaire delved into specific dietary patterns, including the types of milk (e.g., whole, skim, soy), cheese (e.g., regular, low-fat), and spreads (e.g., margarine, butter) consumed. It categorized fruits and vegetables into fresh, frozen, canned, or cooked forms and included specific items, such as kale, carrots, and berries. Grains were further divided into refined and whole-grain products, with items like bread, cereals, rice, and pasta evaluated. Protein sources were comprehensively covered, including meat (beef, pork, lamb, poultry), seafood (fish, shellfish), eggs, and plant-based options (tofu, soy products, lentils). Snacks and sweets, such as chips, cookies, chocolate, and pastries, were listed with frequency options to display indulgence levels.

A portion of the FFQ focused on beverages, with detailed queries about the consumption of water, tea, coffee (with and without caffeine), herbal teas, soft drinks (regular and low-calorie), and alcoholic beverages (beer, wine, liquor). Cooking practices were also explored, such as the types of fats or oils used for frying, sautéing, and baking (e.g., olive oil, lard, shortening) and the frequency of frying food at home or consuming fried items outside.

The supplement section was quite detailed, asking participants to report the use of multivitamins and individual supplements, like vitamins A, C, D, E, and B6; minerals, such as calcium, selenium, and zinc; and other supplements, like fish oil, protein powders, and herbal products. For each, participants specified the frequency, dosage, and, where possible, the brand or formulation.

Open-ended questions further allowed for the inclusion of specific foods, brands, or preparation methods not listed, ensuring a comprehensive dietary profile. Overall, the FFQ combined a systematic approach with user-friendly features, such as examples, clear instructions, and standardized response formats, to capture dietary behaviors. It provided valuable insights into the nutritional habits and health risks of firefighters, supporting tailored dietary recommendations to enhance their health and performance. The FFQ is provided in full in Appendix 1.

2.8 Statistical analysis

2.8.1 Descriptive statistics

We used descriptive statistics to summarize and better understand the main characteristics of our dataset. For continuous variables, we first evaluated the shape of the distribution to determine which measures of central tendency and spread were most appropriate. When the data appeared approximately normally distributed (characterized by symmetry around the mean and a close alignment of the mean, median, and mode) we reported the mean and standard deviation (SD). These two measures provide a concise summary of central tendency and variability. The standard deviation, in particular, reflects how spread out the values are around the mean: a low SD indicates that values are clustered closely around the mean, while a high SD suggests greater variability. In cases where the data were not normally distributed, we described continuous variables using the median along with the first and third quartiles (Q1, Q3), which better capture central tendency and spread in skewed distributions. To support our decision-making regarding the appropriate descriptive measures, we examined histograms and summary statistics to assess the distributional shape.

We also considered the normal distribution in our assessments. The normal, or Gaussian, distribution is a bell-shaped curve commonly found in naturally occurring data. One of its key properties is the empirical rule: approximately 68% of the data lies within one standard deviation of the mean, 95% within two, and 99.7% within three. This provided a useful framework for interpreting the spread and assessing the likelihood of certain values occurring within our dataset.

To further evaluate the relative positions of data points within a normal distribution, we calculated z-scores. These indicate how many standard deviations a value is from the mean, allowing for comparisons across different variables or datasets on a standardized scale as well as the assessment as to whether a particular observation is a potential outlier.

Categorical variables were summarized using frequencies and percentages. This allowed us to describe the distribution of qualitative characteristics within our sample, such as demographic variables or categorical health indicators.

By applying these descriptive techniques, tailored to the nature and distribution of each variable, we were able to generate meaningful summaries of the data. This approach laid the foundation for subsequent analytical steps by identifying trends, highlighting variability, and guiding the selection of appropriate statistical tests.

2.8.2 Principal component analysis

Principal Component Analysis (PCA) was employed in this dissertation as a dimensionality reduction technique to simplify complex dietary data and identify underlying dietary patterns. The primary objective was to reduce a large number of correlated dietary variables, collected from the Food Frequency Questionnaire (FFQ), into a smaller set of uncorrelated components that retained most of the original information. This approach allowed for a more manageable and interpretable dataset, while minimizing information loss.

PCA was applied to the variables to extract linear combinations; principal components, that explained the maximum amount of variance within the dataset.

To determine the optimal number of components to retain, we examined the scree plot and assessed the eigenvalues associated with each principal component. Components with eigenvalues greater than one were initially considered, and the point at which the curve of the scree plot began to level off (the “elbow”) was used as a guide for final selection. This method ensured a balance between dimensionality reduction and the preservation of explanatory power.

The derived components, interpreted as dietary patterns, were rotated using varimax rotation to enhance interpretability and facilitate the identification of meaningful groupings of food items. Each component loading was carefully examined to label the corresponding dietary patterns based on the predominant food groups.

PCA was chosen for this analysis due to its ability to uncover latent structures in the data, reduce multicollinearity among variables, and provide uncorrelated inputs for subsequent regression models. This made it particularly valuable in capturing distinct dietary patterns that could be used as exposure variables in models assessing associations with cardiometabolic outcomes.

2.8.3 Regression analysis

Regression analysis was a key analytical approach used in this dissertation to examine associations between dietary patterns and cardiometabolic health outcomes. The choice of regression models was guided by the nature of the outcome variables and the study design. Linear regression was used for continuous outcomes such as blood pressure, cholesterol levels, and inflammatory markers.

Multivariable regression models were constructed to adjust for potential confounders and to isolate the independent effects of each dietary pattern derived from the PCA. Covariates included in the models were selected based on prior literature and included age, sex, body mass index (BMI), and physical activity levels. The inclusion of these covariates in the regression models helped reduce bias and improve the precision of the estimated associations.

Prior to model fitting, we assessed the underlying assumptions of each regression model. For linear regression, this involved checking for linearity, homoscedasticity, normality of residuals, and absence of multicollinearity among predictors. These were evaluated using residual plots, histograms of residuals, and normal probability plots. Where necessary, data transformations or alternative modelling strategies were considered.

Interpretation of regression coefficients followed standard epidemiological practices. In linear regression, the beta coefficients represented the mean change in the outcome variable associated with a one-unit change in the predictor, adjusted for all other variables in the model.

Confidence intervals and p-values were further used to assess the statistical significance of associations.

The results from these regression analyses were then interpreted in the context of existing literature, considering both statistical and practical significance. Particular attention was paid to the direction and magnitude of associations, as well as to their implications for public health interventions and dietary recommendations. Potential limitations, including residual confounding and measurement error, were acknowledged in the discussion.

In summary, regression analysis provided a structured and rigorous framework to explore the relationships between dietary exposures and health outcomes. By carefully selecting appropriate models, adjusting for relevant covariates, and validating model assumptions, we ensured that the findings presented in this dissertation are both methodologically sound and meaningful within the broader field of epidemiological research.

3 Mediterranean Diet as an Eating Pattern among US Firefighters and Its Association with Cardio-metabolic Outcomes

3.1 Introduction

Firefighting is a hazardous occupation and, even though one might think that on-duty mortality among firefighters is primarily because of burns or smoke inhalation, the most frequent cause of on-duty deaths is sudden cardiac death (SCD) due to underlying cardiovascular disease (CVD)[105]. About half of all on-duty fatalities are the result of SCD, strokes, aneurysms, and other CVD-related conditions. Furthermore, for every on-duty CVD-related death there are an estimated 17 nonfatal on-duty CVD events[57,106,107]. Thus, CVD is not just a leading cause of mortality among firefighters, but also a great cause of morbidity and resulting disability. Even though the cardiometabolic health of firefighters overall is better than the average US citizen, in general over the years there is a decrease in the cardiometabolic health of male firefighters. Among female firefighters cardiometabolic health also shows a steady decrease[108]. Similar to the general U.S. population, obesity affects roughly 35% of U.S. firefighters, which is slightly lower than the 42% prevalence reported in the general adult population[109,110].

Several risk factors have been associated with the risk of CVD. These include obesity, hypertension, and high cholesterol levels[111]. Obesity, which has negative effects on the fitness and performance of firefighters, is also known to be associated with an increased risk of CVD, as well as blood pressure, glucose metabolism, sleep apnoea, and cardiac enlargement[112].

Several population-based studies among volunteer and career firelighters have shown that the rise in obesity prevalence is not the result of an increase in muscle mass[113], but rather it is due to an increase in body fat[113]. This is an issue that affects younger firefighters but also middle-aged and older firefighters alike and a problem that is not recognised at its full extent[114].

In this chapter, we explore the dietary patterns as a contributing factor for the increase in obesity rates. A number of recent studies have shown that the difference between obese and non-obese firefighters is the consumption of more sugary drinks and fast-food[115,116]. These findings are consistent with other population-based studies, which suggest a switch in the dietary pattern of people having a large impact on their health. Shift work and uncontrollable mealtimes, which is the norm among firefighters, also tend to increase the consumption of sugary drinks and fast food with a greater proportion of calories from fat[51,117]. Studies indicate that education, years of experience, nutritional knowledge, and autonomous motivation are among the strongest predictors of healthy food choices; similarly, accessibility to unhealthy foods increases the likelihood of unhealthy food choices[118]. Furthermore, high-performance firefighters are more likely to consume at least five servings of fruits and vegetables daily compared to their lower-performing counterparts[119].

One of the most well-accepted diets in the reduction of CVD risk is the Mediterranean diet. Mediterranean type diets, traditionally followed by countries bordering the Mediterranean Sea, are rich in unrefined grains, fruit, vegetables, and olive oil, and contain a lower consumption of red meat and poultry[120]. Over the years, a large number of studies have demonstrated the effectiveness of the Mediterranean diet in the reduction of CVD mortality. The Mediterranean diet targets obesity, hypertension, diabetes, and metabolic syndrome, all of which are conditions associated with CVD[102,121,122]. Based on the clear benefits of the Mediterranean diet, it is recommended as one of the healthiest options in the USA and other countries[123].

The first step in a nutritional intervention involves the identification of dietary patterns of the target population. Dietary patterns are defined as ‘the quantity, variety or combination of different foods and beverage in a diet and the frequency with which they are habitually consumed[123]. In a survey by Yang et al., obese firefighters were less likely to follow a diet plan (25%) than normal-weight firefighters (33%). Among the 18 diets listed on the survey, 9% of the participants followed the Paleo diet, 8% a low-carbohydrate diet, and 4% a low-fat diet. Only 1% of the firefighters reported following the Mediterranean diet[124]. Similarly, in a study of 28 Swiss airport firefighters, the participants had an unbalanced diet with low-quality food choices and limited fiber intake[125]. Studies among structural firefighters highlight the importance of maintaining a healthy dietary pattern; however, many firefighters fail to adhere to one, with food choices often influenced by colleagues. Dietary interventions, such as the assignment of a Mediterranean diet, have been shown to yield significant health benefits, including improved lipid profiles and reduced cardiovascular disease (CVD) risk. Additionally, team-based counselling has proven to be more effective in promoting healthier dietary habits compared to one-on-one counselling, while general counselling demonstrates better outcomes than no counselling at all[126].

Given that CVD is prevalent among firefighters, it is important to identify the dietary patterns of firefighters. Understanding the type and quality of different foods in the diet of firefighters can help us provide scientific recommendations to improve food intake towards a healthier diet. This chapter aims to identify the dietary patterns of US firefighters and investigate how these are associated with cardio-metabolic outcomes in the specific population. By understanding the relationships between food choices, occupational demands, and cardiovascular health, we aim to develop targeted nutritional recommendations that support disease prevention and health promotion in this critical workforce.

3.2 Methods

3.2.1 Study participants

This cross-sectional study involved 413 active Indianapolis Fire Department (IFD) firefighters enrolled in the "Feeding America's Bravest" study, which aimed to improve eating habits and cardiovascular risk through a Mediterranean diet. Participants were recruited between November 2016 and April 2018, with informed consent obtained by the National Institute of Public Safety Health to ensure ethical compliance. Those without baseline anthropometric data were excluded from the analysis to maintain dataset integrity.

3.2.2 Dietary Assessment

A validated Food Frequency Questionnaire (FFQ) with 131 items was used to assess participants' dietary intake[127]. This comprehensive tool collected detailed information on how often each food item was consumed over the past 12 months. The questionnaire, which was not adapted for firefighters' specific food habits, covered in detail a broad range of food categories, including dairy, fruits, vegetables, eggs, meats, breads, cereals, starches, beverages, sweets, baked goods, and more. By encompassing these diverse categories, the FFQ provided a thorough overview of participants' typical dietary patterns.

3.2.3 Physical Activity

All participants underwent the Public Safety Medical (PSM) examination, supervised by a physician affiliated with the Indianapolis Fire Department (IFD. This comprehensive assessment gathered detailed information on occupational history, smoking status, and medical history. It included a physical evaluation with BMI and body fat percentage measured via bioelectrical impedance analysis, routine lab tests, and resting electrocardiograms to assess heart function. Additionally, maximal treadmill exercise testing was conducted to evaluate cardiovascular fitness and exercise capacity.

3.2.4 Outcome Assessment

At the initial visit, participants underwent comprehensive blood pressure and anthropometric assessments. Resting blood pressure was measured with an appropriately sized cuff while they were seated in a relaxed position. BMI was recorded in kg/m^2, and body fat percentage was estimated using a Bioelectrical Impedance Analyzer (BIA). Biochemical indices were assessed during the medical examination, with blood samples collected within a 12-month window of informed consent. After an overnight fast, 15 mL of blood was drawn into EDTA tubes, with plasma frozen at -80°C for later analysis. Blood lipid profiles were measured through enzymatic analysis, achieving a coefficient of variation of $\leq 3\%$ for cholesterol and $\leq$

5% for triglycerides, using Abbott Laboratories' ARCHITECT c System with designated assay kits and reagents.

3.2.5 Dietary patterns

Dietary patterns refer to the habitual dietary behaviors and food choices individuals or groups consistently follow. These patterns are shaped by cultural, socioeconomic, environmental, and personal factors and play a critical role in determining overall health and well-being. Common diet patterns include the Mediterranean diet, vegetarian and vegan diets, ketogenic diets, intermittent fasting, and the standard American diet.

Dietary patterns significantly influence physical health, mental well-being, and longevity. Scientific literature highlights the profound connection between diet and health outcomes. A 2019 review in *The Lancet* emphasized the importance of plant-based diets for both human health and environmental sustainability. Similarly, several studies in other journals like *Nutrition Reviews* and *American Journal of Clinical Nutrition* have explored the benefits of various diets in preventing non-communicable diseases. Emerging research also focuses on personalized nutrition, where genetic, metabolic, and microbiome data inform dietary recommendations. In the present study, dietary patterns were derived using principal component analysis, which identified distinct patterns such as "Western," and "Mediterranean." The aim was to investigate how adherence to these specific patterns relates to health outcomes.

3.2.6 Statistical Analysis

Principal Component Analysis (PCA) was used to identify dietary patterns of firefighters at baseline. The scree test was used to identify the number of factors present. Loading factors were calculated after a varimax rotation to obtain uncorrelated components that are more easily interpretable. In order to obtain a clearer pattern, a cut-off of $\geq|0.2|$ in factor loadings was applied.

Continuous characteristics were presented as mean ± SD whereas categorical variables were reported as frequency (percentage). Characteristics of interest are presented overall and by tertiles (Low - Medium - High) of the identified dietary patterns and compared using the ANOVA test or the chi-square test of independence, for continuous and categorical variables, respectively.

Linear regression models were used to evaluate the effect of the identified dietary patterns on cardiometabolic outcomes, unadjusted, and after adjusting for age, gender, BMI, % body fat, max METS, and VO2 max. The resulting beta coefficients, together with the corresponding standard errors and p-values, are presented. Regression assumptions were evaluated, including normality of residuals, linearity, and homoscedasticity through residual plots, and the presence of multicollinearity was assessed using the variance inflation factor. As a sensitivity analysis, the identified dietary patterns were used in the models as continuous variables as well as in tertiles.

All statistical analyses were performed using SAS Version 9.3 (SAS Institute Inc., Cary, NC). The alpha level of significance was set at 0.05 and all tests performed were two-sided.

3.3 Results

3.3.1 Participants' characteristics

The participation rate of the study was 95% and there were 426 firefighters who had available information and were included in the current analysis. Table 3.1 describes the baseline characteristics of the participants. The vast majority of the participants were males (94%) with the mean age being 47.2 ± 8.2 years and the average BMI 30.0 ± 4.5 kg/m^2 with participants having 28.1 ± 6.6 % body fat. Only 4% of the participants were smokers, whereas the average amount of alcohol consumed per week was 12.81 ± 20.18 units. The average METS score was 11.6 ± 5.5 and the VO2 max 42.1 ± 5.0. In terms of cardiovascular factors, the participants had on average SBP and DBP of 123.4 ± 8.8 mmHg and 78.3 ± 6.1 mmHg, respectively. Furthermore, the mean total cholesterol was 196.9 ± 38.3 mg/dl whereas the average HLD cholesterol and LDL cholesterol were 49.2 ± 11.4 mg/dl and 122.7 ± 33.1 mg/dl, respectively. Cholesterol ratio, triglycerides, and glucose levels were 4.20 ± 1.30, 124.5 ± 75.7 mg/dl, and 100.0 ± 20.5 mg/dl, respectively.

Table 3.1 Baseline cardiometabolic characteristics of participants

Characteristics	Overall (n=426)
Males	390 (94%)
Age (years)	47.2 (8.2)
Height (m)	1.79 (0.07)
Weight (kg)	96.8 (17.4)
BMI (kg/m^2)	30 (4.5)
% body fat (%)	28.1 (6.6)
Smoking	10 (3.9%)
Alcohol (units per week)	12.81 (20.18)
Max METS	11.6 (5.5)
Est. VO2 max	42.1 (5.0)
Systolic BP (mmHg)	123.4 (8.8)
Diastolic BP (mmHg)	78.3 (6.1)
Cholesterol (mg/dl)	196.9 (38.3)
HDL cholesterol (mg/dl)	49.2 (11.4)
LDL cholesterol (mg/dl)	122.7 (33.1)
Cholesterol Ratio	4.20 (1.30)
Triglycerides (mg/dl)	124.5 (75.7)
Glucose (mg/dl)	100.0 (20.5)

BMI - Body mass index, Max METS- Maximum Metabolic Equivalents of Task, Est. VO2 max -Estimated Maximal Oxygen Uptake, BP-Blood Pressure

3.3.2 Dietary patterns

The scree test of the PCA indicated two distinct factors and these were identified as a Mediterranean Diet (MD) component and a Standard American Diet (SAD) component.

The total number of food items included in the analysis was 148, out of which 96 had a loading factor above the pre-set cut-off of |0.2|. The Mediterranean style diet included 57 of these items and comprised of things like vegetables (such as raw spinach (0.673) and romaine lettuce (0.601)), fruits (such as peaches (0.554) and apples (0.368)), red wine (0.258), nuts (such as walnuts (0.201) and other nuts (0.259)), and brown rice (0.246). Table 3.2 provides a detailed list of all 57 items with the corresponding estimated loading factor, listed in descending order of the loading factor.

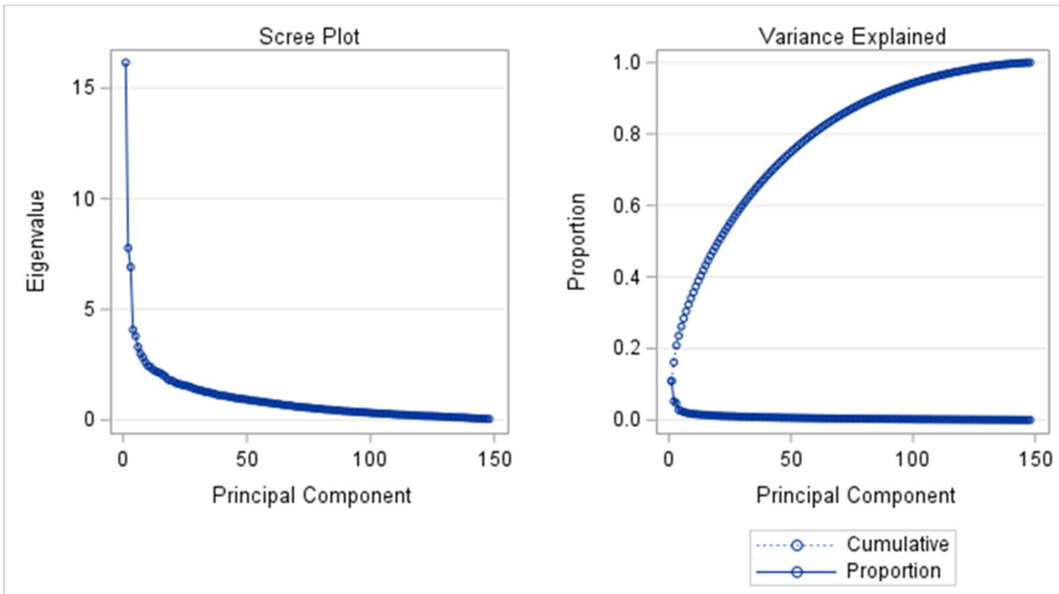

Figure 5 Scree Plot and Variance Explained from Principal Component Analysis

Figure 5 shows the scree plot (left) that displays the eigenvalues of the principal components, illustrating the point at which the explained variance levels off, used to determine the number of components to retain and the variance explained plot (right) shows the proportion of variance accounted for by each principal component and the cumulative variance, demonstrating that most of the variability in the data is captured by the first few components.

Table 3.2 Loading factors from PCA analysis for top scored food items that are part of Dietary Pattern - Mediterranean Diet

Food Item	Loading Factor
Raw spinach	0.673
Romaine lettuce	0.601
Beans	0.599
Cantaloupe	0.564
Peaches	0.554
Cooked spinach	0.553
Celery	0.543
Peppers	0.538
Raw carrot	0.476
Cooked carrot	0.475
Orange winter squash	0.465
Orange	0.454
Blueberries	0.453
Peas	0.433
Apricot	0.432
Low carb bars	0.424
Low calory beverage without caffeine	0.422
Cream cheese	0.404
Avocado	0.402
Salsa	0.399
Sweet potato	0.397
Tomato	0.396
Energy bars	0.391
Banana	0.390
Rye bread	0.390
Cabbage	0.381
Kale	0.369
Apple	0.368
String beans	0.334
Olive oil	0.328
Cottage ricotta cheese	0.315
Tomato sauce	0.300

Tofu	0.290
English muffin/Bagels/Rolls	0.287
Raisin grapes	0.286
Bacon	0.266
White wine	0.265
Breakfast bars	0.260
Other nuts (other than peanuts/walnuts)	0.259
Red wine	0.258
Potato	0.256
Zucchini	0.252
Margarine	0.251
Brown rice	0.246
Pure butter	0.236
Eggs	0.228
Pretzel	0.215
Yogurt	0.212
Tomato juice	0.212
Apple juice	0.211
Plain yogurt	0.210
Peanut butter	0.209
Coffee	0.209
Cooked cereal (other than oatmeal)	0.206
Popcorn	0.204
Walnuts	0.201
Fresh fried potatoes	0.200

Similarly, thirty-nine items scored loading factors above |0.2| in the Standard American diet, and those included items like red meat (such as hamburger (0.294) and pork (0.291), pasta (0.235), and sweets (such as brownies (0.301) and ready-made pie (0.288)). The detailed list of all 39 items and their loading factor, listed in descending order of the loading factor, is provided in Table 3.3.

Table 3.3 Loading factors from PCA analysis for top scored food items that are part of Dietary Pattern - Standard American Diet

Food Item	Loading Factor
Other Fish (other than dark meat fish)	0.900
Corn	0.877
Dark meat fish	0.877
Brussels	0.863
Chicken with skin	0.835
Cauliflower	0.831
Broccoli	0.811
Mayonnaise	0.754
Sweets	0.752
Bologna	0.728
Ice lettuce	0.701
Cooked oatmeal	0.699
Orange juice	0.694
Strawberries	0.673
Mixed vegetables	0.647
Whole grain bread	0.582
Chicken sandwich	0.566
Beef burger sandwich	0.560
Cooked onions	0.476
Hotdog	0.475
Chicken without skin	0.458
Breaded fish pieces	0.452
Oil and vinegar	0.443
Onions as a garnish	0.433
White rice	0.370
Beef	0.304
Brownie	0.301
Chicken hot dog	0.301
Processed meat	0.296
Hamburger	0.294
Cooked Shrimp	0.292
Pork	0.291

Carbonated drink with sugar but no caffeine	0.288
Ready-made Pie	0.288
White bread	0.281
Punch	0.273
Oat Bran	0.271
Other fresh juice (other than orange and grapefruit)	0.241
Pasta	0.235
Cake	0.200

3.3.3 Categorization of participants according to the diet pattern

The 426 participants that provided information about their diet preferences were categorized in different diet styles using tertiles of their Mediterranean Diet (MD) and Standard American Diet (SAD) diet components. For each dietary pattern, individual food items contributed through their loading factors, and a total score was calculated for each participant by summing the weighted contributions of these items, allowing classification into tertiles of adherence. This is presented in Table 3.4. A number of our participants had a score in the high tertile in both MD and SAD (n=87) where participants who had score in the low tertile on MD had the tendency to have a score in the low tertile on SAD as well (n=81). The tertile cutoffs were defined using equal intervals to categorize participants' scores.

Table 3.4 Different dietary patterns of participants.

Standard American Diet	Mediterranean Diet			Total
	Low	Medium	High	
Low	81	46	15	142
Medium	44	58	40	142
High	17	38	87	142
Total	142	142	142	426

3.3.4 Association of dietary patterns with cardiometabolic outcomes

Table 3.5A and Table 3.5B compare health and physiological characteristics between individuals in the Low, Medium, and High adherence levels within each of the Standard American Diet (SAD) and the Mediterranean Diet (MD) pattern. They include physical metrics (e.g., height, weight), health indicators (e.g., body fat percentage, cholesterol levels), fitness measures (e.g., VO2 max, Max METS), blood pressure (diastolic and systolic), and blood metrics (e.g., HDL, LDL, triglycerides, and glucose). Mean values and standard deviation are provided, along with the p-values of the F-test from the ANOVA analysis, checking for statistical significance in terms of differences in the average values of the three groups of adherence.

For weight, SAD shows a significant difference between the Low adherence and High adherence groups (average of 93.3 ± 16.20 kg vs. 101.11 ± 19.18 kg, respectively, $p < 0.001$). In contrast, average weight under MD remains relatively stable across adherence levels, from 96.00 ± 14.80 kg in the Low adherence group to 97.80 ± 18.33 kg in the High adherence group ($p = 0.698$). Body fat percentage for SAD increases slightly from 27.24 ± 6.95 % (Low) to 29.03 ± 6.70 % (High) with $p = 0.084$, while for MD, it is similar in all three groups and it takes average values between 27.74 ± 7.30 % (High) and 28.31 ± 6.87 % (Medium), with $p = 0.778$.

Triglycerides show a marked increase in SAD, from 106.79 ± 59.75 mg/dL in the Low adherence group to 145.20 ± 93.08 mg/dL in the High adherence group ($p < 0.001$). In MD, the range is narrower, from 119.56 ± 64.83 mg/dL to 129.11 ± 76.01 mg/dL in the Medium and High adherence groups, respectively, $p = 0.581$. Similarly, HDL cholesterol within tertiles of SAD decreases significantly from 51.52 ± 12.00 mg/dL (Low) to 47.29 ± 10.66 mg/dL (High), resulting in $p = 0.008$, while within MD tertiles the mean HDL cholesterol shows more stability, ranging from 48.54 ± 10.64 mg/dL (Low) to 49.90 ± 11.37 mg/dL (High), with $p = 0.612$.

VO2 max, an indicator of cardiorespiratory fitness, decreases slightly in SAD from 42.58 ± 5.31 to 41.58 ± 4.89 in the Low and High groups ($p = 0.258$), and remains stable in MD around 42 ± 5 ($p = 0.960$). Blood pressure shows no significant trends in either diet. Diastolic BP in SAD ranges from 78.01 ± 6.08 mmHg to 78.80 ± 6.19

mmHg (p = 0.539), while in MD, it ranges from 77.72 ± 6.38 mmHg to 78.70 ± 6.08 mmHg to (p = 0.338).

Table 3.5A Cardiometabolic characteristics - Standard American Diet

Characteristic	**Standard American Diet**			
	Low	**Medium**	**High**	**p**
Height (m)	1.79±0.07	1.79±0.07	1.80±0.07	0.155
Weight (kg)	93.3±16.20	96.02± 15.71	101.11± 19.18	<0.001
% body fat (%)	27.24 ± 6.95	27.89 ± 6.17	29.03 ± 6.70	0.084
Max METS	12.16 ± 9.24	11.29 ± 1.31	11.24 ± 2.43	0.318
VO2 max	42.58 ± 5.31	42.19 ± 4.69	41.58 ± 4.89	0.258
Diastolic BP (mmHg)	78.21 ± 5.86	78.01 ± 6.08	78.80 ± 6.19	0.539
Systolic BP (mmHg)	123.05 ± 8.86	123.17 ± 8.72	123.98 ± 8.93	0.639
Cholesterol (mg/dl)	193.15 ± 38.28	199.59 ± 39.99	197.55 ± 37.22	0.363
HDL cholesterol (mg/dl)	51.52 ± 12.00	48.84 ± 11.19	47.29 ± 10.66	0.008
LDL cholesterol (mg/dl)	119.03 ± 31.70	126.90 ± 33.73	122.15± 33.43	0.150
Cholesterol Ratio	3.95 ± 1.52	4.24 ± 1.08	4.37 ± 1.25	0.023
Triglycerides (mg/dl)	106.79 ± 59.75	120.64 ± 64.14	145.20 ± 93.08	<.001
Glucose (mg/dl)	97.82 ± 18.02	102.44 ± 27.60	99.77± 13.20	0.180

Table 3.5B Cardiometabolic characteristics - Mediterranean Diet

Characteristic	**Mediterranean Diet**

	Low	Medium	High	p
Height (m)	1.79 ± 0.07	1.79 ± 0.07	1.80 ± 0.07	0.779
Weight (kg)	96.00 ± 14.80	96.77 ± 19.00	97.80 ± 18.33	0.698
% body fat (%)	28.012 ± 5.71	28.31 ± 6.87	27.74 ± 7.30	0.778
Max METS	11.96 ± 9.12	11.28 ± 1.58	11.45 ± 2.44	0.578
VO2 max	42.19 ± 4.70	42.01 ± 5.06	42.13 ± 5.18	0.960
Diastolic BP (mmHg)	78.62 ± 5.67	78.70 ± 6.08	77.72 ± 6.38	0.338
Systolic BP (mmHg)	123.32 ± 8.38	123.41 ± 9.14	123.49 ± 9.01	0.987
Cholesterol (mg/dl)	196.84 ± 39.51	194.77 ± 36.96	198.69 ± 39.06	0.700
HDL cholesterol (mg/dl)	48.54 ± 10.64	49.10 ± 12.14	49.90 ± 11.37	0.612
LDL cholesterol (mg/dl)	122.83± 31.67	122.01 ± 33.96	123.32 ± 33.67	0.947
Cholesterol Ratio	4.27 ± 1.63	4.16 ± 1.16	4.14 ± 1.06	0.647
Triglycerides (mg/dl)	124.80 ± 87.07	119.56 ± 64.83	129.11 ± 76.01	0.581
Glucose (mg/dl)	101.20 ± 20.46	98.19 ± 19.10	100.64 ± 21.78	0.440

Prior to interpreting the regression results, a comprehensive evaluation of the regression assumptions was performed. Diagnostic plots were generated for each model to assess linearity, normality of residuals, homoscedasticity and presence of influential observations. Indicative figures 6-8 present the diagnostic panels for models predicting HDL cholesterol, total cholesterol, and triglycerides, respectively.

Figure 6 displays the diagnostic plots for the regression model with HDL cholesterol as the dependent variable. The residual plots appear to be approximately symmetrically distributed, though some slight deviations from normality are visible in the Q-Q plot. The residual plot suggests no strong non-linearity or heteroscedasticity. The model explains a modest portion of the variance in HDL cholesterol (R^2=0.173; Adjusted R^2=0.157).

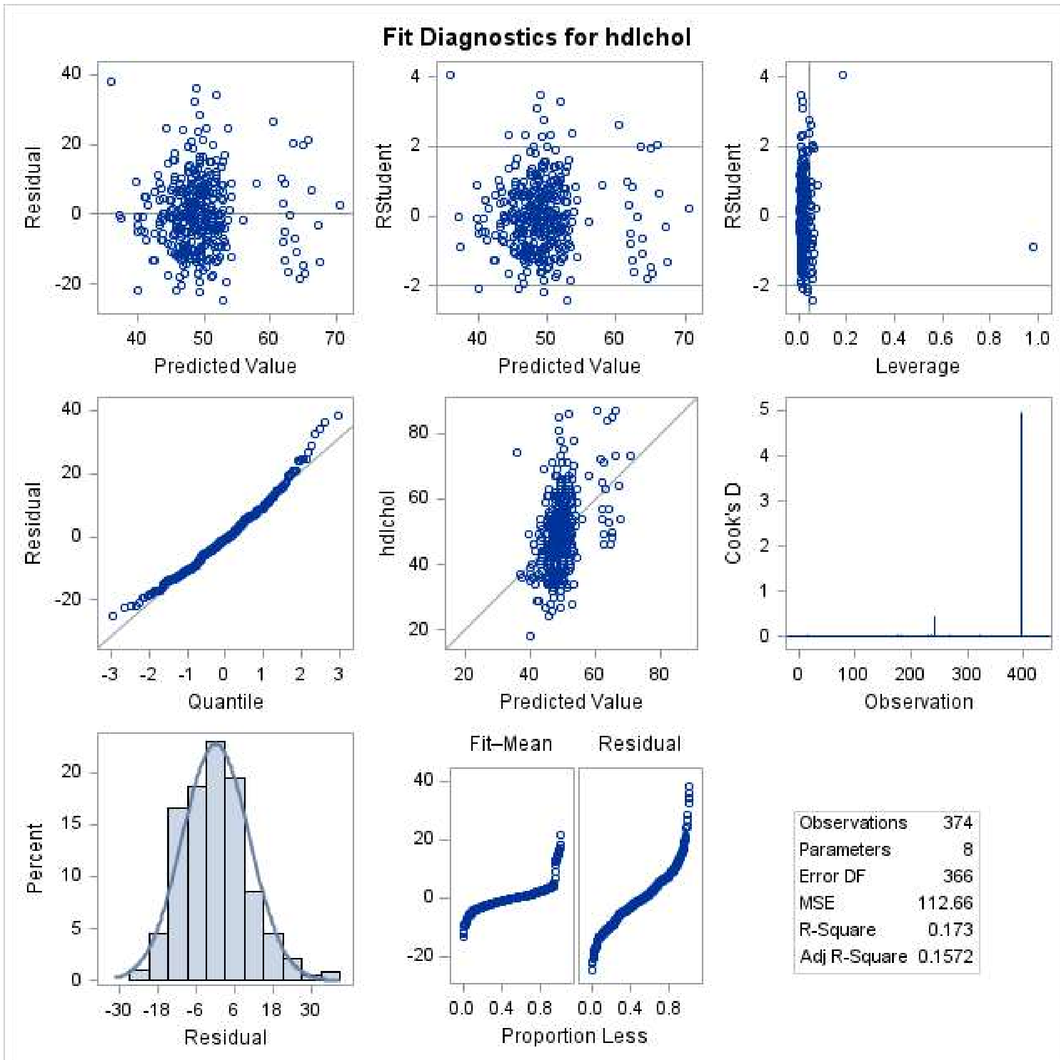

Figure 6 Fit diagnostics for HDL cholesterol

Figure 7 displays the diagnostic plots for the regression model with total cholesterol as the dependent variable. Residuals appear more normally distributed than in the HDL model but show greater variability and have some outliers present. The Residual vs. Predicted plot exhibits a symmetric distribution but seem widespread, suggesting limited predictive precision. The leverage and Cook's D plots suggest the presence of at least one high-leverage influential observation. The model's explanatory power is quite limited ($R^2 = 0.031$; Adjusted $R^2 = 0.012$.

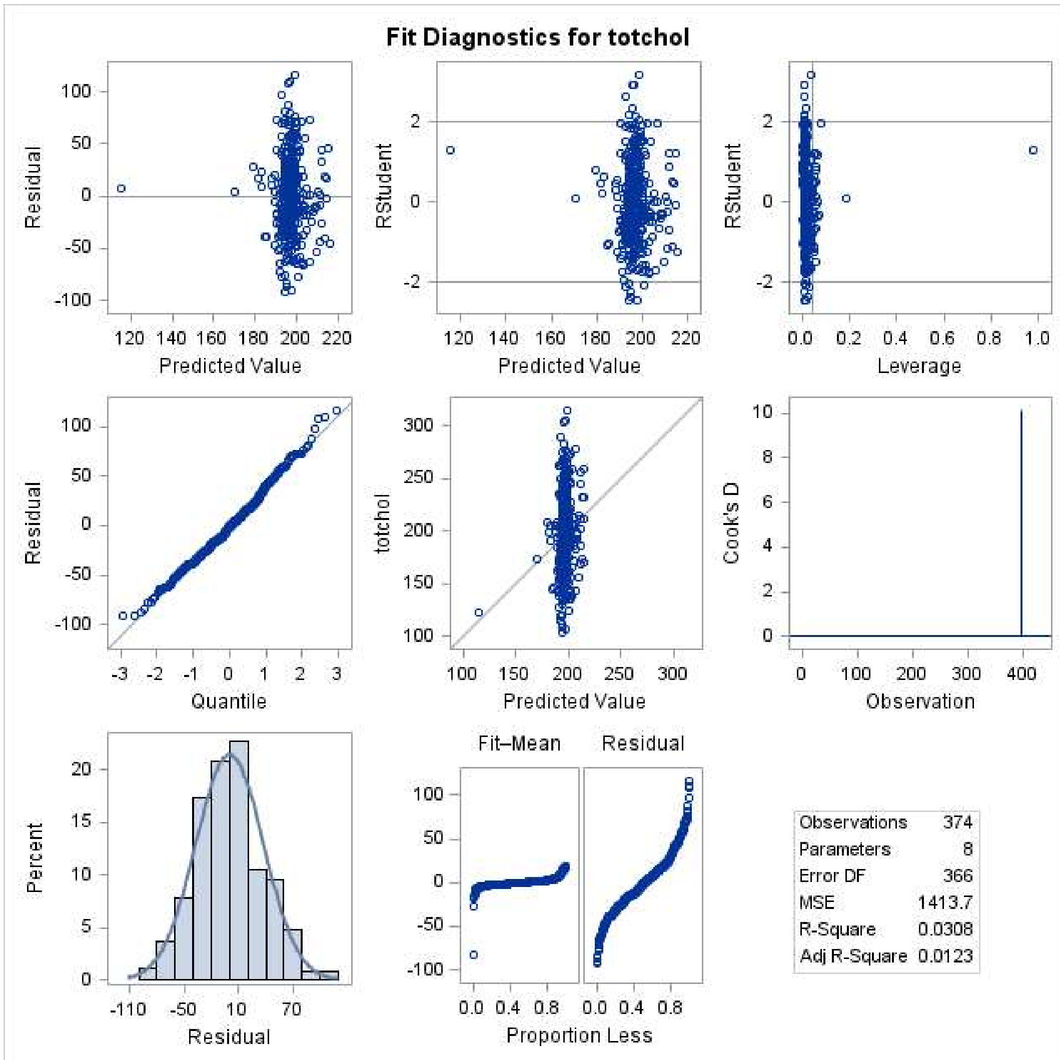

Figure 7 Fit diagnostics for total cholesterol

Figure 8 presents the diagnostics for the regression model predicting triglycerides levels. There are some high values, as evident in the residual and studentized residual plots, as well as the histogram. The normal Q-Q plot shows some skewness likely drawn by the presence of a few high triglyceride values. Cook's D and leverage plots show some potential influential data points that may affect the fit of the model. Although slightly better than the total cholesterol model, the explanatory power remains low ($R^2 = 0.097$; Adjusted $R^2 = 0.079$).

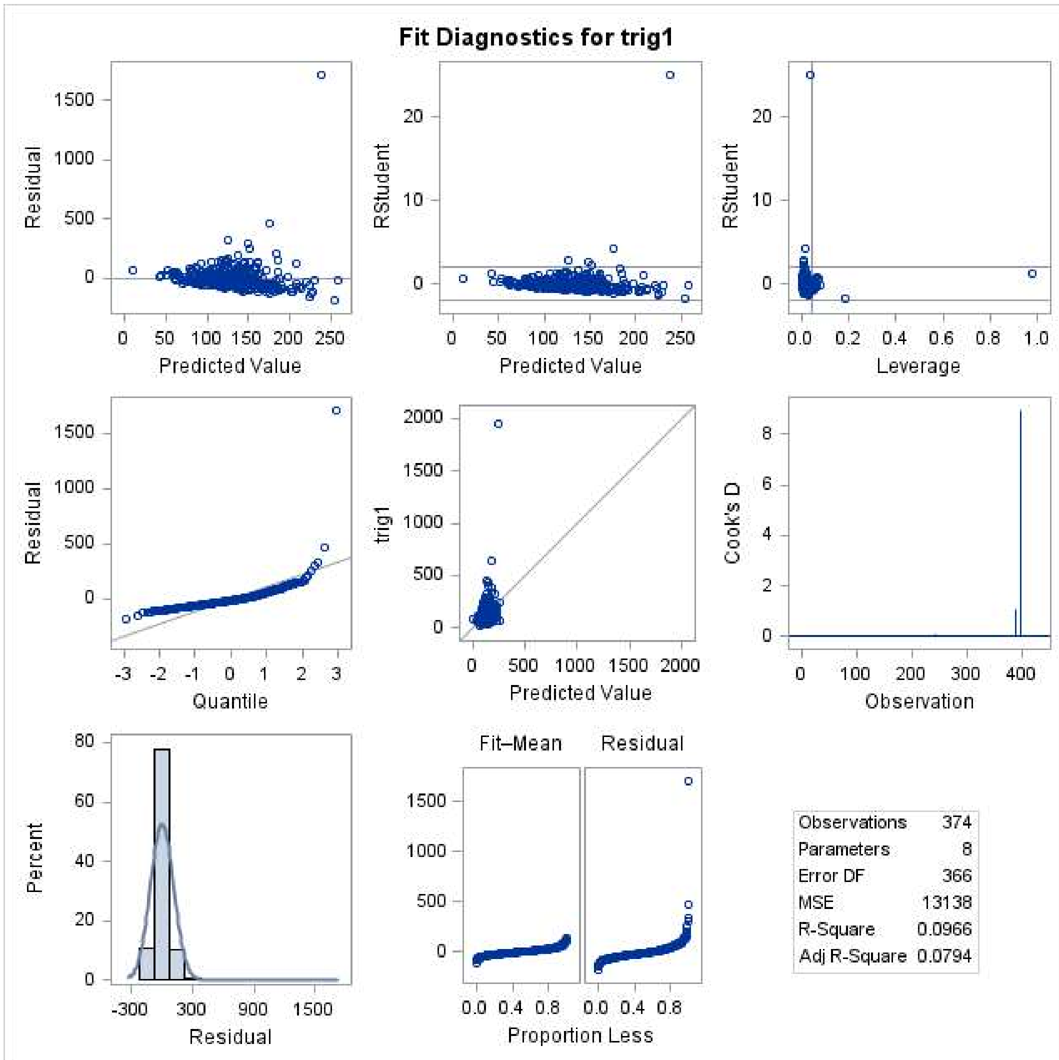

Figure 8 Fit diagnostics for triglycerides

The associations of dietary patterns, as a continuous variable of SAD or MD score, with cardio-metabolic outcomes in both simple and multivariable regression models are shown in Table 3.6. In the unadjusted models, a unit increase in the SAD score was associated with significant increases in total cholesterol (β=4.58, p=0.014), LDL cholesterol (β=3.88, p=0.017), and a non-statistically significant decrease in HDL cholesterol (β=-0.59, p=0.292). There was also a significant association between MD and HDL cholesterol with an increase in HDL for a unit increase in MD (β=1.14, p=0.045). In multivariable models, after adjusting for age, gender, VO2 max, max METS, BMI, and body fat %, SAD was associated with a higher cholesterol levels (β=4.49, p=0.015) and cholesterol ratio (β=0.12, p=0.026), as well as a decrease in HDL cholesterol (β=-0.292, p=0.578), though this was not statistically significant. We also observed an increase in triglycerides (β=5.83, p=0.090), albeit the effect of SAD score on triglycerides was not statistically significant. On the other hand, MD was significantly associated with an increase in HDL cholesterol (β=1.20, p=0.036) in the adjusted analysis and a non-statistically significant decrease in cholesterol ratio (β=-0.05, p=0.358).

Table 3.6 Association of diet patterns with cardiometabolic outcomes.

	Unadjusted models						**Adjusted models***					
Outcome	**Standard American Diet**			**Mediterranean diet**			**Standard American Diet**			**Mediterranean diet**		
	β	**se**	**p**	**β**	**se**	**p**	**β**	**Se**	**p**	**β**	**se**	**p**
BMI	0.23	0.23	0.292	0.15	0.24	0.527	0.02	0.19	0.922	0.30**	0.21	0.15
Body Fat%	0.45	0.33	0.166	-0.22	0.35	0.537	0.26	0.27	0.331	0.02**	0.20	0.94
Cholesterol	4.58	1.86	0.014	0.85	1.92	0.657	4.49	1.84	0.015	1.18	2.02	0.56
HDL cholesterol	-0.59	0.56	0.29	1.14	0.57	0.045	-0.292	0.52	0.578	1.20	0.57	0.04
LDL cholesterol	3.88	1.61	0.017	-0.03	1.66	0.985	3.76	1.63	0.022	-0.31	1.79	0.87
Cholesterol ratio	0.14	0.06	0.033	-0.08	0.07	0.244	0.12	0.05	0.026	-0.05	0.06	0.36
Triglycerides	7.73	3.69	0.037	-0.09	3.79	0.982	5.83	3.43	0.090	1.37	3.75	0.72
Glucose	-0.53	1.00	0.594	-1.05	1.02	0.305	-0.97	0.94	0.506	-0.01	1.03	0.99

**Adjusted for gender, max METS, VO2 max, age, BMI, and body fat %. **Adjusted for gender, max METS, VO2 max, age.*

Table 3.7 examines the effects of dietary adjustments and adherence levels (Low, Medium, High) in the Standard American Diet (SAD) and the Mediterranean Diet (MD) on various health metrics. Data is presented in terms of regression coefficients (β), standard errors (se), and p-values. These are shown for crude values, adjusted models, and models further adjusted for diet patterns, capturing how dietary adherence impacts health outcomes.

For total cholesterol, crude values in SAD show a β of 4.40 (p = 0.344) for High vs. Low adherence, and this changes to 4.78 (p = 0.328) after adjustment. MD shows minimal change, with β = 3.32 (p = 0.488) for High vs. Low after adjustment. Triglycerides in SAD display significant increases, with a crude coefficient of 38.41 (p < 0.0001) for High vs. Low, dropping to -33.49 (p = 0.028) after diet adjustment, indicating that dietary patterns strongly influence triglyceride levels. Given this reversal, we see that the initially observed increase in triglycerides is likely confounded by dietary habits, and once adjusted, the association suggests an inverse relationship independent of diet.

HDL cholesterol decreases significantly in SAD, with crude values showing β = -4.22 (p = 0.002) for High vs. Low; this is weakened but remains significant with β = -2.88 (p = 0.037) after adjustment. MD demonstrates no significant relation with HDL, with adjusted β = 1.24 (p = 0.360) for High vs. Low. For BMI, SAD shows a significant crude increase of β = 1.88 (p = 0.0006) for High vs. Low, which flips to a significant decrease after diet adjustment, with β = -2.05 (p = 0.0004). Body fat percentage follows a similar trend, with SAD showing crude β = 1.73 (p = 0.028), switching to β = -2.22 (p = 0.010) after adjustment. These findings suggest that the observed adverse effects of SAD on HDL cholesterol, BMI, and body fat percentage are at least partially driven by dietary factors, as evidenced by the reversal of associations after adjustment.

Similarly, there are notable increases in glucose between SAD tertiles, with a crude β = 4.62 (p = 0.065) for Medium vs. Low adherence, which becomes β = 5.58 (p = 0.027) after adjustment. MD shows minimal changes, with β = 1.21 (p = 0.628) after adjustment. Finally, cholesterol ratio in SAD shows a significant crude increase of β = 0.42 (p = 0.007) for High vs. Low adherence, becoming moderate with β = 0.32 (p = 0.054) after adjustment, and reversing to a significant decrease of β = -0.56 (p = 0.0009) after diet pattern adjustment.

We also examined potential interactions between dietary adherence and key covariates such as age, sex, and baseline health metrics. None of these interactions were statistically significant, indicating that the reported associations are consistent across subgroups.

Table 3.7 Association of dietary patterns in tertiles with cardiometabolic outcomes

		Standard American Diet				Mediterranean Diet			
		High vs. Low		Medium vs. Low		High vs. Low		Medium vs. Low	
		β (se)	p	β (se)	p	β (se)	p	β (se)	p
Total Cholesterol	**Crude**	4.40 (4.64)	0.344	6.43 (4.68)	0.170	1.85 (4.64)	0.690	-2.07 (4.69)	0.659
	Adjusted	4.78 (4.88)	0.328	9.46 (4.81)	0.050	3.32 (4.78)	0.488	-0.19 (4.80)	0.969
	Adjusted for Diet Pattern	-4.07(5.00)	0.416	2.43(4.80)	0.612	-0.27(4.61)	0.953	-1.40(4.62)	0.762
Triglycerides	**Crude**	38,41 (9.01)	<0.0001	13.86 (9.07)	0.128	4.30 (9.19)	0.640	-5.24 (9.27)	0.571
	Adjusted	14.60 (14.94)	0.3292	1.82 (14.73)	0.902	-5.57 (14.55)	0.703	-18.95 (14.61)	0.195
	Adjusted for Diet Pattern	-33.49(15.20)	0.028	-31.13(14.61)	0.034	10.89 (14.16)	0.442	-8.88(14.17)	0.531
HDL cholesterol	**Crude**	-4.22 (1.37)	0.002	-2.67(1.38)	0.053	1.36 (1.38)	0.324	0.57(1.39)	0.684
	Adjusted	-2.88 (1.38)	0.037	2.40 (1.36)	0.078	1.24 (1.35)	0.360	0.01 (1.36)	0.992
	Adjusted for Diet Pattern	5.91(1.45)	<0.0001	3.07(1.40)	0.028	-1.67(1.38)	0.225	-0.84(1.38)	0.541
LDL cholesterol	**Crude**	3.12 (4.05)	0.442	7.86(4.06)	0.053	0.49 (4.06)	0.904	-0.82 (4.87)	0.840
	Adjusted	3.60 (4.39)	0.413	10.82 (4.32)	0.013	3.18 (4.32)	0.463	3.46 (4.33)	0.424
	Adjusted for Diet Pattern	-3.40(4.51)	0.451	5.96(4.34)	0.171	-1.62(4.18)	0.700	1.18(4.19)	0.779
Cholesterol ratio	**Crude**	0.42 (0.16)	0.007	0.29 (0.16)	0.067	-0.11 (0.16)	0.480	-0.14 (0.16)	0.377
	Adjusted	0.32 (0.16)	0.054	0.34 (0.16)	0.037	-0.10 (0.16)	0.530	-0.02 (0.161)	0.882
	Adjusted for Diet Pattern	-0.56(0.17)	0.0009	-0.25(0.16)	0.118	0.20(0.16)	0.207	0.08(0.16)	0.604
Glucose	**Crude**	1.95 (2.48)	0.432	4.62 (2.50)	0.065	-0.56 (2.48)	0.821	-3.01 (2.50)	0.229
	Adjusted	1.69 (2.55)	0.508	5.58 (2.52)	0.027	1.21 (2.50)	0.628	-2.54 (2.51)	0.312
	Adjusted for Diet Pattern	-3.06(2.64)	0.247	1.44(2.54)	0.569	0.41(2.46)	0.870	-2.53(2.46)	0.306
BMI at baseline	**Crude**	1.88 (0.55)	0.0006	0.59 (0.55)	0.297	0.40 (0.55)	0.468	0.20 (0.55)	0.720

	Adjusted for Diet Pattern	-2.05(0.58)	0.0004	-1.39(0.558)	0.013	-0.37(0.55)	0.500	-0.23(0.55)	0.678
Body fat%	**Crude**	1.73 (0.81)	0.028	0.65 (0.81)	0.425	-0.38 (0.81)	0.641	0.19 (0.82)	0.817
	Adjusted for Diet Pattern	-2.22(0.86)	0.010	-1.40(0.83)	0.091	0.50(0.81)	0.537	0.78(0.81)	0.333

3.4 Discussion

The dietary habits of first responders, particularly firefighters, play a crucial role in their overall health and performance. Our study identified two predominant dietary patterns among Indianapolis firefighters: the Standard American Diet (SAD) and the Mediterranean Diet (MD). These findings align with existing literature that explores dietary behaviors among first responders and their associations with health outcomes[124]. Several studies of focus groups found that firefighters have an unhealthy diet when eating at the firehouse, with large portions of food, unhealthy comfort foods, and second servings, whereas at the comfort of their home, they follow a healthier diet[128].

Moreover, several studies have previously argued that the majority of firefighters do not follow any specific dietary plan, although they may have their own routine in place in terms of eating habits. In our population, both dietary patterns share common food items, mainly fruits and vegetables. However, the MD is richer in vegetables, such as spinach, pepper, peas, and dairy, whereas the SAD is richer in meat and processed foods, such as beef, hamburger, bacon, sausage, etc. Sharing common food items and mainly fruit and vegetables could be attributed to the fact that people nowadays tend to eat a variety of different foods. Therefore, there is no surprise that people who consume a more Western diet tend to also eat fruits and vegetables as reflected in the dietary pattern. Our analysis shows that the Mediterranean diet was associated with higher HDL cholesterol levels. These results are in agreement with those of other studies, suggesting that the Mediterranean pattern, which is characterized by high consumption of vegetables, is a “healthy” diet and can help lower cardiovascular risk[129].

In general, the adherence to the MD improves lipid profiles, including increases in HDL and stabilization of triglycerides[130,131]. A study by Richard et al. found that the MD improved endothelial function and reduced blood pressure, further reinforcing its cardiovascular benefits[114,115132]. Furthermore, greater consumption of fruits and vegetables, which is another element of the Mediterranean Diet, is linked with higher fiber, folate, and potassium intakes. Dietary fiber may play a protective role against non-communicable diseases and even though the mechanism for this is not fully understood, higher intakes of fruits and vegetables are strongly associated with lower CVD development[17,133].

In contrast, the Standard American Diet was characterized by high consumption of red meat and sugary foods[134]. Meat and meat products are common constituents of the standard American diet; in accordance with the US Department of Agriculture (USDA), consumers ate on average 100.8 kg of red meat and poultry in 2018[135]. Meta-analysis studies showed that the greater consumption of processed meat is associated with a 42% higher risk of developing coronary heart disease and 19% higher risk of developing type II diabetes. In our study, the Standard American diet was associated with an increase in LDL cholesterol and total cholesterol levels[136,137]. These results support the fact that high saturated fat diets are associated with worse cardiometabolic outcomes.

4 The Dietary Inflammatory Index and cardiometabolic parameters in US firefighters

4.1 Introduction

Cardiovascular diseases (CVD) account for more than 30% of global deaths, with more than 18 million people dying from CVD-related conditions[138]. Several studies have identified inflammation as the main underlying cause of CVD[139,140]. A poor diet, which includes large quantities of calorically dense foods, rich in simple carbohydrates and fat, is known to be pro-inflammatory[141,142]. The chronic inflammation caused by such a diet provides a substrate for mechanisms that operate systemically or locally through tissue-simmering inflammation to increase the risk of CVD[143,144]. By contrast, a nutrient-dense diet abundant in fruits, vegetables, and fish exhibits anti-inflammatory properties that can improve immune response, thereby offering protection against a range of chronic non-communicable diseases, including diabetes, cancer, and CVD[145,146], as well as infectious diseases, such as COVID-19[147,148].

The Dietary Inflammatory Index (DII®) was developed to quantify the potential effect of diet in connection to putative inflammation-related health parameters[149]. The DII quantifies the impact of diet on an individual's level of inflammatory potential, based on 45 food parameters. The DII was developed and validated by researchers at the University of South Carolina and has been used extensively in different populations and across a wide variety of health conditions[150,151]. The Energy-adjusted Dietary Inflammatory Index (E-DII™) was developed to account for the influence of total energy consumption on inflammation[151]. Both the DII and E-DII are based on the careful reviews and scoring of 1943 peer-reviewed articles[152]. A pro-inflammatory diet, indicated by a high DII score, typically contains high concentrations of saturated fats and refined carbohydrates, and low concentrations of polyunsaturated fatty acids (PUFAs) and flavonoids. A low DII score results from consuming less energy-dense foods and from eating more fruits and vegetables.

Evidence has shown that the DII can capture the inflammatory potential from diet and, therefore, represents an important innovation in addressing the association between dietary inflammation and health parameters[153,154]. Over 50 studies have validated the use of the DII or E-DII as a measure of inflammation linking it to markers such as CRP, IL-6, and TNF-α- R2[155–159]. Additionally, over 1,000 studies demonstrated an increased risk of chronic disease, including CVD and metabolic syndrome, in people with higher DII scores[160–163]. For example, the DII score was used in a large case-control study in Italy, where researchers examined the association between DII scores and breast cancer risk. The study involved over 3,000 women and found that those with higher DII scores had a 75% higher risk of developing breast cancer compared to those with more anti-inflammatory diets[164]. This study was crucial in highlighting that diet-related inflammation could play a direct role in cancer development.

Similarly, in the Australian Longitudinal Study on Women's Health, a study of over 6,000 women, it was reported that higher DII scores were linked with an increased risk of developing depressive symptoms over time[165]. This suggests that the DII is not only relevant to physical health but also to mental health, likely due to the relationship between inflammation and neuro-inflammation, which is implicated in depression.

Another notable example of the importance of DII is the National Health and Nutrition Examination Survey (NHANES) data analysis from the United States. Researchers found that higher DII scores were associated with increased mortality from all causes, particularly cardiovascular mortality, further emphasizing the predictive value of DII for long-term health outcomes[166]. The DII has also been explored in relation to the metabolic syndrome and type 2 diabetes. A study conducted in Iran among 3,800 adults reported that higher DII scores were significantly associated with greater odds of metabolic syndrome and insulin resistance[167]. The inflammation-modulating role of diet could be a key pathway linking poor dietary patterns to these disorders.

Among firefighters, the most frequent cause of on-duty death is sudden cardiac death (SCD), due to underlying CVD and/or cardiomegaly[168], with almost half of all on-duty fatalities attributed to CVD[60,112] and caused by SCD, strokes, aneurysms, and other CVD-related conditions. Firefighters have very demanding jobs, yet their eating habits are often similar to those of the general U.S population, and many of the meals at the fire station include processed foods and sugar-sweetened beverages[115,169,170].

There have not been many studies looking at the association of DII and cardiovascular risk parameters among firefighters. A study conducted by Vatandoost et al., among firefighters of the Tehran region in Iran, suggested that HDL and hs-CRP levels are high among firefighters with high DII scores. However, there were no significant differences in the mean levels of HDL cholesterol and CRP in the observed population, after adjusting for other relevant confounders[171].

Considering the importance of firefighters being in good physical condition, and the demanding nature of their work, it is important to investigate the association between diet-associated inflammation and CVD risk indices in this group of individuals. The aim of this study was to identify the association between DII/E-DII scores and cardiometabolic parameters among US firefighters. This would give us a better understanding of the dietary habits of firefighters and provide a connection of the energy adjusted DII (E-DII) scores (derived from the dietary habits of this population) with CVD by allowing us to evaluate whether those with higher E-DII levels have an elevated risk for CVD, compared to those with lower E-DII scores.

4.2 Methods

4.2.1 Dietary Assessment and Diet Inflammatory Index

A validated food frequency questionnaire was administered at the commencement of the study to establish baseline dietary habits among participants[120]. The questionnaire collected information on food consumption (as an average consumption over the period of the previous year) of 131 different items and participants were questioned about their frequency of consuming specific foods over the past year. Food items included fruit, vegetables, meat, cereal, sweets, baked goods etc. For each food item, a standard portion size and nine response options ranging from "never or less than once per month" to "6 or more times per day" were provided (see Appendix 1). Nutrient and energy intake was determined by multiplying the reported food consumption with its respective nutrient and energy content using data from the US Department of Agriculture database, supplemented with information from manufacturers.

The inflammatory potential of individuals' diets was assessed using the Dietary Inflammatory Index (DII) and the Energy-adjusted DII (E-DII). These indices measure the inflammatory impact of diets on a scale ranging from highly anti-inflammatory (low scores) to highly pro-inflammatory (high scores). The DII was developed through a comprehensive process, detailed elsewhere[165], involving a thorough literature review that identified 45 food parameters, such as macronutrients, vitamins, minerals, flavonoids, and whole food items, like garlic and others, linked to six inflammatory biomarkers (interleukins (IL)-1b, -4, -6, -10, tumor-necrosis factor-alpha (TNFa), and C-reactive protein (CRP)). In the majority of studies not all 45 parameters are provided but rather a reduced number is available, and, hence, the calculation of DII is adjusted accordingly - in our study, from the information collected in the FFQ, 29 food parameters were available for further use.

To calculate the DII scores, the self-reported values were converted into z-scores using a global comparative database from 11 countries, by subtracting from the individual's self-reported value the mean of the global database and then dividing by the standard deviation. Z-scores were then transformed into proportions (ranging from 0 to 1) and centered at zero by doubling each and subtracting 1. The sum of these scores provided the overall DII score. The Energy-adjusted DII scores which were calculated per 1000 kcal consumption using a density approach, followed a similar procedure but utilized an energy-adjusted global comparison database. Both DII and E-DII scores can range from approximately -9 to +8, indicating a spectrum from minimally pro-inflammatory to maximally pro-inflammatory, respectively. The scoring methodology and scaling are consistent between DII and E-DII, ensuring compatibility across different studies.

For this study, all available food parameters from the FFQ (29 out of the possible 45) were used to calculate an individual's overall DII score. For the E-DII, energy was in the denominator, so, 28 parameters were used for the computation. The food parameters used included: alcohol, caffeine, zinc, fiber, omega-3, Isoflavones, selenium, flavonols, vitamin B12, carbohydrate, anthocyanidins, iron, omega-6, protein, selenium, flavonones, vitamin B6, cholesterol, magnesium, riboflavin, thiamin, beta carotene, vitamin D, fat, niacin, flavones, SFA, vitamin C, and energy.

4.2.2 Anthropometric parameters

Data on physical activity was collected during the participants' assessments from the fire department medical examinations at Public Safety Medical (PSM) clinics, which is led by an IFD-contracted physician. The examination included the collection of occupational, smoking, and medical history; a physical examination, including body mass index (BMI= weight (kg)/height $(m)^2$) and body fat measurements (using bioelectrical impedance); routine laboratory tests; resting electrocardiograms; and maximal treadmill exercise testing.

4.2.3 Risk Parameters

During the baseline visit, participants underwent blood pressure and anthropometric assessments. Resting blood pressure was measured while seated, and height, weight, and BMI were also recorded. Body fat percentage was estimated using a Bioelectrical Impedance Analyzer (BIA). Additional biochemical indices were evaluated during medical exams, with measurements taken closest to the study consent date and within a 12-month period. After an overnight fast, 15 mL of blood was collected in EDTA tubes, with plasma frozen at -80°C. Blood lipid profiles were analyzed using automated high-throughput enzymatic methods, with a coefficient of variation of ≤3% for cholesterol and ≤5% for triglycerides, using the ARCHITECT c System from Abbott Laboratories Statistical Analysis.

4.2.4 Statistical Analysis

Characteristics measured on a continuous scale and having a normal distribution are presented as mean ± standard deviation (SD), whereas categorical variables are reported as frequency (percentage). Normality of continuous variables was assessed visually using histograms and box plots, and, when appropriate, with the Shapiro-Wilk test. After evaluating the model's Goodness of Fit using the Hosmer-Lemeshow test, it was decided that the E-DII performed better than the DII and it was thereafter used in the analysis.

Variables of interest are shown overall and stratified by levels of E-DII score (low vs. high, with the cut-off point being the median=-0.09); the two groups are compared using the t-test and the chi-square test of independence, for quantitative and qualitative characteristics, respectively. Linear regression models were fit to assess the effect of E-DII score on cardiometabolic risk, after adjusting for age, gender, BMI, body fat percent, max metabolic equivalents (METS), and oxygen consumption (VO_2). The resulting beta coefficients are presented, together with the corresponding 95% confidence intervals and p-values. As a sensitivity analysis, E-DII scores were used in the models as continuous variables as well as in a binary form (low vs. high).

All the statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). The alpha level of significance was set at 0.05 and all the tests performed were two-sided.

4.3 Results

There were 426 participants with available data for whom the average E-DII was calculated. The average E-DII was 0.03 ± 1.8. Table 4.1 presents the baseline characteristics of the participants categorized into low (below the median, n=213) and high (above the median, n=213) E-DII (Dietary Inflammatory Index) score groups, with p-values indicating statistical difference between the two groups.

Males comprised 94% of the sample, with 90.6% in the low and 94.4% in the high E-DII group, while females made up 6% (p=0.055). The overall mean age was 48.4 ± 8.2 years, with no significant difference between groups (p=0.216). Height was similar across groups (p=0.102), but weight was significantly higher in the high E-DII group (97.0 ± 18.6 kg) compared to the low group (92.6 ± 17.5 kg) (p=0.014). Similarly, BMI (30.6 ± 4.7 kg/m^2 vs. 29.3 ± 4.1 kg/m^2, p=0.002) and body fat percentage (28.8 ± 0.4 vs. 27.3 ± 0.5, p=0.03) were also higher in the high E-DII group. No significant differences were observed in diastolic (p=0.134) or systolic blood pressure (p=0.356). Cardiovascular fitness measures, including max METS (overall, 11.5 ± 5.4) and VO2 max (overall, 42.1 ± 4.9 mL/(kg·min)), showed no significant differences (p=0.78 and p=0.22, respectively).

Blood lipid profiles indicated that total cholesterol (200.9 ± 38.5 mg/dl vs. 192.8 ± 37.8 mg/dL, p=0.03), cholesterol ratio (4.41 ± 0.10 vs. 3.98 ± 0.07, p=0.001), and triglycerides (145.8 ± 156.3 mg/dl vs. 113.3 ± 60.7 mg/dL, p=0.005) were significantly higher in the high E-DII group, while HDL cholesterol was lower (47.9 ± 11.1 mg/dl vs. 50.4 ± 11.6 mg/dL, p=0.02). LDL cholesterol (p=0.33) and glucose levels (p=0.50) showed no significant differences. These findings suggest that higher E-DII scores are associated with greater weight, BMI, body fat, total cholesterol, triglycerides, and a higher cholesterol ratio, indicating poorer metabolic health, while no significant differences were observed in blood pressure, cardiovascular fitness, LDL cholesterol, or glucose levels.

Table 4.1 Baseline characteristics – Overall and by E-DII Score group

Characteristic		Overall (n=413)	E- DII Score		
			Low (n=213)	High (n=213)	p
Sex	Male	390 (94%)	90.6%	94.4%	
	Female	23 (6%)	9.4%	5.6%	0.055
Age (years)		48.4 ± 8.2	45.6 ± 8.7	44.6 ± 7.8	0.216
Height (m)		1.77 ± 0.07	1.78 ± 0.07	1.79 ± 0.06	0.102
Weight (kg)		96.8 ± 17.3	92.6 ± 17.5	97.0 ± 18.6	0.014
Diastolic BP (mmHg)		78.4 ± 6.1	78.3 ± 6.0	81.03 ± 28.4	0.134
Systolic BP (mmHg)		181.0 ± 17.9	179.7 ± 19.4	182.3 ± 16.2	0.356
BMI (kg/m^2)		30.0 ± 4.5	29.3 ± 4.1	30.6 ± 4.7	0.002
% body fat		28.1 ± 6.1	27.3 ± 0.5	28.8 ± 0.4	0.03
Max METS*		11.5 ± 5.4	11.4 ± 2.2	11.6 ± 7.3	0.78
VO_2 max (mL/(kg·min))		42.1 ± 4.9	42.3 ± 5.3	41.7 ± 4.6	0.22
Total Cholesterol (mg/dl)		196.9 ± 38.3	192.8 ± 37.8	200.9 ± 38.5	0.03
HDL cholesterol (mg/dl)		49.1 ± 11.4	50.4 ± 11.6	47.9 ± 11.1	0.02
LDL cholesterol (mg/dl)		121.9 ± 34.6	120.2 ± 33.2	123.6 ± 35.9	0.33
Cholesterol Ratio		4.20 ± 1.30	3.98 ± 0.07	4.41 ± 0.10	0.001
Triglycerides (mg/dl)		129.3 ± 117.1	113.3 ± 60.7	145.8 ± 156.3	0.005
Glucose (mg/dl)		100.0 ± 20.3	99.3 ± 20.9	100.6 ± 19.8	0.50

**metabolic equivalents- one MET is defined as 3.5 mL O2 uptake/kg per min, which is the resting oxygen uptake in a sitting position*

The association among tertiles of E-DII scores and different cardio-metabolic parameters is shown in Table 4.2. Several outcomes, including BMI, body fat percentage, HDL cholesterol, triglycerides, and glucose, showed no statistically significant differences between Medium vs. Low and High vs. Low E-DII levels. However, total cholesterol was significantly higher in the High vs. Low E-DII comparison (β = 10.37, p = 0.04), indicating that higher E-DII may be linked to increased cholesterol levels. Additionally, the cholesterol ratio showed a borderline significant difference (β = 0.32, p = 0.05), suggesting a potential relationship between higher E-DII and cholesterol imbalance. LDL cholesterol tended toward significance in the Low vs. Median comparison (p = 0.08), indicating a possible association. While other markers did not reach statistical significance, the trends suggest that E-DII may influence cholesterol-related outcomes more than other metabolic measures, potentially increasing cardiovascular risk.

Table 4.2 Association of tertiles of E-DII scores with cardiometabolic parameters

Outcome	Median Vs Low E-DII			High Vs Low E-DII		
	β	95% CI	p	β	95% CI	p
BMI	-0.13	-1.14, 0.89	0.81	0.49	-0.54,1.49	0.36
Body Fat %	-0,40	-1.81, 1.02	0.58	1.13	-0.29, 2.54	0.12
Total Cholesterol	5.51	-4.02, 15.04	0.26	10.37	0.74, 21.01	0.04
HDL cholesterol	-1.38	-4.09, 1.32	0.32	-1.02	-3.75, 1.71	0.46
LDL cholesterol	7.85	-0.80, 16.49	0.08	6.51	-2.21, 15.22	0.14
Cholesterol ratio	0.20	-0.12, 0.52	0.22	0.32	-0.00, 0.65	0.05
Triglycerides	-3.96	-33.0, 25.1	0.79	23.9	-5.48, 53.30	0.11
Glucose	0.91	-4.11, 5.93	0.72	0.15	-4.93, 5.23	0.95

**Model adjusted for age, gender, VO2 max, max METS; model additionally adjusted for BMI for all cardiometabolic parameters except for BMI and body fat (%)*

A detailed assessment of the effect of a unit increase in the E-DII score as a continuous measure with a number of metabolic health outcomes using unadjusted and multivariable models is presented in Table 4.3, with regression coefficients (β), 95%

confidence intervals (CI), and p-values (p) shown for each outcome. In both crude and adjusted models, E-DII showed a significant positive association with BMI, with β = 1.38 (95% CI: 0.52, 2.24, p = 0.002) in the unadjusted model and β = 0.98 (95% CI: 0.16, 1.80, p = 0.02) in the adjusted model, suggesting that higher E-DII is associated with an increase in BMI. A unit increase in E-DII was significantly associated with higher BMI in both models, with β = 0.29 (95% CI: 0.03, 0.55, p = 0.03) in the unadjusted model and β = 0.32 (95% CI: 0.07, 0.58, p = 0.01) in the adjusted model. Similarly, body fat percentage increases per unit increase in E-DII, with β = 1.44 (95% CI: 0.16, 2.72, p = 0.03) unadjusted and β = 1.50 (95% CI: 0.36, 2.65, p = 0.01) adjusted, indicating a consistent positive association.

Total cholesterol also rises significantly with each unit increase in E-DII (unadjusted: β = 8.07, 95% CI: 0.71, 15.44, p = 0.03; adjusted: β = 8.11, 95% CI: 0.27, 15.95, p = 0.04). HDL cholesterol shows a significant inverse association in the unadjusted model (β = -2.51, 95% CI: -4.70, -0.32, p = 0.03), but this association is attenuated and no longer significant after adjustment (β = -0.78, 95% CI: -3.00, 1.45, p = 0.49). LDL cholesterol does not show a statistically significant relationship with E-DII in either model (unadjusted: β = 3.35, p = 0.33; adjusted: β = 5.29, p = 0.14).

The cholesterol ratio increases significantly with a unit increase in E-DII in the unadjusted model (β = 0.43, 95% CI: 0.19, 0.68, p = 0.001), while the adjusted model shows a borderline significant association (β = 0.25, 95% CI: -0.01, 0.52, p = 0.06). Triglycerides are significantly elevated in the unadjusted model (β = 31.87, 95% CI: 9.44, 54.31, p = 0.006), though this association is not maintained after adjustment (β = 14.84, 95% CI: -9.15, 38.82, p = 0.23). Finally, glucose levels show no significant change per unit increase in E-DII in either model (unadjusted: β = 1.35, p = 0.50; adjusted: β = -1.25, p = 0.55).

These findings suggest that a higher E-DII score (reflecting a more pro-inflammatory diet) is associated with increases in BMI, body fat percentage, total cholesterol, and cholesterol ratio, though some associations are attenuated after adjusting for potential confounders.

Table 4.3 Association of E-DII scores with cardiometabolic parameters (continuous data)

Outcome	Unadjusted models			Adjusted models*		
	β	95% CI	p	β	95% CI	p
BMI	1.38	0.52, 2.24	0.002	0.98	0.16, 1.80	0.02
Body Fat%	1.44	0.16, 2.72	0.03	1.50	0.36, 2.65	0.01
Total Cholesterol	8.07	0.71, 15.44	0.03	8.11	0.27, 15.95	0.04
HDL cholesterol	-2.51	-4.70, -0.32	0.03	-0.78	-3.00, 1.45	0.49
LDL cholesterol	3.35	-3.36, 10.05	0.33	5.29	-1.82, 12.41	0.14
Cholesterol ratio	0.43	0.19, 0.68	0.001	0.25	-0.01, 0.52	0.06
Triglycerides	31.87	9.44, 54.31	0.006	14.84	-9.15, 38.82	0.23
Glucose	1.35	-2.58, 5.28	0.50	-1.25	-5.37, 2.88	0.55

**Model adjusted for age, gender, VO2 max, max METS; model additionally adjusted for BMI for all cardiometabolic parameters except for BMI and body fat (%)*

4.4 Discussion

The present study indicated that a large proportion of firefighters had high inflammatory dietary patterns. This finding aligns with other analysis of our cohort, which indicated that many participants adhered to a Standard American Diet (SAD); a dietary pattern identified by high intake of red and processed meats, refined carbohydrates, added sugars, and saturated fats[172]. Such diets are well-documented in the literature to promote systemic low-grade inflammation, and our findings corroborate this epidemiological trend. This observation is also consistent with other research investigating the dietary habits of firefighters, which reported similar tendencies toward energy-dense, nutrient-poor dietary intake[59,98,173–175].

A significant association was found between energy-adjusted Dietary Inflammatory Index (E-DII) scores and adverse cardiometabolic outcomes. More specifically, higher

E-DII scores were linked to increased body mass index (BMI), unfavorable cholesterol ratios, and elevated total cholesterol levels. These results are in agreement with those of Ruiz-Canela et al. (2015), who demonstrated that higher DII values were positively associated with general and central adiposity, even when controlling for adherence to a Mediterranean dietary pattern[163]. Our study showed that E-DII scores were associated with BMI ($\beta = 0.49$, $p = 0.36$), cholesterol ratio ($\beta = 0.32$, $p = 0.05$), and total cholesterol ($\beta = 10.37$, $p = 0.04$) even after adjusting for age, gender, VO2 max, max METS, BMI and % body fat. Although the association with BMI did not reach statistical significance, the direction of the relationship is still noteworthy. These findings are further supported by Sokol et al. (2016), who reported that individuals with higher DII scores were at greater risk for obesity, elevated triglycerides, and increased waist-to-hip ratios[176].

Despite growing evidence supporting the role of Dietary Inflammatory Index in predicting cardiometabolic outcomes, there are still inconsistencies across the studies. The heterogeneity observed across different studies regarding DII and cardiometabolic risk may be attributed to a range of factors. Population-level differences in genetic predispositions, environmental exposures, and socio-cultural dietary practices can result in varying inflammatory responses to similar dietary patterns[177]. Moreover, methodological differences, including how DII scores are computed, the selection of inflammatory biomarkers, and the statistical models employed, may also account for discrepancies in reported associations.

Our findings are in line with a growing body of literature that links pro-inflammatory diets with a heightened risk of cardiometabolic disorders[95,161,176]. High DII scores are indicative of diets that may promote systemic inflammation, a known contributor to the pathogenesis of cardiovascular disease (CVD). Inflammatory processes associated with such dietary patterns have been shown to impair endothelial function, elevate oxidative stress, and accelerate the progression of atherosclerosis[94].

Notably, elevated E-DII scores in our sample were significantly associated with increased BMI and percentage of body fat. These findings are consistent with previous studies indicating that individuals with higher adiposity exhibit greater levels of inflammatory markers and elevated CVD risk. Adipose tissue, particularly visceral fat, functions as an active endocrine organ, releasing cytokines, such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α), which may exacerbate inflammatory responses[178,179]. It is plausible that demographic factors, such as age, sex, and ethnicity, may further modify the relationship between diet and inflammation. For example, some studies report stronger associations between DII scores and cardiovascular risk among predominantly Caucasian populations[180], which may be attributable to gene-diet interactions and varying baseline inflammatory profiles.

Additionally, our study found that higher E-DII scores were significantly associated with elevated cholesterol levels, even after adjusting for gender, BMI, and body fat percentage. This suggests that the pro-inflammatory nature of the diet may independently contribute to dyslipidemia. A study conducted among Indonesian males reported similar findings, wherein increased DII scores corresponded with higher total cholesterol concentrations. Elevated cholesterol is a critical risk factor for atherosclerosis and is often asymptomatic, thereby reinforcing its classification as a "silent killer"[181,182].

In summary, the findings of this study contribute to a robust body of evidence highlighting the role of dietary inflammation in cardiometabolic health. Firefighters may be particularly vulnerable to the consequences of poor dietary habits due to occupational stress, shift work, and limited access to nutritious meals. Interventions aimed at reducing dietary inflammation, such as adherence to anti-inflammatory dietary patterns like the Mediterranean or DASH diets[183], may yield significant benefits in reducing systemic inflammation and improving cardiometabolic profiles in this population.

Future research should investigate whether targeted nutritional interventions that lower E-DII scores can elicit measurable improvements in inflammatory biomarkers and clinical outcomes in firefighter cohorts. Moreover, it would be valuable to explore whether individual-level factors, such as genetic variation or baseline metabolic status, influence the effectiveness of such dietary strategies.

5 Adherence to Mediterranean diet score and its association with health biomarkers

5.1 Introduction

Maintaining a healthy diet is fundamental to the overall well-being of an individual. A well-balanced diet provides essential nutrients, minerals and vitamins to support fundamental physiological functions, improve the immune system and optimize energy levels. Proper nutrition fuels the body and mind, ensuring the optimal performance of daily activities while reducing the risk of a number of health conditions[184]. Longitudinal studies tracking dietary intake through food frequency questionnaires (FFQs) have shown that consistent adherence to healthy dietary patterns, particularly the Mediterranean diet, is associated with sustained improvements in these health outcomes over time[185].

One of the most important benefits of adhering to a healthy diet is the prevention of several chronic diseases. Diets rich in fruit and vegetables, like the Mediterranean diet, help regulate one's metabolism and help maintain a healthy weight, thereby lowering the risk of obesity-related conditions, like type 2 diabetes, hypertension, and heart conditions[186]. Higher adherence scores to the Mediterranean diet, reflecting more frequent consumption of key components, such as fruits, vegetables, whole grains, legumes, and olive oil, are consistently associated with reduced risk of these chronic conditions[187]. Antioxidant-rich foods combat oxidative stress and inflammation, reducing the likelihood of several health conditions, such as cancer and neurodegenerative diseases[188,189].

Heart health is particularly influenced by dietary choices. Diets high in trans fats, saturated fats, and refined sugars contribute to high cholesterol, arterial plaque buildup, and hypertension, increasing the risk of stroke and heart attack[190]. Conversely, consuming nutrient-dense foods, such as those found in the Mediterranean diet, rich in omega-3 fatty acids, fiber, and monounsaturated fats, supports an individual's cardiovascular function by improving lipid profiles, reducing blood pressure, and enhancing arterial health[191,192]. Changes in diet adherence over time, monitored via repeated FFQs or adherence scoring, have shown that improving adherence to the Mediterranean diet leads to measurable reductions in cardiovascular risk markers[193].

A healthy diet also plays a crucial role in cognitive function and mental well-being. Nutrients like omega-3 fatty acids, B vitamins, and antioxidants contribute to improved brain function, memory retention, and a reduced risk of other disorders, such as Alzheimer's disease and dementia. Large studies suggest that a Mediterranean-type diet can reduce the risk of dementia by up to 23%[194,195]. Furthermore, research evidence indicates that dietary patterns influence mood regulation. Diets high in processed foods, refined sugars, and unhealthy fats have been linked to increased rates of depression and anxiety, whereas balanced, nutrient-rich diets support mental health by promoting the production of neurotransmitters, such as serotonin and dopamine[196,197]. Monitoring adherence to the Mediterranean diet over time allows for the evaluation of whether sustained dietary patterns confer greater cognitive and mental health benefits[198].

Additionally, gut health, a crucial component of a person's overall health, is directly influenced by diet. A fiber-rich diet with probiotic and prebiotic foods fosters a balanced gut microbiome, enhancing digestion, immune function, and even mental health through the gut-brain axis. Poor dietary choices, including excessive consumption of processed foods and sugars, can lead to dysbiosis, contributing to gastrointestinal disorders, inflammation, and weakened immunity[199,200]. High Mediterranean diet adherence scores are associated with greater fiber intake and improved microbiome diversity, suggesting a protective role over time[201].

Beyond disease prevention, adhering to a healthy diet fosters a better quality of life. Proper nutrition enhances energy levels, improves sleep patterns, and supports physical endurance and strength. It also contributes to skin health, hormonal balance, and overall vitality[199]. By prioritizing the consumption of whole, unprocessed foods, individuals can achieve sustainable health benefits and prevent the negative consequences associated with poor dietary habits[202]. Tracking diet adherence longitudinally allows researchers to identify patterns of dietary change and their impact on quality-of-life metrics.

Adherence to the Mediterranean diet, as measured by the Mediterranean Diet Adherence Score (MEDAS) and other measures, has been extensively studied for its impact on cardiometabolic health. A systematic review and meta-analysis of observational studies found that individuals with the highest adherence to the Mediterranean diet had a 19% reduced risk of cardiovascular disease (CVD) incidence compared to those with the lowest adherence relative risk (RR: 0.81; 95% CI: 0.74-0.88)[203]. Similarly, another meta-analysis reported a 17% reduction in CVD incidence among those with the highest diet quality, which includes adherence to the Mediterranean diet, compared to those with the lowest diet quality (RR: 0.83; 95% CI: 0.82-0.84)[204]. Furthermore, adherence to the Mediterranean diet has been consistently associated with improvements in various cardiometabolic risk factors. A study from the Multi-Ethnic Study of Atherosclerosis (MESA) examined the relationship between MEDAS and left ventricular (LV) structure and function. Higher MEDAS was associated with lower LV mass and a lower prevalence of LV hypertrophy, suggesting a beneficial effect on cardiac remodeling[205]. Repeated assessments of diet adherence using FFQs over time indicate that maintaining or improving MEDAS scores is associated with progressive improvements in cardiometabolic outcomes[206].

Despite the extensive evidence supporting the benefits of a healthy diet, particularly the Mediterranean diet, much of the research is focused on the broad population. There remains a gap in understanding how adherence to the Mediterranean diet influences cardiometabolic outcomes in specific populations like firefighters. In particular, examining changes in diet adherence over time is important, as longitudinal patterns may reveal how sustained or improved adherence impacts cardiovascular disease risk. Firefighters, who are generally healthy but work in a physically and psychologically demanding occupational setting, represent a unique population in which these associations are understudied.

Furthermore, there are limited studies exploring the association of healthy diet and cardiometabolic outcomes using standardized adherence metrics like the Mediterranean Diet Adherence Score. This chapter aims to address this gap by investigating the relationship between Mediterranean diet adherence as evaluated by the MEDAS score with different cardiometabolic health indicators. By focusing on temporal changes in adherence and their link to CVD-related outcomes, this study provides targeted insights relevant to the occupational health of firefighters.

5.2 Methods

5.2.1 Study participants

The study included 426 active IFD firefighters, who were recruited between November 2016 and April 2018 as part of the FAB study. All individuals provided informed consent, and the study was conducted in full compliance with ethical guidelines. Participants who did not have any baseline data were excluded from the current analysis. The total number of participants in this chapter differs from other chapters due to missing data on Mediterranean diet adherence and other key variables, and sample sizes vary across analyses depending on the availability of complete data for each outcome.

5.2.2 Dietary assessment

To assess the participants' dietary intake, a validated 131-item FFQ was administered, which gathered detailed information on the frequency of consumption of various foods over the previous 12 months. The questionnaire covered a range of foods categories, including dairy products, meats, sweets, fruit and vegetables, offering an in-depth view of typical dietary habits. Data were collected at different time points during the study, allowing for the evaluation of diet changes over time. For the current analysis the information at baseline and at 6 months after recruiting are being used.

5.2.3 Risk parameters

During the initial visit, participants underwent assessments of blood pressure and had anthropometric measurements performed. Resting blood pressure was recorded while participants were seated, and height, weight, and Body Mass Index (BMI) were documented. Body fat percentage was estimated using a Bioelectrical Impedance Analyzer (BIA). Additional biochemical indices were evaluated during medical examinations, with measurements taken closest to the study consent date, within a 12-month period. Following an overnight fast, 15 mL of blood was collected in EDTA tubes, and plasma samples were stored at -80°C. Blood lipid profiles were analysed using automated high-throughput enzymatic methods, with coefficients of variation ≤3% for cholesterol and ≤5% for triglycerides, utilizing the ARCHITECT c System from Abbott Laboratories. The same procedures were followed for collecting measurements at other time points during the study.

5.2.4 Mediterranean Diet Adherence Score

The Mediterranean diet adherence score (MEDAS) is a valuable tool for assessing adherence to the Mediterranean diet, a dietary pattern consistently associated with numerous health benefits[70]. Using the MEDAS provides a standard evidence-based score to evaluate how closely an individual's diet aligns with the core components of the Mediterranean diet, such as high intake of fruit, vegetables, legumes, whole grains, nuts, and olive oil, moderate consumption of fish and wine, and low intake of red meat and processed foods[207].

One major advantage of the MEDAS score is the ability to quantify dietary adherence in a simple, interpreted format. The scoring system is comprised of 14 items, and it was derived from the PREDIMED study[208]. The MEDAS questionnaire includes questions about dietary habits, such as the use of olive oil as the main cooking fat, the amount of olive oil consumed daily, and the number of servings of vegetables and fruits eaten each day. It also evaluates the intake of red meat, butter, margarine, cream, and sugar-sweetened beverages, with lower consumption of these items being favorable. This approach further examines the frequency of wine consumption, aiming for moderate intake, and assesses the weekly consumption of legumes, fish or seafood, nuts, and baked goods, encouraging higher intake of healthy items, and it further favors limited consumption of sweets. Additionally, it assesses whether individuals eat poultry more often than red or processed meats, and how frequently they consume traditional Mediterranean dishes made with tomato, garlic, onion, or leeks sautéed in olive oil. Each item is scored based on specific criteria, and the total score reflects the individual's overall adherence to the Mediterranean dietary pattern, with higher scores indicating greater compliance and potential health benefits (Appendix II). The MEDAS score can range from 0-14. A MEDAS score ≤5 for an individual is considered indicative of weak adherence to the Mediterranean diet, a score 6-9 points indicates that there is fair adherence, whereas a MEDAS over 10 points means that there is good adherence to the Mediterranean diet[209]. This scoring system allows clinicians, public health professionals and researchers to compare adherence levels across populations and track changes over time in a convenient way.

In research settings, MEDAS has been extensively used and linked to a reduced risk of CVD, type 2 diabetes, metabolic syndrome, cancer, as well as all-death mortality[210]. In addition, MEDAS supports personalized dietary assessments and interventions. By identifying specific dietary components that fall below the optimal levels, health professionals can tailor recommendations to help individuals improve their eating habits[210]. Furthermore, the use of MEDAS can strengthen public health initiatives, allowing for monitoring of population-level dietary trends and the evaluation of the effectiveness of nutrition programs aimed at promoting the Mediterranean diet[211].

5.2.5 Statistical analysis

Continuous variables with normal distributions are presented as mean ± standard deviation (SD), while categorical variables are reported as frequency (percentage). Results are presented overall and by adherence level, with low adherence defined as ≤6 and high adherence defined as ≥7 points. The two groups were compared using independent t-tests for continuous variables and chi-square tests for categorical variables.

Regression analysis was used to evaluate the association of cardiometabolic outcomes with PREDIMED scores. The change in adherence was defined as a one-unit increase in the PREDIMED score difference between baseline and 6 months. Regression models were adjusted for age and gender; however, adjustments for VO2 max and maximum METS were not possible due to lack of data. Additionally, fluctuations in the number of participants occurred because of missing values in the dataset. The suitability of the models was assessed using residual analysis to ensure that model assumptions were met.

All statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). The alpha level of significance was set at 0.05, and all tests were two-sided.

5.3 Results

Table 5.1 presents a comparison of various demographic and health characteristics between two groups based on their PREDIMED scores, which assess adherence to the Mediterranean diet: a low-score group (≤6 points, n = 342) and a high-score group (≥7 points, n = 145). In terms of sex distribution, a significantly higher proportion of males were in the low-score group compared to the high-score group. There were no statistically significant differences in age, height, weight, or blood pressure between the groups.

However, the high-score group had a significantly lower body mass index (BMI) than the low-score group (29.4 vs. 30.3, *p* = 0.03). Similarly, total cholesterol levels were lower in the high-score group (190.7 vs. 199.2 mg/dL, *p* = 0.04), as was the cholesterol ratio (3.9 *vs*. 4.3, *p* = 0.01), indicating better lipid profiles. Other parameters, including percent body fat, HDL and LDL cholesterol, triglycerides, glucose, maximal METS, and VO_2 max, showed no statistically significant differences between the groups. Overall, higher adherence to the Mediterranean diet was associated with slightly better cardiovascular and metabolic markers.

Table 5.1 Baseline characteristics overall and by PREDIMED score group

Characteristic		Overall n=482	PREDIMED score		
			Low (≤6 points) (n=342)	High (≥7 points) (n=145)	p
Sex*	Male	390 (94%)	283 (73%)	107 (74%)	<0.001
	Female	32 (6%)	23 (27%)	9 (26%)	0.30
Age (years)		47.5 (7.6)	47.4 (7.7)	47.8 (8.6)	0.85
Height (m)		1.78 (0.08)	1.79 (0.09)	1.77 (0.08)	0.20
Weight (kg)		95.7 (17.7)	96.4 (17.7)	93.9 (17.7)	0.20
Diastolic BP (mmHg)		79.3 (6.5)	79.6 (6.6)	78.7 (6.2)	0.50
Systolic BP (mmHg)		181.0 (19.9)	181.6 (17.8)	179.7 (18.2)	0.34

BMI (kg/m²)	30.0 (4.4)	30.3 (4.4)	29.4 (4.5)	0.03
% body fat	27.1 (6.4)	27.8 (6.5)	25.8 (6.3)	0.29
Max METS*	11.5 (5.4)	11.6 (6.3)	11.3 (1.5)	0.69
VO2 max (mL/(kg.min))	42.0 (5.0)	41.8 (4.7)	42.6 (5.5)	0.17
Total Cholesterol (mg/dl)	196.9 (38.3)	199.2 (39.5)	190.7 (34.1)	0.04
HDL cholesterol (mg/dl)	49.1 (11.4)	48.7 (11.5)	50.2 (11.1)	0.24
LDL cholesterol (mg/dl)	121.9 (34.5)	123.2 (35.8)	118.5 (30.9)	0.22
Cholesterol Ratio	4.2 (1.3)	4.3 (1.4)	3.9 (0.9)	0.01
Triglycerides (mg/dl)	126.6 (72.8)	128.6 (77.3)	121.9 (61.4)	0.56
Glucose (mg/dl)	99.6 (26.3)	101.0 (29.8)	96.1 (6.3)	0.23

**Reduced sample size because of some missing observations*

The different characteristics at 6 months including cardiometabolic outcomes that were available in the two groups based of their PREDIMED score group are shown in Table 5.2. Out of the 336 participants that had available data for this analysis 231 of them belonged to the low adherence group and 105 participants in the high adherence group. In terms of body weight, the low-score group had an average weight of 97.3 ± 16.5 kg while the high-score group averaged 95.2 ±19.1 kg, with no statistically significant difference between the two groups ($p = 0.31$). BMI was slightly lower in the high-score group at 29.6 ±5.1 kg/m² compared to 30.2 ± 4.3 kg/m² in the low-score group ($p = 0.27$). Body fat percentage was similar in the groups (28.1 ± 6.2 % in the low group and 27.7 ± 7.4 % in the high group ($p = 0.53$)). HDL cholesterol was marginally lower in the high-score group at 47.4 ±12.7 mg/dL compared to 48.9 ±12.6 mg/dL in the low group ($p = 0.39$), and LDL cholesterol followed a similar trend, with values of 122.5 ± 30.4 mg/dL and 118.6 ± 33.2 mg/dL, respectively ($p = 0.36$). The cholesterol ratio was identical at 4.3 in both groups, with standard deviations of 2.1 and 1.6, respectively, and showed no difference ($p = 0.95$). Overall, none of the measured variables reached statistical significance, with similar cardiometabolic profiles in individuals with high and low adherence to the Mediterranean diet in this sample at 6 months.

Table 5.2 Participants' characteristics at 6 months

Characteristic	**PREDIMED score**		
	Low (≤6 points) (n=231)	**High (≥7 points) (n=105)**	**p**
Weight (kg)	97.3 (16.5)	95.2 (19.1)	0.31
BMI (kg/m^2)	30.2 (4.3)	29.6 (5.1)	0.27
% body fat	28.1 (6.2)	27.7 (7.4)	0.53
HDL cholesterol (mg/dl)	48.9 (12.6)	47.4 (12.7)	0.39
LDL cholesterol (mg/dl)	122.5 (30.4)	118.6 (33.2)	0.36
Cholesterol Ratio	4.3 (2.1)	4.3 (1.6)	0.95

Before interpreting the regression results, a comprehensive evaluation of the regression assumptions was conducted. Diagnostic plots were generated for each model to assess linearity, normality of residuals, homescedasticity, and the presence of influential observations. Figures 9-14 present the diagnostic panels for the regression models prediction.

Figure 9 displays the diagnostic plots for the regression model with % body fat at 6 months as the dependent variable. The residuals appear to be approximately symmetrically distributed, and some slight deviations from normality are visible, though not concerning, in the Q-Q plot. The residual plot suggests no strong non-linearity or heteroscedasticity. The model explains a modest portion of the variance in % body fat (R^2=0.344; Adjusted R^2=0.281).

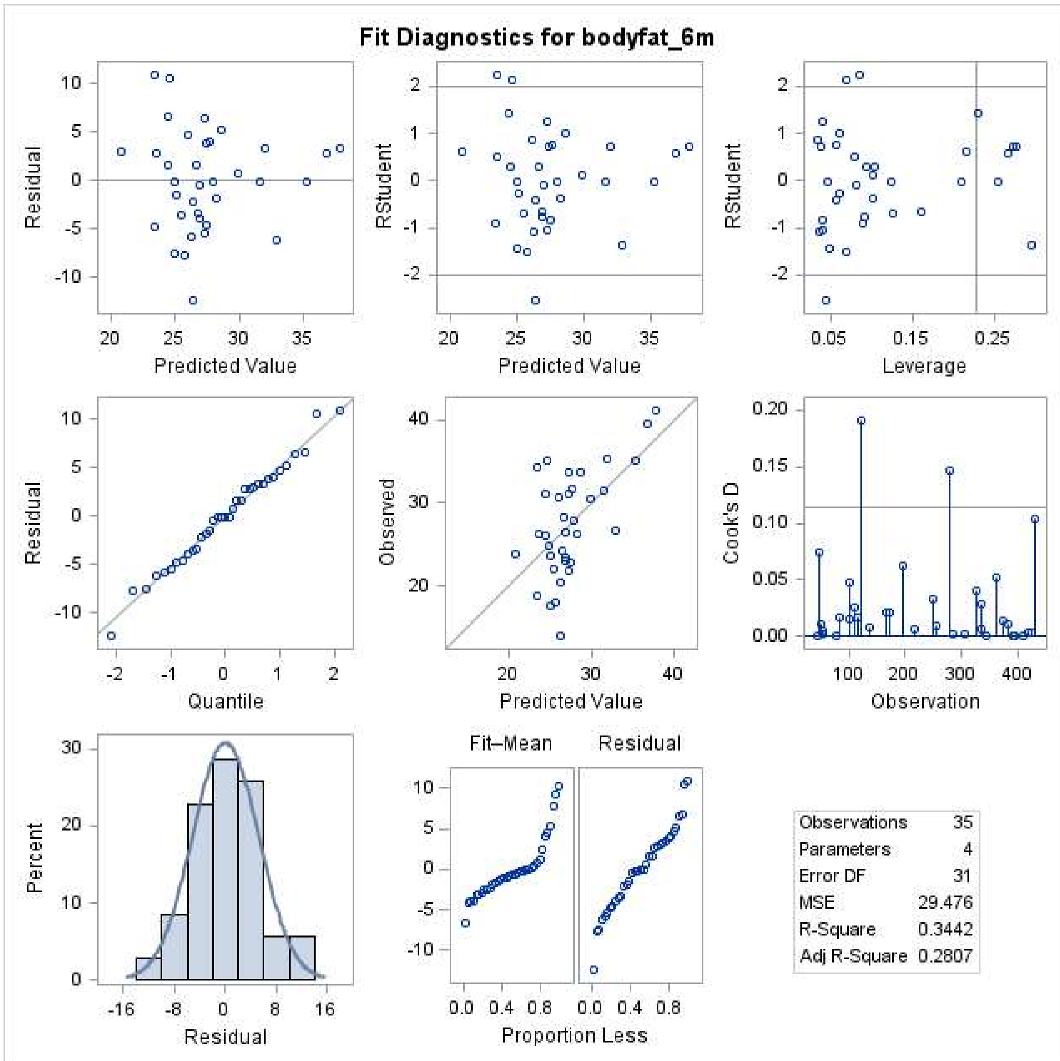

Figure 9 Fit diagnostics for %body fat

Figure 10 shows the diagnostic plots for the regression model for BMI at 6 months. The residual vs. the predicted values plot does not show strong patterns, even though the scatter suggests a potential mild heteroscedasticity. The model explains a low portion of the variability in BMI among participants (R^2=0.117; Adjusted R^2=0.031).

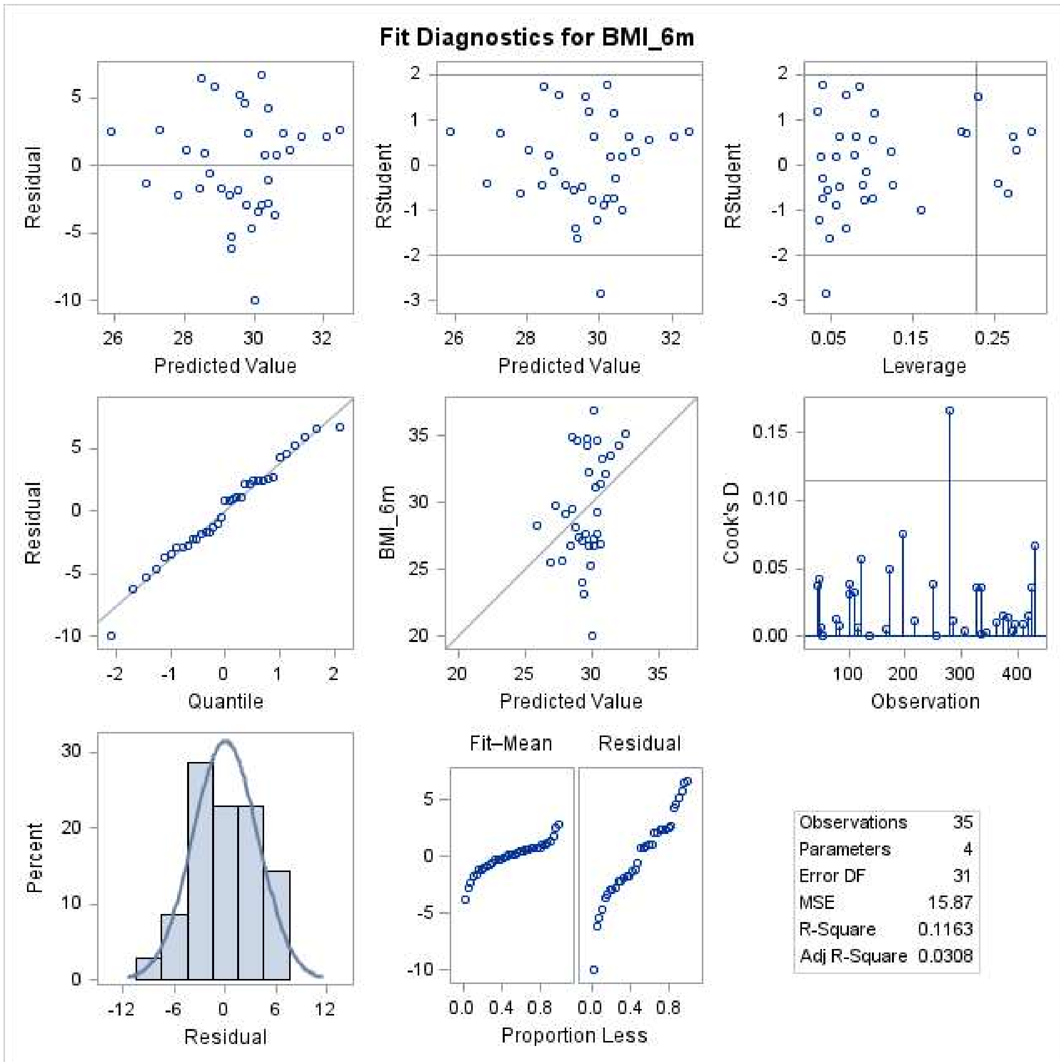

Figure 10 Fit diagnostics for BMI

Figure 11 presents the diagnostics for the regression model predicting cholesterol ratio at 6 months. There are some potential outliers, as evident in the residual and studentized residual plots. The explanatory power remains low ($R^2 = 0.034$; Adjusted $R^2 = -0.159$.

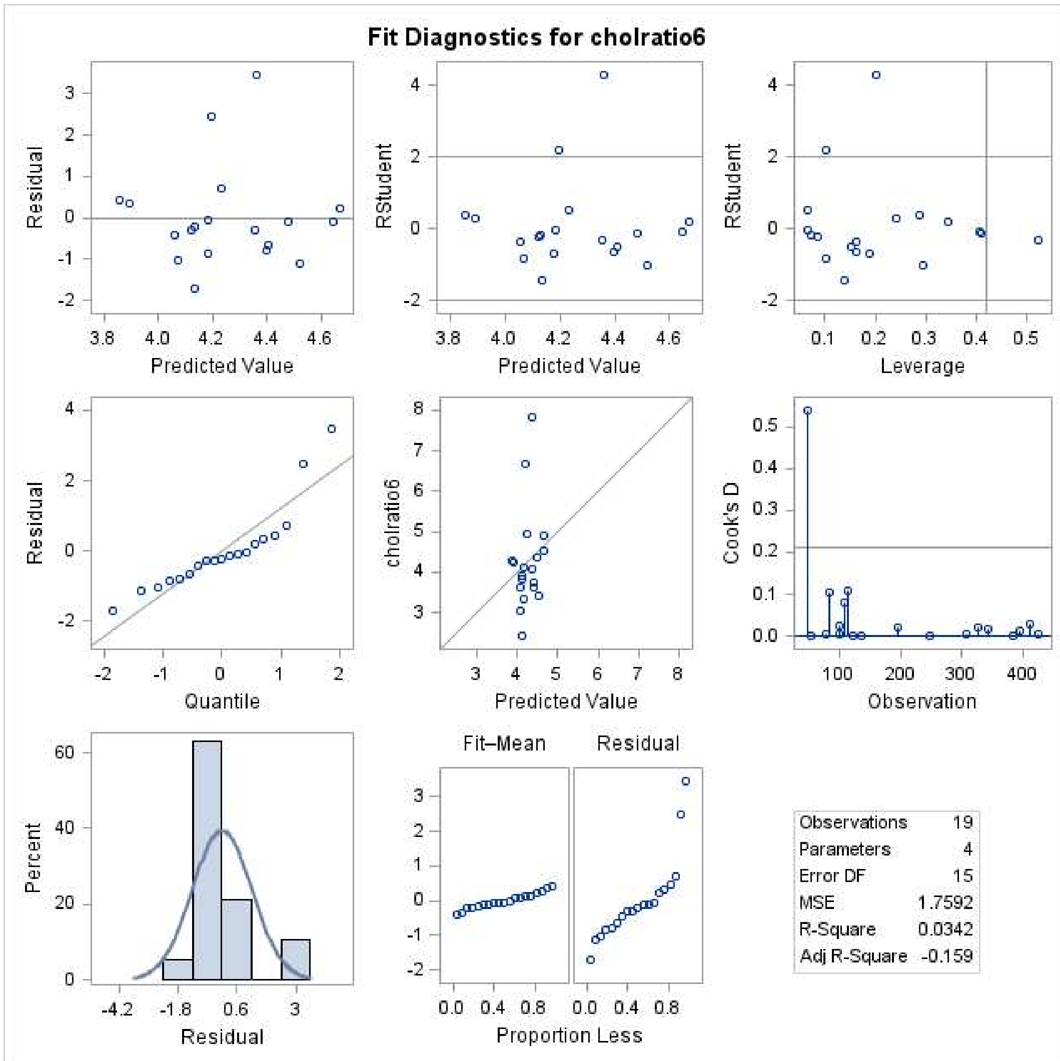

Figure 11 Fit diagnostics for cholesterol ratio

Figure 12 presents the diagnostics for the regression model predicting HDL levels at 6 months. The residual and studentized residual plots indicate that the residuals are randomly dispersed, though there are a few potential outliers. The Q-Q plot suggests mild deviations from normality, indicating a slight skewness. The histogram of residuals also shows a somewhat symmetric distribution. The leverage and Cook's D plots identify a few observations with moderately high influence, though none appear to exceed critical thresholds. However, the overall model fit is poor, with low explanatory power ($R^2 = 0.087$; Adjusted $R^2 = -0.095$), suggesting that the predictors explain very little of the variability in HDL in the group of firefighters observed.

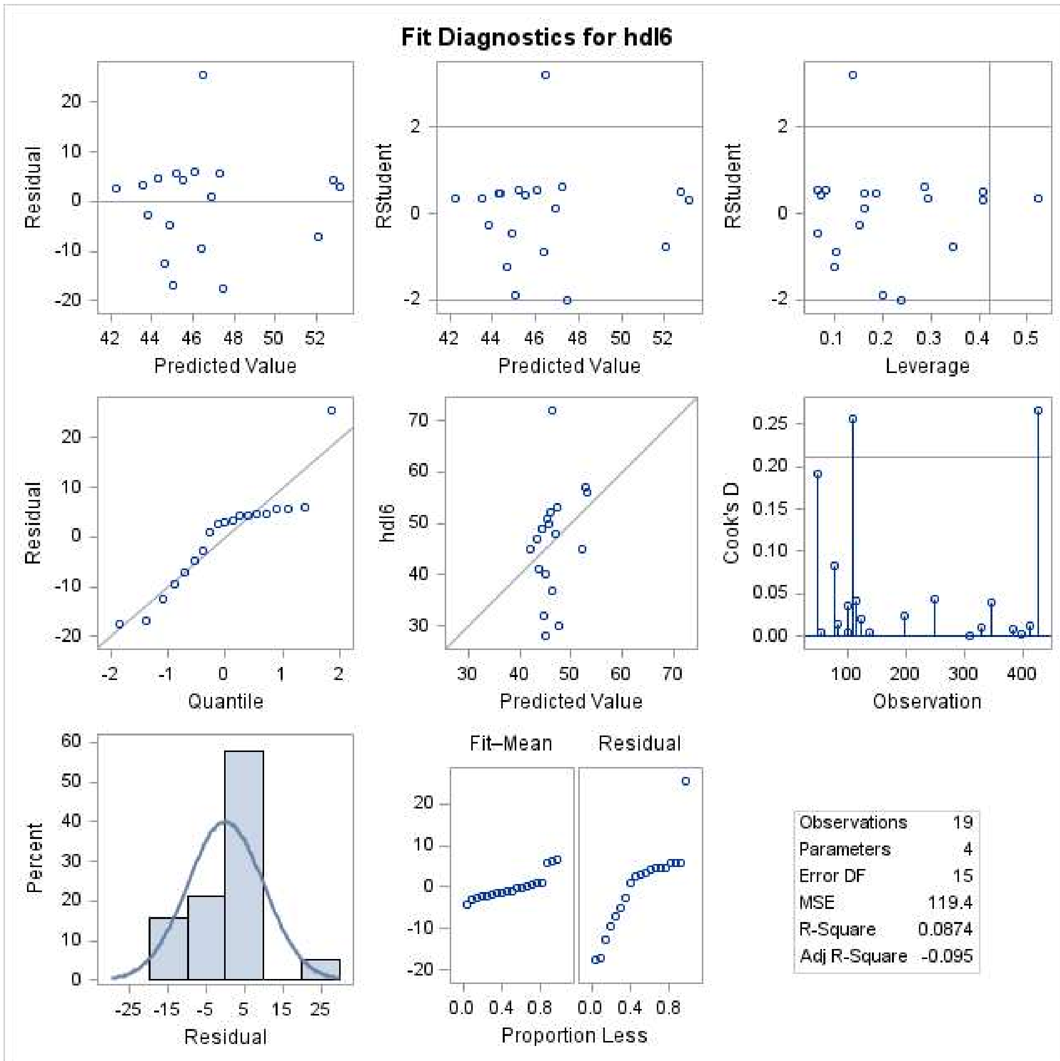

Figure 12 Fit diagnostics for HDL cholesterol

Figure 13 displays diagnostic plots for the linear regression model predicting LDL cholesterol at 6 months. The residuals plot shows some variability and potential heteroscedasticity. The Q-Q plot and histogram suggest normality of the residuals, though a few residuals deviate from the expected line. The model shows better explanatory power ($R^2 = 0.4251$; adjusted $R^2 = 0.3101$).

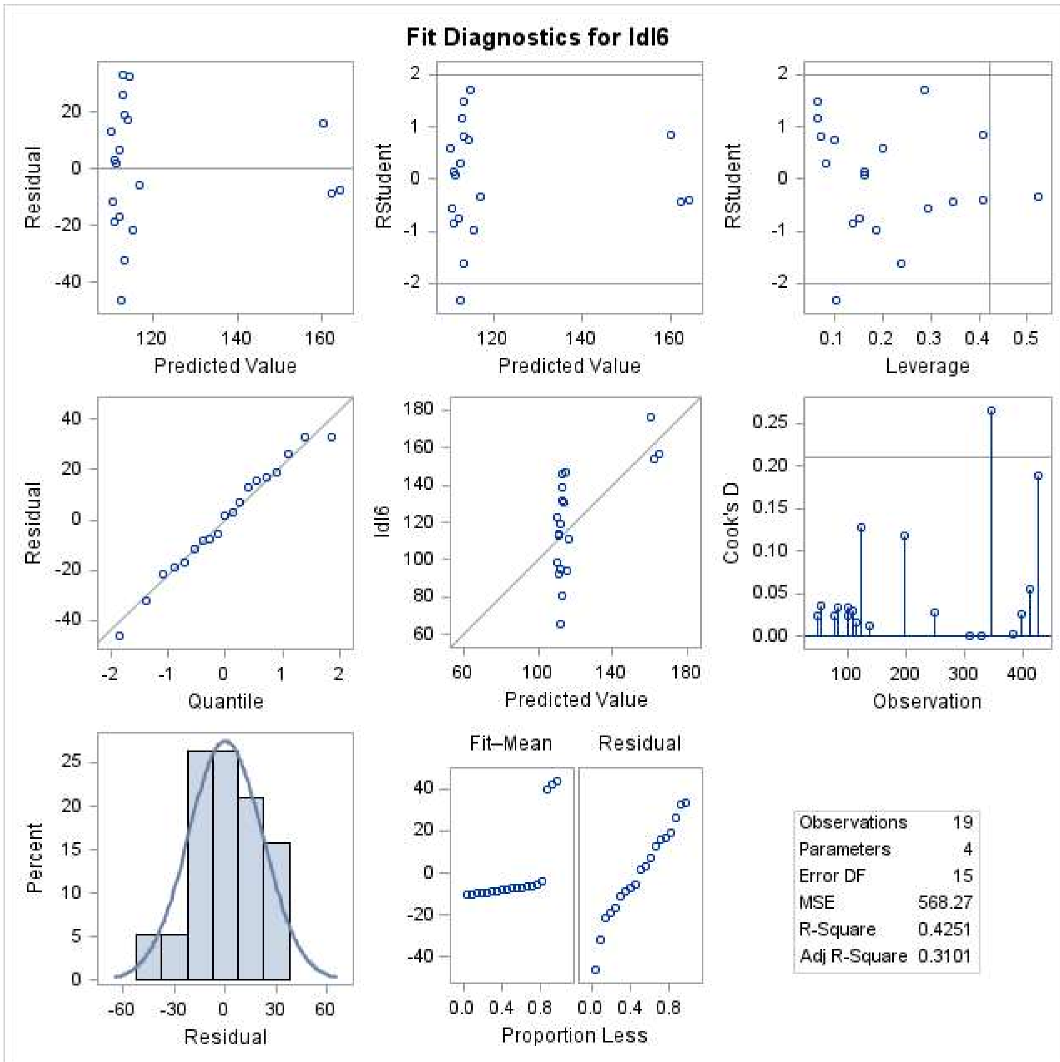

Figure 13 Fit diagnostics for LDL cholesterol

Figure 14 presents the diagnostics for the regression model predicting weight at 6-month follow-up. The residual and studentized residual plots do not present strong signs of heteroscedasticity even though there are some extreme values, particularly in the negative residual range. Compared to the HDL model, this model explains more variability in the outcome ($R^2 = 0.1995$; Adjusted $R^2 = 0.122$) but still exhibits limited predictive power.

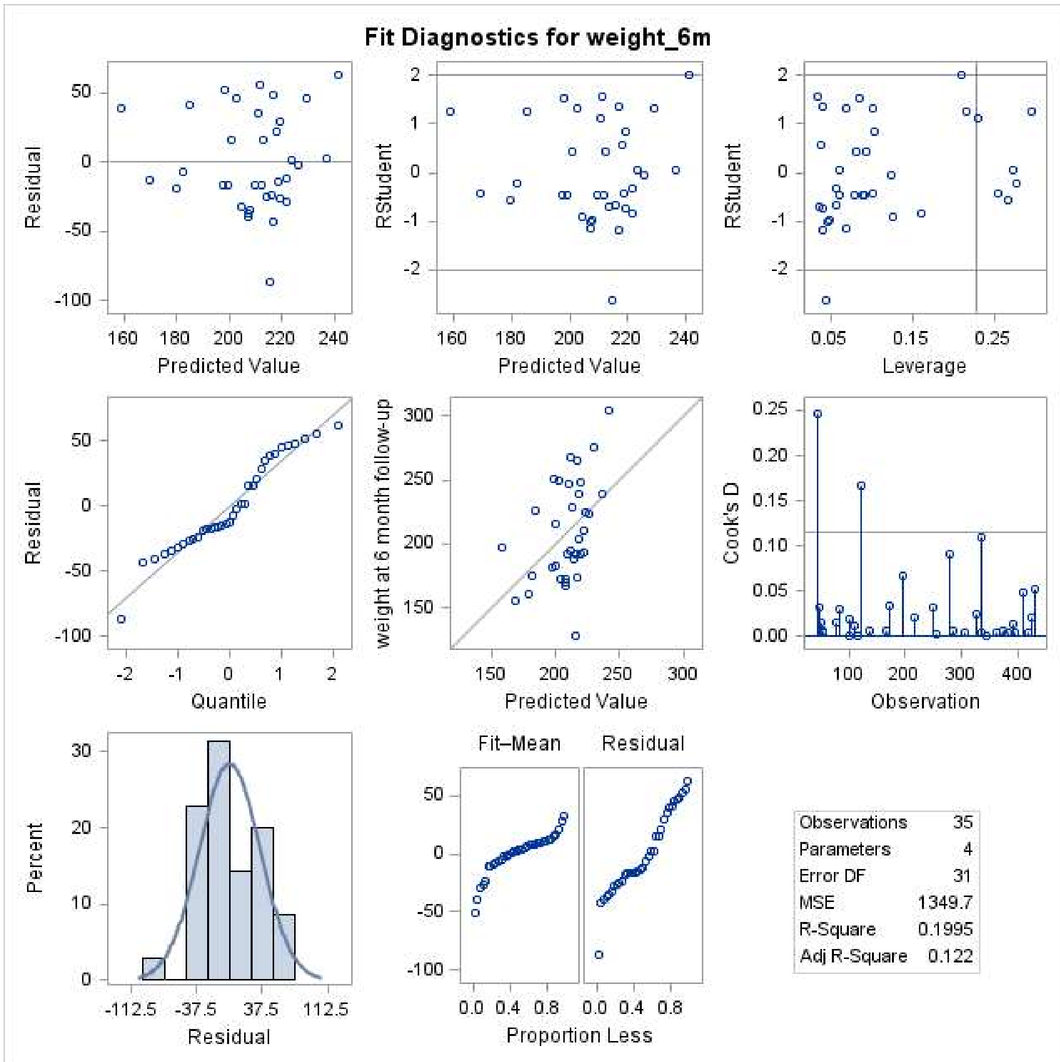

Figure 14 Fit diagnostics for weight

The associations between changes in the PREDIMED score and cardio-metabolic outcomes in multivariable regression models adjusted for age and gender, are shown in Table 5.3. A unit increase in the PREDIMED score was not significantly associated with changes in BMI (β = -0.5, 95% C.I: -1.3, 0.28, p = 0.20), weight (β =-5.4 , 95% C.I: -12.6 to 1.9, p = 0.14), or HDL cholesterol (β = 0.5, 95% C.I: -3.1 to 4.2, p = 0.75). Similarly, there were no statistically significant associations observed for cholesterol ratio (β = -0.01, 95% C.I: -0.4 to 0.4, p = 0.96). However, a significant association was observed between the PREDIMED score and % body fat, where each one-point increase in the score was associated with a modest but statistically significant decrease % body fat (β = -1.2, 95% CI: -2.3 to -0.1, p = 0.03). Overall, while most cardio-metabolic outcomes did not show statistically significant associations with changes in diet adherence, the observed trends were in the direction expected, being suggestive of more favorable outcomes when diet is improved.

Table 5.3 Association of change in PREDIMED score with cardiometabolic outcomes at 6 months

Outcome	**Model (adjusted for age and gender)**		
	β	***95 % C.I.***	***p***
BMI	-0.5	-1.3, 0.28	0.20
% body fat	-1.2	-2.3, -0.1	0.03
Weight	-5.4	-12.6, 1.9	0.14
HDL cholesterol	0.5	-3.1,4.2	0.75
LDL cholesterol	1.1	-6.7,9.0	0.77
Cholesterol ratio	-0.01	-0.4,0.4	0.96

5.4 Discussion

In this chapter we explored the relationship between adherence to the Mediterranean diet, as assessed by the PREDIMED score, and various cardiometabolic outcomes. Our findings demonstrate that individuals with higher PREDIMED scores tended to exhibit more favorable cardiometabolic profiles, particularly in terms of lipid parameters and body composition.

Participants with high adherence to the Mediterranean diet (PREDIMED score ≥7) showed significantly lower body mass index (BMI) and body fat percentage compared to those with lower adherence. Specifically, BMI was significantly lower in the high adherence group (29.4 kg/m² vs. 30.3 kg/m², p=0.03), aligning with previous studies that have shown the Mediterranean diet's effectiveness in managing body weight and fat distribution due to its high content of fiber, unsaturated fats, and low energy density foods[212213]. A systematic review and meta-analysis by Esposito et al. demonstrated that Mediterranean diet adherence was associated with reduced BMI and waist circumference, in line with our findings[214].

Importantly, lipid profiles were markedly improved among participants with high adherence. Total cholesterol, LDL cholesterol, and the cholesterol ratio were all significantly lower in the high PREDIMED group. For example, LDL cholesterol was 118 mg/dL in the high adherence group compared to 123 mg/dL in the low group (p=0.22). These findings are consistent with the original PREDIMED study and its subsequent analyses, which demonstrated that adherence to a Mediterranean diet enriched with extra-virgin olive oil or nuts improved lipid profiles and reduced cardiovascular disease risk[215216]. The mechanisms by which the Mediterranean diet influences lipid benefits include its high monounsaturated fat content, antioxidant-rich foods, and reduced intake of refined carbohydrates and trans fats[217].

Interestingly, while HDL cholesterol and triglycerides were more favorable in the high adherence group, these differences were not statistically significant. The limited sample size of the high adherence group (n=145 in Table 5.1) may explain the lack of significance. Nonetheless, other large-scale studies have reported improvements in HDL levels and triglyceride reductions with Mediterranean diet adherence[218,219]. It is possible that a longer duration of adherence or larger sample size might have revealed stronger associations in our population.

Glucose levels, while slightly lower in the high PREDIMED group, were not significantly different between groups. This is not surprising, as several studies have indicated that the Mediterranean diet is protective against the development of type 2 diabetes and improves glycemic control[219]. However, the short follow-up duration and small sample in the high adherence group likely limited our ability to detect significant differences in glycemic markers.

Regarding fitness parameters, such as maximal metabolic equivalents (METs) and VO_2 max, there were no significant differences between adherence groups. This suggests that while dietary factors are influential for cardiometabolic markers like lipid levels and adiposity, they may not directly influence fitness levels in the absence of regular physical activity interventions or that it takes longer to see any significant impact on these measures based on diet alone. This finding is in agreement with other studies suggesting that diet and exercise independently contribute to cardiovascular health[220].

The six-month follow-up data (Table 5.2) showed average BMI and body fat remained relatively high across the cohort, with modest lipid improvements. Even though the regression models did not show any significant associations between PREDIMED scores and cardiometabolic outcomes previous longitudinal studies have shown that sustained Mediterranean diet adherence is associated with significant reductions in cardiovascular events, diabetes incidence, and mortality[221,222].

The findings must be interpreted within the context of several limitations. Foremost is the very small size of the highest adherence group, which limits statistical power and may mask real differences. The predominance of male participants (94%) also restricts the generalizability to broader populations. Additionally, the cross-sectional nature of the baseline analysis prevents causal inference as well as the short duration of follow-up data available. Future studies should aim for larger, more balanced cohorts and explore adherence changes over time in relation to cardiometabolic outcomes.

Despite these limitations, our findings support the well-established cardiometabolic benefits of the Mediterranean diet. Even modest adherence levels (PREDIMED score $\geq$7) were associated with improved cholesterol ratios (3.9 vs. 4.3, p=0.006), suggesting that even partial adherence can yield meaningful health benefits. These results underscore the importance of dietary patterns in preventive cardiology and reinforce the value of promoting Mediterranean-style eating, particularly in populations at high risk of cardiovascular disease.

6 Conclusion

This dissertation explored the impact of dietary patterns, with a primary focus on the Mediterranean Diet (MD), on cardiometabolic outcomes among United States firefighters. Firefighters represent a unique and critical occupational group who, despite their demanding physical tasks, face elevated risks for cardiovascular disease (CVD), obesity, and metabolic syndrome, due to lifestyle-related factors, including irregular work shifts, high stress, and inconsistent access to nutritious foods. Using both cross-sectional and longitudinal data from the "Feeding America's Bravest" (FAB) study, this dissertation work provides compelling evidence on the role of diet, particularly anti-inflammatory eating patterns, in mitigating cardiometabolic risk within this population. This chapter synthesizes the key findings, discusses the implications of the results, addresses the limitations, and offers comprehensive directions for future research.

Summary of Key Findings

The study yielded several important findings, derived through principal component analysis, regression modeling, and longitudinal tracking of dietary adherence, using validated tools such as the Food Frequency Questionnaire (FFQ), the Dietary Inflammatory Index (DII), and the PREDIMED Score. One of the results of the study was the identification of two distinct dietary patterns in US firefighters: the Mediterranean-style diet and the Standard American Diet (SAD). Each was characterized by specific clusters of foods, with the former being rich in fruits, vegetables, legumes, whole grains, nuts, and healthy fats (particularly olive oil), and the latter, on the contrary, being high in red meats, processed foods, refined sugars, and saturated fats.

Firefighters whose dietary behaviors aligned more closely with the Mediterranean diet exhibited significantly better cardiometabolic profiles. These included lower body mass index (BMI), decreased body fat percentage, reduced levels of LDL cholesterol and triglycerides, and elevated HDL cholesterol levels. Additionally, systolic and diastolic blood pressure were generally more favorable among those adhering to this dietary model. These findings were consistent across multiple analytical approaches, providing robust support for the cardioprotective role of the Mediterranean diet.

Conversely, firefighters adhering to the Standard American Diet showed higher BMI and body fat percentage, elevated LDL cholesterol, and worse triglyceride-to-HDL ratio, which are well-recognized markers of cardiovascular risk. This dietary pattern was also positively associated with higher DII scores, indicating its pro-inflammatory nature. The DII proved a valuable metric, clearly delineating the relationship between dietary composition and systemic inflammation, a known pathway in the development of atherosclerosis and CVD.

Furthermore, the six-month longitudinal analysis utilizing the PREDIMED score demonstrated that even modest improvements in adherence to the Mediterranean Diet led to meaningful changes in health biomarkers. Participants who increased their PREDIMED score experienced reductions in body fat percentage, total cholesterol, and triglycerides, along with improvements in HDL cholesterol. Notably, the effectiveness of the FAB intervention, which combined structured education, food accessibility strategies, and family engagement, highlighted the importance of multi-level, appropriate interventions in producing sustainable dietary behavior change.

These findings contribute to a growing body of literature supporting the Mediterranean diet as one of the most effective eating patterns for promoting cardiovascular health. While much of the existing research has focused on the general population or high-risk clinical groups, this dissertation provides evidence specific to firefighters - a population whose job-related stress, irregular schedules, and unique culture can significantly impact health behaviors. By grounding the intervention within the lived experience of firefighters, this work offers a template for how nutritional strategies can be implemented in real-world occupational settings.

One particularly novel aspect of this research was the application of the Dietary Inflammatory Index (DII) in a firefighter cohort. By quantifying the inflammatory potential of their diets, this study helped explain how food choices influence the overall health and disease progression. Firefighters with diets high in pro-inflammatory foods (e.g., refined grains, red and processed meats, and sugary beverages) demonstrated elevated inflammatory and lipid profiles, reinforcing the hypothesis that diet-induced inflammation plays a pivotal role in cardiovascular health.

Moreover, this study highlights the importance of dietary pattern analysis over nutrient-specific or food-specific analyses. The use of principal component analysis (PCA) allowed for the identification of real-world dietary behaviors rather than theoretical models of nutrient intake. This approach highlights the complexity of human diets and better reflects the real-world food choices firefighters make in their everyday life.

Strengths and Limitations

This study possesses several strengths that enhance the validity and relevance of its findings. The study was based on real-world data collected from a large sample of career firefighters, increasing the ecological validity and practical relevance of the findings. The combination of different analysis techniques such as PCA, different assessment methods, such as the use of DII, and different scoring methods, such as MEDAS, provided a comprehensive evaluation of dietary quality and inflammatory potential, offering multiple perspectives on dietary behavior. In addition, the use of clinical and anthropometric data, including VO2 max, METs, blood pressure, and lipid profiles, allowed a thorough assessment of cardiometabolic health.

However, several limitations should be considered. The participants were drawn from a limited geographical area and from a single occupational setting, which may limit the applicability of findings to other geographic or occupational settings. Furthermore, the use of the FFQ relies on the participants' memory and honesty, which may introduce recall and social desirability bias. The short-term follow-up of six months, while it sufficiently detects some biomarker changes, does not capture long-term health outcomes or adherence. Firefighting is a predominantly male occupation; however, the predominance of male participants restricts analysis of sex-specific differences in dietary impact. Lastly, we did not account for any potential residual confounding, such as psychological stress, sleep quality, or genetic predisposition, which may have influenced the outcomes.

Implications for Cyprus and Greece

Firefighters in Cyprus and Greece encounter comparable cardiometabolic risks largely attributable to the high occupational stress, irregular work schedules, and intense physical demands inherent in their profession[223]. Although both countries are geographically situated within the Mediterranean region and thus traditionally associated with the health-promoting Mediterranean Diet, there has been a noticeable decline in adherence to this dietary pattern, influenced by contemporary lifestyle and dietary trends[224]. This shift poses increased health risks for firefighters, who require optimal physical fitness and resilience. The findings of this study underscore the potential for structured dietary interventions to markedly improve cardiometabolic health outcomes in this population. Importantly, intervention strategies that incorporate educational programs, digital health tools, and family engagement demonstrate high adaptability and feasibility within the local contexts of fire departments in Cyprus and Greece. Implementing such tailored interventions could enhance firefighters' overall health, potentially reducing the burden of cardiometabolic diseases. Furthermore, conducting a similar study in either Cyprus or Greece would provide valuable comparative data, enriching understanding of occupational health challenges specific to these regions. These insights could critically inform the development of national policies aimed at safeguarding the health and well-being of firefighters, ensuring targeted, culturally appropriate preventive measures are adopted within the Mediterranean occupational health framework.

Implications for Practice

The practical implications of this research are substantial. First, it confirms that even small, feasible dietary improvements can lead to meaningful health benefits in a high-risk occupational group. Fire departments should consider integrating dietary education and support into their wellness programming. Interventions should not be limited to formal training but could include on-site access to healthier food options, cooking classes, nutrition workshops, and partnerships with local grocers for discounts on healthy foods.

Second, the findings support the adoption of anti-inflammatory dietary models in occupational health programs. By using tools like the DII, wellness professionals can tailor dietary interventions to reduce inflammation and target specific metabolic pathways linked to disease risk.

Third, the success of the family-inclusive approach used in the FAB intervention suggests that similar strategies should be adopted more widely. Fire departments might consider offering family-oriented health events, recipe sharing groups, or access to online nutrition education platforms that engage both firefighters and their household members.

Finally, these findings contribute to a broader conversation about preventive health in first responder populations. Cardiovascular events remain the leading cause of on-duty mortality in firefighters. Therefore, shifting the paradigm from reactive medical care to proactive lifestyle intervention is not only beneficial for individual health but also critical for organizational readiness and public safety.

Future Research Directions

The results of this dissertation point to several key areas for further investigation.

Future research should examine whether the observed changes in cardiometabolic biomarkers are maintained or enhanced over longer periods and whether they are associated with reduced incidence of CVD events, disability, or premature retirement.

In addition, replicating this research in different fire departments--including volunteer stations, departments in rural areas, or in different regions of the US would provide a broader understanding of the external validity of these findings.

Future studies should incorporate objective biomarkers of dietary intake and inflammation, such as blood levels of omega-3 fatty acids, carotenoids, CRP, and IL-6. These can validate self-reported data and provide deeper insight into physiological mechanisms.

Digital health tools, including smartphone apps for dietary tracking and wearable devices for physical activity and sleep monitoring, could enhance data collection, personalize interventions, and increase engagement.

Cost-effectiveness analyses that quantify reductions in healthcare utilization, sick days, or injury rates, as a result of dietary interventions, could support policy decisions and justify investment in wellness programming.

Future work should also explore the psychological and social determinants of dietary change in firefighters, including the role of peer influence, motivation, stress, and mental health.

Finally, research should assess the impact of department-wide or municipal policies that promote healthy food procurement, restrict access to unhealthy foods, or offer incentives for health behaviors.

Final Remarks

The findings presented in this dissertation underscore the transformative potential of dietary change in improving the health of US firefighters. Cardiovascular disease remains a leading cause of morbidity and mortality in this profession, yet it is largely preventable through modifiable behaviors. The Mediterranean Diet, with its anti-inflammatory properties and emphasis on the whole, nutrient-dense foods, emerges as a powerful tool for improving cardiometabolic outcomes.

This work contributes to the evidence base for occupational nutrition interventions and demonstrates that health-promoting behavior change is possible even in challenging environments. Importantly, the success of the FAB intervention shows that when dietary change is supported by education, environmental modifications, and family involvement, it can lead to sustainable improvements in health and wellbeing.

Ultimately, enhancing the health of firefighters through better nutrition is not just an individual benefit. It is a matter of public safety, workforce resilience, and social responsibility. As fire departments, municipalities, and policymakers consider how to best protect and support those who serve, integrating dietary strategies like the Mediterranean Diet into wellness programming should be a top priority. The lessons learned here can also be extended to other first responders and occupational groups, paving the way for a healthier and more sustainable workforce.

BIBLIOGRAPHY

1. Dernini S, Berry EM, Serra-Majem L, et al. 20 Hellenic Health Foundation. 2016;(7):1322-1330. doi:10.1017/S1368980016003177
2. Hidalgo-Mora JJ, García-Vigara A, Sánchez-Sánchez ML, García-Pérez MÁ, Tarín J, Cano A. The Mediterranean diet: A historical perspective on food for health. *Maturitas*. 2020;132:65-69. doi:10.1016/J.MATURITAS.2019.12.002
3. Capurso A. The Mediterranean diet: a historical perspective. *Aging Clin Exp Res*. 2024;36(1):1-6. doi:10.1007/S40520-023-02686-3/FIGURES/1
4. Altomare R, Cacciabaudo F, Damiano G, et al. The Mediterranean Diet: A History of Health. *Iran J Public Health*. 2013;42(5):449. Accessed July 5, 2024. /pmc/articles/PMC3684452/
5. Sikalidis AK, Kelleher AH, Kristo AS, Wang HHX. Mediterranean Diet. *Encyclopedia 2021, Vol 1, Pages 371-387*. 2021;1(2):371-387. doi:10.3390/ENCYCLOPEDIA1020031
6. Ferro-Luzzi A, Cialfa E, Leclercq C, Toti E. The mediterranean diet revisited. Focus on fruit and vegetables. *Int J Food Sci Nutr*. 1994;45(4):291-300. doi:10.3109/09637489409166170
7. Lăcătușu CM, Grigorescu ED, Floria M, Onofriescu A, Mihai BM. The Mediterranean Diet: From an Environment-Driven Food Culture to an Emerging Medical Prescription. *Int J Environ Res Public Health*. 2019;16(6). doi:10.3390/IJERPH16060942
8. Centre for Health Protection - The Food Pyramid – A Guide to a Balanced Diet. Accessed July 5, 2024. https://www.chp.gov.hk/en/static/90017.html
9. Zalaquett N, Lidoriki I, Lampou M, et al. Adherence to the Mediterranean Diet and the Risk of Head and Neck Cancer: A Systematic Review and Meta-Analysis of Case-Control Studies. *Nutrients*. 2025;17(2). doi:10.3390/NU17020287
10. Mediterranean dietary patterns in the 1960s - Seven Countries Study | The first study to relate diet with cardiovascular disease. Accessed July 5, 2024. https://www.sevencountriesstudy.com/mediterranean-dietary-patterns/

11. About the Seven Countries Study. Accessed July 5, 2024. https://www.sevencountriesstudy.com/about-the-study/

12. Keys A, Menotti A, Aravanis C, et al. The seven countries study: 2,289 deaths in 15 years. *Prev Med (Baltim)*. 1984;13(2):141-154. doi:10.1016/0091-7435(84)90047-1

13. Shannon OM, Ranson JM, Gregory S, et al. Mediterranean diet adherence is associated with lower dementia risk, independent of genetic predisposition: findings from the UK Biobank prospective cohort study. *BMC Med*. 2023;21(1):1-13. doi:10.1186/S12916-023-02772-3/FIGURES/3

14. Féart C, Samieri C, Barberger-Gateau P. Mediterranean diet and cognitive function in older adults. *Curr Opin Clin Nutr Metab Care*. 2010;13(1):14. doi:10.1097/MCO.0B013E3283331FE4

15. Fu J, Tan LJ, Lee JE, Shin S. Association between the mediterranean diet and cognitive health among healthy adults: A systematic review and meta-analysis. *Front Nutr*. 2022;9:946361. doi:10.3389/FNUT.2022.946361/FULL

16. Omega-3 Fatty Acids - Health Professional Fact Sheet. Accessed March 23, 2025. https://ods.od.nih.gov/factsheets/Omega3FattyAcids-HealthProfessional/

17. Widmer RJ, Flammer AJ, Lerman LO, Lerman A. The Mediterranean Diet, its Components, and Cardiovascular Disease. *Am J Med*. 2015;128(3):229-238. doi:10.1016/J.AMJMED.2014.10.014

18. Schwingshackl L, Hoffmann G. Mediterranean dietary pattern, inflammation and endothelial function: A systematic review and meta-analysis of intervention trials. *Nutrition, Metabolism and Cardiovascular Diseases*. 2014;24(9):929-939. doi:10.1016/J.NUMECD.2014.03.003

19. Milenkovic T, Bozhinovska N, Macut D, et al. Mediterranean Diet and Type 2 Diabetes Mellitus: A Perpetual Inspiration for the Scientific World. A Review. *Nutrients*. 2021;13(4):1307. doi:10.3390/NU13041307

20. Martínez-González MA, Salas-Salvadó J, Estruch R, Corella D, Fitó M, Ros E. Benefits of the Mediterranean Diet: Insights From the PREDIMED Study. *Prog Cardiovasc Dis*. 2015;58(1):50-60. doi:10.1016/J.PCAD.2015.04.003

21. Salas-Salvadó J, Bulló M, Babio N, et al. Reduction in the incidence of type 2 diabetes with the Mediterranean diet: results of the PREDIMED-Reus nutrition intervention randomized trial. *Diabetes Care*. 2011;34(1):14-19. doi:10.2337/DC10-1288

22. Ros E. The PREDIMED study. *Endocrinol Diabetes Nutr*. 2017;64(2):63-66. doi:10.1016/J.ENDINU.2016.11.003

23. Toledo E, Hu FB, Estruch R, et al. Effect of the Mediterranean diet on blood pressure in the PREDIMED trial: Results from a randomized controlled trial. *BMC Med*. 2013;11(1):1-10. doi:10.1186/1741-7015-11-207/TABLES/3

24. Ros E, Martínez-González MA, Estruch R, et al. Mediterranean Diet and Cardiovascular Health: Teachings of the PREDIMED Study. *Advances in Nutrition*. 2014;5(3):330S-336S. doi:10.3945/AN.113.005389

25. Vitale M, Masulli M, Calabrese I, et al. Impact of a Mediterranean Dietary Pattern and Its Components on Cardiovascular Risk Factors, Glucose Control, and Body Weight in People with Type 2 Diabetes: A Real-Life Study. *Nutrients*. 2018;10(8). doi:10.3390/NU10081067

26. Ditano-Vázquez P, Torres-Peña JD, Galeano-Valle F, et al. The fluid aspect of the mediterranean diet in the prevention and management of cardiovascular disease and diabetes: The role of polyphenol content in moderate consumption of wine and olive oil. *Nutrients*. 2019;11(11). doi:10.3390/nu11112833

27. Shen J, Wilmot KA, Ghasemzadeh N, et al. Mediterranean Dietary Patterns and Cardiovascular Health. *Annu Rev Nutr*. 2015;35(1):425-449. doi:10.1146/ANNUREV-NUTR-011215-025104

28. Martín-Rodríguez A, Belinchón-deMiguel P, Rubio-Zarapuz A, et al. Advances in Understanding the Interplay between Dietary Practices, Body Composition, and Sports Performance in Athletes. *Nutrients 2024, Vol 16, Page 571*. 2024;16(4):571. doi:10.3390/NU16040571

29. Xiao YL, Gong Y, Qi YJ, Shao ZM, Jiang YZ. Effects of dietary intervention on human diseases: molecular mechanisms and therapeutic potential. *Signal*

Transduction and Targeted Therapy 2024 9:1. 2024;9(1):1-34. doi:10.1038/s41392-024-01771-x

30. Gherasim A, Arhire LI, Niță O, Popa AD, Graur M, Mihalache L. The relationship between lifestyle components and dietary patterns. *Proc Nutr Soc*. 2020;79(3):311. doi:10.1017/S0029665120006898

31. Wang W, Liu Y, Li Y, et al. Dietary patterns and cardiometabolic health: Clinical evidence and mechanism. *MedComm (Beijing)*. 2023;4(1). doi:10.1002/MCO2.212

32. Lăcătușu CM, Grigorescu ED, Floria M, Onofriescu A, Mihai BM. The Mediterranean Diet: From an Environment-Driven Food Culture to an Emerging Medical Prescription. *Int J Environ Res Public Health*. 2019;16(6):942. doi:10.3390/IJERPH16060942

33. Muscogiuri G, Verde L, Sulu C, et al. Mediterranean Diet and Obesity-related Disorders: What is the Evidence? *Curr Obes Rep*. 2022;11(4):287. doi:10.1007/S13679-022-00481-1

34. Dominguez LJ, Veronese N, Di Bella G, et al. Mediterranean diet in the management and prevention of obesity. *Exp Gerontol*. 2023;174:112121. doi:10.1016/J.EXGER.2023.112121

35. Smith DL, Fehling PC, Frisch A, Haller JM, Winke M, Dailey MW. The prevalence of cardiovascular disease risk factors and obesity in firefighters. *J Obes*. 2012;2012. doi:10.1155/2012/908267

36. Soares EMKVK, Smith D, Grossi Porto LG. Worldwide prevalence of obesity among firefighters: a systematic review protocol. *BMJ Open*. 2020;10(1). doi:10.1136/BMJOPEN-2019-031282

37. Dobson M, Choi B, Schnall PL, et al. Exploring occupational and health behavioral causes of firefighter obesity: a qualitative study. *Am J Ind Med*. 2013;56(7):776-790. doi:10.1002/AJIM.22151

38. Munir F, Clemes S, Houdmont J, Randall R. Overweight and obesity in UK firefighters. *Occup Med (Lond)*. 2012;62(5):362-365. doi:10.1093/OCCMED/KQS077

39. Mathias KC, Bode ED, Stewart DF, Smith DL. Changes in Firefighter Weight and Cardiovascular Disease Risk Factors over Five Years. *Med Sci Sports Exerc*. 2020;52(11):2476. doi:10.1249/MSS.0000000000002398

40. Torre SB Della, Wild P, Dorribo V, Amati F, Danuser B. Eating Habits of Professional Firefighters: Comparison With National Guidelines and Impact Healthy Eating Promotion Program. *J Occup Environ Med*. 2019;61(5):E183-E190. doi:10.1097/JOM.0000000000001565

41. Torre SB Della, Wild P, Dorribo V, Amati F, Danuser B. Eating Habits of Professional Firefighters: Comparison with National Guidelines and Impact Healthy Eating Promotion Program. *J Occup Environ Med*. 2019;61(5):E183-E190. doi:10.1097/JOM.0000000000001565

42. Gendron P, Lajoie C, Laurencelle L, Trudeau F. Cardiovascular Disease Risk Factors in Québec Male Firefighters. *J Occup Environ Med*. 2018;60(6):e300-e306. doi:10.1097/JOM.0000000000001309

43. Joe MJ, Hatsu IE, Tefft A, Mok S, Adetona O. Dietary Behavior and Diet Interventions among Structural Firefighters: A Narrative Review. *Nutrients*. 2022;14(21). doi:10.3390/NU14214662

44. Smith DL, Fehling PC, Frisch A, Haller JM, Winke M, Dailey MW. Clinical Study The Prevalence of Cardiovascular Disease Risk Factors and Obesity in Firefighters. *J Obes*. 2012;2012. doi:10.1155/2012/908267

45. Jahnke SA, Poston WSC, Jitnarin N, C. Keith Haddock. Health Concerns of the U.S. Fire Service: Perspectives From the Firehouse. *Am J Health Promot*. 2012;27(2):111. doi:10.4278/AJHP.110311-QUAL-109

46. Choi BK, Schnall P, Dobson M, et al. Exploring occupational and behavioral risk factors for obesity in firefighters: A theoretical framework and study design. *Saf Health Work*. 2011;2(4):301-312. doi:10.5491/SHAW.2011.2.4.301

47. Elsner KL, Kolkhorst FW. Metabolic demands of simulated firefighting tasks. *Ergonomics*. 2008;51(9):1418-1425. doi:10.1080/00140130802120259

48. Elsner KL, Kolkhorst FW. Metabolic demands of simulated firefighting tasks. Published online 2008. doi:10.1080/00140130802120259

49. National Fire Department Registry Quick Facts. Accessed March 7, 2025. https://apps.usfa.fema.gov/registry/summary

50. Soteriades ES, Smith DL, Tsismenakis AJ, Baur DM, Kales SN. Cardiovascular disease in US firefighters: A systematic review. *Cardiol Rev*. 2011;19(4):202-215. doi:10.1097/CRD.0b013e318215c105

51. Lowden A, Moreno C, Holmbäck U, Lennernäs M, Tucker P. Eating and shift work - Effects on habits, metabolism, and performance. *Scand J Work Environ Health*. 2010;36(2):150-162. doi:10.5271/sjweh.2898

52. McEwen BS, Stellar E. Stress and the Individual: Mechanisms Leading to Disease. *Arch Intern Med*. 1993;153(18):2093-2101. doi:10.1001/ARCHINTE.1993.00410180039004

53. Gonzalez DE, Lanham SN, Martin SE, et al. Firefighter Health: A Narrative Review of Occupational Threats and Countermeasures. *Healthcare*. 2024;12(4):440. doi:10.3390/HEALTHCARE12040440

54. Firefighters and Mental Health: The Fear of Raising Your Hand. Accessed March 7, 2025. https://www.firefighternation.com/health-wellness/firefighter-mental-health/firefighters-and-mental-health-the-fear-of-raising-your-hand/

55. O'Toole M, Mulhall C, Eppich W. Breaking down barriers to help-seeking: preparing first responders' families for psychological first aid. *Eur J Psychotraumatol*. 2022;13(1). doi:10.1080/20008198.2022.2065430

56. Kales SN, Soteriades ES, Christophi CA, Christiani DC. Emergency Duties and Deaths from Heart Disease among Firefighters in the United States. *New England Journal of Medicine*. 2007;356(12):1207-1215. doi:10.1056/NEJMoa060357

57. Soteriades ES, Smith DL, Tsismenakis AJ, Baur DM, Kales SN. Cardiovascular Disease in US Firefighters. *Cardiol Rev*. 2011;19(4):202-215. doi:10.1097/CRD.0b013e318215c105

58. Haller JM, Smith DL. Examination of Strenuous Activity Preceding Cardiac Death during Firefighting Duties. *Safety 2019, Vol 5, Page 50*. 2019;5(3):50. doi:10.3390/SAFETY5030050

59. Kales SN, Smith DL. Firefighting and the heart. *Circulation*. 2017;135(14):1296-1299. doi:10.1161/CIRCULATIONAHA.117.027018

60. Smith DL, Barr DA, Kales SN. Extreme sacrifice: sudden cardiac death in the US Fire Service. *Extrem Physiol Med*. 2013;2(1):6. doi:10.1186/2046-7648-2-6

61. Fahs CA, Huimin Yan, Ranadive S, et al. Acute effects of firefighting on arterial stiffness and blood flow. *Vasc Med*. 2011;16(2):113-118. doi:10.1177/1358863X11404940

62. Khoshdel AR, Carney SL, Nair BR, Gillies A. Better Management of Cardiovascular Diseases by Pulse Wave Velocity: Combining Clinical Practice with Clinical Research using Evidence-Based Medicine. *Clin Med Res*. 2007;5(1):45. doi:10.3121/CMR.2007.708

63. Phillips AA, Warburton DER, Flynn SW, Fredrikson D, Lang DJ. Assessment of arterial stiffness among schizophrenia-spectrum disorders using aortic pulse wave velocity and arterial compliance: A pilot study. *Psychiatry Res*. 2014;215(1):14-19. doi:10.1016/J.PSYCHRES.2013.10.020

64. Safar ME, Czernichow S, Blacher J. Obesity, arterial stiffness, and cardiovascular risk. *J Am Soc Nephrol*. 2006;17(4 Suppl 2):S109-11. doi:10.1681/ASN.2005121321

65. Arora R, Khandpur R. Significance of central aortic stiffness in cardiovascular disease. *Am J Ther*. 2009;16(6). doi:10.1097/MJT.0B013E3181727DFC

66. Otero-Luis I, Saz-Lara A, Moreno-Herráiz N, et al. Exploring the Association between Mediterranean Diet Adherence and Arterial Stiffness in Healthy Adults: Findings from the EvasCu Study. *Nutrients*. 2024;16(13). doi:10.3390/NU16132158

67. Wagenseil JE, Mecham RP. Vascular extracellular matrix and arterial mechanics. *Physiol Rev*. 2009;89(3):957-989. doi:10.1152/PHYSREV.00041.2008

68. Mitchell GF. Recent Advances in Hypertension: Arterial Stiffness and Hypertension. *Hypertension*. 2014;64(1):13. doi:10.1161/HYPERTENSIONAHA.114.00921

69. Smith DL, Barr DA, Kales SN. Extreme sacrifice: sudden cardiac death in the US Fire Service. *Extrem Physiol Med*. 2013;2(1):6. doi:10.1186/2046-7648-2-6

70. Gumus D, Topal GG, Sevim S, Kizil M. Adherence to Mediterranean diet and dietary changes according to the fear of COVID-19 during the pandemic: a cross-sectional study. *J Nutr Sci*. 2023;12:e56. doi:10.1017/JNS.2023.40

71. Hunter AL, Shah ASV, Langrish JP, et al. Fire Simulation and Cardiovascular Health in Firefighters. *Circulation*. 2017;135(14):1284-1295. doi:10.1161/CIRCULATIONAHA.116.025711

72. Jarosz W, Kowalczyk P, Marciniak A. The determination of basic fire-fighters rescue operations of key practical importance. *MATEC Web of Conferences*. 2018;247. doi:10.1051/MATECCONF/201824700055

73. Yunus MNH, Jaafar MH, Mohamed ASA, Azraai NZ, Amil N, Zein RM. Biomechanics Analysis of the Firefighters' Thorax Movement on Personal Protective Equipment during Lifting Task Using Inertial Measurement Unit Motion Capture. *Int J Environ Res Public Health*. 2022;19(21). doi:10.3390/IJERPH192114232

74. Fire Prevention Week: An Expert's Advocacy Guide. Accessed October 22, 2024. https://www.forensicscolleges.com/blog/resources/fire-prevention-week

75. Yung M, Du B, Gruber J, Yazdani A. Developing a Canadian fatigue risk management standard for first responders: Defining the scope. *Saf Sci*. 2021;134. doi:10.1016/J.SSCI.2020.105044

76. Briley ME, Montgomery DH, Blewett J. Dietary intakes of police department employees in a wellness program. *J Am Diet Assoc*. 1990;90(1):65-68. doi:10.1016/s0002-8223(21)01466-8

77. Kreider RB, Campbell B. Protein for exercise and recovery. *Physician and Sportsmedicine*. 2009;37(2):13-21. doi:10.3810/PSM.2009.06.1705,

78. Siri-Tarino PW, Sun Q, Hu FB, Krauss RM. Saturated Fatty Acids and Risk of Coronary Heart Disease: Modulation by Replacement Nutrients. *Curr Atheroscler Rep*. 2010;12(6):384. doi:10.1007/S11883-010-0131-6

79. Cintineo HP, Arent MA, Antonio J, Arent SM. Effects of Protein Supplementation on Performance and Recovery in Resistance and Endurance Training. *Front Nutr*. 2018;5:83. doi:10.3389/FNUT.2018.00083

80. Frost C, Toczko M, Merrigan JJ, Martin JR. The effects of sleep on firefighter occupational performance and health: A systematic review and call for action. *Sleep Epidemiology*. 2021;1:100014. doi:10.1016/J.SLEEPE.2021.100014

81. Caldwell JA, Caldwell JL, Thompson LA, Lieberman HR. Fatigue and its management in the workplace. *Neurosci Biobehav Rev*. 2019;96:272-289. doi:10.1016/J.NEUBIOREV.2018.10.024

82. Billings JM, Haddock CK, Jahnke SA. Intra-Tour Variation of Firefighter Sleep Duration and Sleep-Wake Cycle within the 24/48 and 48/96 Shift Schedules. *Behavioral Sleep Medicine*. 2023;21(1):1-12. doi:10.1080/15402002.2021.2021912

83. Hegg-Deloye S, Brassard P, Jauvin N, et al. Current state of knowledge of post-traumatic stress, sleeping problems, obesity and cardiovascular disease in paramedics. *Emergency Medicine Journal*. 2014;31(3):242-247. doi:10.1136/EMERMED-2012-201672

84. Williams JE, Mosley TH, Kop WJ, Couper DJ, Welch VL, Rosamond WD. Vital Exhaustion as a Risk Factor for Adverse Cardiac Events (From the Atherosclerosis Risk in Communities [ARIC] Study). *Am J Cardiol*. 2010;105(12):1661. doi:10.1016/J.AMJCARD.2010.01.340

85. Wickwire EM, Geiger-Brown J, Scharf SM, Drake CL. Shift Work and Shift Work Sleep Disorder: Clinical and Organizational Perspectives. *Chest*. 2016;151(5):1156. doi:10.1016/J.CHEST.2016.12.007

86. Fan J, Smith AP. The impact of workload and fatigue on performance. *Communications in Computer and Information Science*. 2017;726:90-105. doi:10.1007/978-3-319-61061-0_6

87. Sotos-Prieto M, Mattei J. Mediterranean Diet and Cardiometabolic Diseases in Racial/Ethnic Minority Populations in the United States. *Nutrients*. 2018;10(3). doi:10.3390/NU10030352

88. Morera LP, Marchiori GN, Medrano LA, Defagó MD. Stress, Dietary Patterns and Cardiovascular Disease: A Mini-Review. *Front Neurosci*. 2019;13:1226. doi:10.3389/FNINS.2019.01226

89. Schwingshackl L, Knüppel S, Michels N, et al. Intake of 12 food groups and disability-adjusted life years from coronary heart disease, stroke, type 2 diabetes, and colorectal cancer in 16 European countries. *Eur J Epidemiol*. 2019;34(8):765-775. doi:10.1007/S10654-019-00523-4

90. Clemente-Suárez VJ, Beltrán-Velasco AI, Redondo-Flórez L, Martín-Rodríguez A, Tornero-Aguilera JF. Global Impacts of Western Diet and Its Effects on Metabolism and Health: A Narrative Review. *Nutrients*. 2023;15(12). doi:10.3390/NU15122749

91. Christ A, Lauterbach M, Latz E. Western Diet and the Immune System: An Inflammatory Connection. *Immunity*. 2019;51(5):794-811. doi:10.1016/J.IMMUNI.2019.09.020

92. Minihane AM, Vinoy S, Russell WR, et al. Low-grade inflammation, diet composition and health: current research evidence and its translation. *Br J Nutr*. 2015;114(7):999. doi:10.1017/S0007114515002093

93. Zhao S, Gao W, Li J, et al. Dietary inflammatory index and osteoporosis: the National Health and Nutrition Examination Survey, 2017–2018. *Endocrine*. 2022;78(3):587-596. doi:10.1007/S12020-022-03178-6/METRICS

94. Calder PC, Ahluwalia N, Albers R, et al. A Consideration of Biomarkers to be Used for Evaluation of Inflammation in Human Nutritional Studies. *British Journal of Nutrition*. 2013;109(SUPPL. S1). doi:10.1017/S0007114512005119

95. Li J, Lee DH, Hu J, et al. Dietary Inflammatory Potential and Risk of Cardiovascular Disease Among Men and Women in the U.S. *J Am Coll Cardiol*. 2020;76(19):2181. doi:10.1016/J.JACC.2020.09.535

96. Li J, Lee DH, Hu J, et al. Dietary Inflammatory Potential and Risk of Cardiovascular Disease Among Men and Women in the U.S. *J Am Coll Cardiol*. 2020;76(19):2181. doi:10.1016/J.JACC.2020.09.535

97. Shivappa N, Godos J, Hébert JR, et al. Dietary Inflammatory Index and Cardiovascular Risk and Mortality—A Meta-Analysis. *Nutrients*. 2018;10(2):200. doi:10.3390/NU10020200

98. Romanidou M, Tripsianis G, Hershey MS, et al. Association of the Modified Mediterranean Diet Score (mMDS) with Anthropometric and Biochemical Indices in US Career Firefighters. *Nutrients 2020, Vol 12, Page 3693*. 2020;12(12):3693. doi:10.3390/NU12123693

99. Wang E, Fang C, Zhang J, Wang Y. Association between dietary inflammatory index and all-cause mortality risk in adults with coronary heart disease in the United States. *Scientific Reports 2024 14:1*. 2024;14(1):1-10. doi:10.1038/s41598-024-75381-6

100. Qing L, Zhu Y, Yu C, Zhang Y, Ni J. Exploring the association between dietary Inflammatory Index and chronic pain in US adults using NHANES 1999–2004. *Sci Rep*. 2024;14(1):1-11. doi:10.1038/S41598-024-58030-W;SUBJMETA=1692,174,308,375,499,692,699;KWRD=EPIDEMIOLOGY,NEUROPATHIC+PAIN,RISK+FACTORS

101. Murga-Garrido SM, Hong Q, Cross TWL, et al. Gut microbiome variation modulates the effects of dietary fiber on host metabolism. *Microbiome 2021 9:1*. 2021;9(1):1-26. doi:10.1186/S40168-021-01061-6

102. Romagnolo DF, Selmin OI. Mediterranean Diet and Prevention of Chronic Diseases. *Nutr Today*. 2017;52(5):208. doi:10.1097/NT.0000000000000228

103. Saber N, Teymoori F, Kazemi Jahromi M, et al. From adolescence to adulthood: Mediterranean diet adherence and cardiometabolic health in a prospective cohort study. *Nutr Metab Cardiovasc Dis*. 2024;34(4):893-902. doi:10.1016/J.NUMECD.2023.12.017

104. Nutrition Questionnaire Service Center | Department of Nutrition | Harvard T.H. Chan School of Public Health. Accessed January 22, 2025. https://hsph.harvard.edu/department/nutrition/nutrition-questionnaire-service-center/

105. Firefighters' Cancer Risk Heightened Due To Smoke Inhalation | RAE Systems. Accessed June 24, 2020. https://www.raesystems.com/news-events/press-room/firefighters%E2%80%99-cancer-risk-heightened-due-smoke-inhalation

106. Kales SN, Soteriades ES, Christophi CA, Christiani DC. Emergency duties and deaths from heart disease among firefighters in the United States. *New England Journal of Medicine*. 2007;356(12):1207-1215. doi:10.1056/NEJMoa060357

107. Smith DL, Barr DA, Kales SN. Extreme sacrifice: Sudden cardiac death in the US Fire Service. *Extrem Physiol Med*. 2013;2(1). doi:10.1186/2046-7648-2-6

108. Moffatt SM, Stewart DF, Jack K, et al. Cardiometabolic health among United States firefighters by age. *Prev Med Rep*. 2021;23:101492. doi:10.1016/J.PMEDR.2021.101492

109. Emmerich SD, Fryar CD, Stierman B, Ogden CL. Obesity and Severe Obesity Prevalence in Adults: United States, August 2021-August 2023 Key findings Data from the National Health and Nutrition Examination Survey. Published online 2021. Accessed July 30, 2025. https://www.cdc.gov/nchs/products/index.htm.

110. Beckett A, Scott JR, Chater AM, Ferrandino L, Aldous JWF. The Prevalence of Metabolic Syndrome and Its Components in Firefighters: A Systematic Review and Meta-Analysis. *Int J Environ Res Public Health*. 2023;20(19):6814. doi:10.3390/IJERPH20196814/S1

111. Cardiovascular diseases (CVDs). Accessed February 5, 2019. https://www.who.int/en/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)

112. Kales SN, Tsismenakis AJ, Zhang C, Soteriades ES. Blood Pressure in Firefighters, Police Officers, and Other Emergency Responders. *Am J Hypertens*. 2009;22(1):11-20. doi:10.1038/ajh.2008.296

113. Soteriades ES, Hauser R, Kawachi I, Liarokapis D, Christiani DC, Kales SN. *Descriptive Epidemiology Obesity and Cardiovascular Disease Risk Factors in Firefighters: A Prospective Cohort Study*.; 2005.

114. Yang J, Teehan D, Farioli A, Baur DM, Smith D, Kales SN. Sudden cardiac death among firefighters ≤45 years of age in the United States. *American Journal of Cardiology*. 2013;112(12):1962-1967. doi:10.1016/j.amjcard.2013.08.029

115. Yang J, Farioli A, Korre M, Kales SN. Modified Mediterranean Diet Score and Cardiovascular Risk in a North American Working Population. Gong Y, ed. *PLoS One*. 2014;9(2):e87539. doi:10.1371/journal.pone.0087539

116. Pereira MA, Kartashov AI, Ebbeling CB, et al. Fast-food habits, weight gain, and insulin resistance (the CARDIA study): 15-year prospective analysis. *Lancet*. 2005;365(9453):36-42. doi:10.1016/S0140-6736(04)17663-0

117. Esquirol Y, Bongard V, Mabile L, Jonnier B, Soulat JM, Perret B. Shift work and metabolic syndrome: Respective impacts of job strain, physical activity, and dietary rhythms. *Chronobiol Int*. 2009;26(3):544-559. doi:10.1080/07420520902821176

118. Sire T, Carbonneau N, Houle J, Trudeau F, Gendron P. Factors Related to Firefighters' Food Behaviors at the Fire Station: A Quantitative Study. *J Occup Environ Med*. 2024;66(11). doi:10.1097/JOM.0000000000003214

119. Easton M, Kraus K. A Study on the Impact of Diet on Unified Fire Authority Firefighter Performance. *Curiosity: Interdisciplinary Journal of Research and Innovation*. Published online June 8, 2023. doi:10.36898/001C.77823

120. The Mediterranean diet: (EUFIC). Accessed June 24, 2020. https://www.eufic.org/en/healthy-living/article/the-mediterranean-diet?gclid=CjwKCAjw88v3BRBFEiwApwLevc-P49mYLKXkgkJcl1VLxzsYribBD-OM7vhxDTLd9TLYOrlcSoksHRoCeT0QAvD_BwE

121. Delgado-Lista J, I. A, Perez-Martinez P, Garcia-Rios A, Lopez-Miranda J, Perez-Jimenez F. Mediterranean Diet and Cardiovascular Risk. In: *Cardiovascular Risk Factors*. InTech; 2012. doi:10.5772/31016

122. de Lorgeril M, Salen P, Martin JL, Monjaud I, Delaye J, Mamelle N. Mediterranean diet, traditional risk factors, and the rate of cardiovascular complications after myocardial infarction: final report of the Lyon Diet Heart

Study. *Circulation*. 1999;99(6):779-785. Accessed February 26, 2019. http://www.ncbi.nlm.nih.gov/pubmed/9989963

123. Dietary Health | USDA. Accessed April 28, 2022. https://www.usda.gov/topics/food-and-nutrition/dietary-health

124. Yang J, Farioli A, Korre M, Kales SN. Dietary preferences and nutritional information needs among career firefighters in the United States. *Glob Adv Health Med*. 2015;4(4):16-23. doi:10.7453/gahmj.2015.050

125. Bucher Della Torre S, Wild P, Dorribo V, Amati F, Danuser B. Eating Habits of Professional Firefighters. *J Occup Environ Med*. 2019;61(5):e183-e190. doi:10.1097/JOM.0000000000001565

126. Joe MJ, Hatsu IE, Tefft A, Mok S, Adetona O. Dietary Behavior and Diet Interventions among Structural Firefighters: A Narrative Review. *Nutrients 2022, Vol 14, Page 4662*. 2022;14(21):4662. doi:10.3390/NU14214662

127. Sotos-Prieto M, Cash SB, Christophi C, et al. Rationale and design of feeding America's bravest: Mediterranean diet-based intervention to change firefighters' eating habits and improve cardiovascular risk profiles. *Contemp Clin Trials*. 2017;61:101-107. doi:10.1016/J.CCT.2017.07.010

128. M. Muegge C, M. Kleinschmidt V, A. Johnson K, et al. Focus groups to inform a nutrition intervention for career firefighters. *Clinical Nutrition and Metabolism*. 2018;1(2). doi:10.15761/cnm.1000108

129. Hernáez Á, Castañer O, Elosua R, et al. Mediterranean Diet Improves High-Density Lipoprotein Function in High-Cardiovascular-Risk Individuals. *Circulation*. 2017;135(7):633-643. doi:10.1161/CIRCULATIONAHA.116.023712

130. Filippou CD, Thomopoulos CG, Kouremeti MM, et al. Mediterranean diet and blood pressure reduction in adults with and without hypertension: A systematic review and meta-analysis of randomized controlled trials. *Clinical Nutrition*. 2021;40(5):3191-3200. doi:10.1016/j.clnu.2021.01.030

131. Cowell OR, Mistry N, Deighton K, et al. Effects of a Mediterranean diet on blood pressure: A systematic review and meta-Analysis of randomized controlled trials

and observational studies. *J Hypertens*. 2021;39(4):729-739. doi:10.1097/HJH.0000000000002667,

132. Davis CR, Hodgson JM, Woodman R, Bryan J, Wilson C, Murphy KJ. A Mediterranean diet lowers blood pressure and improves endothelial function: Results from the MedLey randomized intervention trial. *American Journal of Clinical Nutrition*. 2017;105(6):1305-1313. doi:10.3945/AJCN.116.146803,

133. Lăcătușu CM, Grigorescu ED, Floria M, Onofriescu A, Mihai BM. The mediterranean diet: From an environment-driven food culture to an emerging medical prescription. *Int J Environ Res Public Health*. 2019;16(6). doi:10.3390/ijerph16060942

134. Grotto D, Zied E. The standard American diet and its relationship to the health status of Americans. *Nutrition in Clinical Practice*. 2010;25(6):603-612. doi:10.1177/0884533610386234

135. USDA ERS - Food Availability and Consumption. Accessed June 24, 2020. https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/food-availability-and-consumption/

136. Micha R, Wallace SK, Mozaffarian D. Red and processed meat consumption and risk of incident coronary heart disease, stroke, and diabetes mellitus: A systematic review and meta-analysis. *Circulation*. 2010;121(21):2271-2283. doi:10.1161/CIRCULATIONAHA.109.924977

137. Aune D, Ursin G, Veierød MB. Meat consumption and the risk of type 2 diabetes: A systematic review and meta-analysis of cohort studies. *Diabetologia*. 2009;52(11):2277-2287. doi:10.1007/s00125-009-1481-x

138. WHO | Obesity and overweight. *WHO*. Published online 2017. Accessed January 30, 2018. http://www.who.int/mediacentre/factsheets/fs311/en/

139. Sorriento D, Iaccarino G. Inflammation and Cardiovascular Diseases: The Most Recent Findings. *Int J Mol Sci*. 2019;20(16). doi:10.3390/IJMS20163879

140. Motlagh AD, Rezaei M, Tajary Z, et al. Association between the empirical dietary inflammatory index and musculoskeletal pain in community-dwelling

older adults: a cross-sectional study. *Osong Public Health Res Perspect*. 2023;14(1):51-58. doi:10.24171/j.phrp.2022.0194

141. Clemente-Suárez VJ, Mielgo-Ayuso J, Martín-Rodríguez A, Ramos-Campo DJ, Redondo-Flórez L, Tornero-Aguilera JF. The Burden of Carbohydrates in Health and Disease. *Nutrients*. 2022;14(18). doi:10.3390/NU14183809

142. Tan BL, Norhaizan ME, Liew WPP. Nutrients and Oxidative Stress: Friend or Foe? *Oxid Med Cell Longev*. 2018;2018. doi:10.1155/2018/9719584

143. Diet, Inflammation, and Health - 1st Edition. Accessed August 24, 2023. https://shop.elsevier.com/books/diet-inflammation-and-health/hebert/978-0-12-822130-3

144. Vahid F, Bohn T, Chiriboga D, Hébert JR. Diet, inflammation, and cardiovascular disease. *Diet, Inflammation, and Health*. Published online January 1, 2022:367-472. doi:10.1016/B978-0-12-822130-3.00015-6

145. Phillips CM, Chen LW, Heude B, et al. Dietary Inflammatory Index and Non-Communicable Disease Risk: A Narrative Review. *Nutrients*. 2019;11:1873. doi:10.3390/nu11081873

146. Marx W, Veronese N, Kelly JT, et al. The Dietary Inflammatory Index and Human Health: An Umbrella Review of Meta-Analyses of Observational Studies. doi:10.1093/advances/nmab037

147. Zhao L, Wirth MD, Petermann-Rocha F, et al. Diet-Related Inflammation Is Associated with Worse COVID-19 Outcomes in the UK Biobank Cohort. *Nutrients*. 2023;15(4):884. doi:10.3390/NU15040884/S1

148. Manzano M, Talavera-Rodríguez A, Moreno E, et al. Relationship of Diet to Gut Microbiota and Inflammatory Biomarkers in People with HIV. *Nutrients*. 2022;14(6). doi:10.3390/NU14061221

149. Vahid F, Shivappa N, Faghfoori Z, et al. Validation of a Dietary Inflammatory Index (DII) and Association with Risk of Gastric Cancer: a Case-Control Study. *Asian Pac J Cancer Prev*. 2018;19(6):1471. doi:10.22034/APJCP.2018.19.6.1471

150. Shivappa N, Hebert JR, Marcos A, et al. Association between dietary inflammatory index and inflammatory markers in the HELENA study. *Mol Nutr Food Res*. 2017;61(6). doi:10.1002/MNFR.201600707

151. Hébert JR, Shivappa N, Wirth MD, Hussey JR, Hurley TG. Perspective: The Dietary Inflammatory Index (DII)—Lessons Learned, Improvements Made, and Future Directions. *Advances in Nutrition*. 2019;10(2):185. doi:10.1093/ADVANCES/NMY071

152. Hébert JR, Shivappa N, Wirth MD, Hussey JR, Hurley TG. Perspective: The Dietary Inflammatory Index (DII)-Lessons Learned, Improvements Made, and Future Directions. Published online 2019. doi:10.1093/advances/nmy071

153. Hebert JR. What constitutes an anti-inflammatory diet? How does this contrast with a pro-inflammatory diet? In: Hebert JR, Hofseth LJ, eds. *Diet, Inflammation, and Health*. Academic Press/ Elsevier; 2022:787-818.

154. Hebert JR. Methods and tools used to describe and quantify the associations between diet, inflammation and health. In: Hebert JR, Hofseth LJ, eds. *Diet, Inflammation, and Health*. Academic Press/ Elsevier; 2022:163-226.

155. Millar SR, Navarro P, Harrington JM, et al. Dietary score associations with markers of chronic low-grade inflammation: a cross-sectional comparative analysis of a middle- to older-aged population. *Eur J Nutr*. 2022;61(7):3377-3390. doi:10.1007/S00394-022-02892-1/TABLES/4

156. Pieczyńska J, Płaczkowska S, Pawlik-Sobecka L, Kokot I, Sozański R, Grajeta H. Association of Dietary Inflammatory Index with Serum IL-6, IL-10, and CRP Concentration during Pregnancy. *Nutrients*. 2020;12(9):1-14. doi:10.3390/NU12092789

157. Yang Y, Hozawa A, Kogure M, et al. Dietary Inflammatory Index Positively Associated With High-Sensitivity C-Reactive Protein Level in Japanese From NIPPON DATA2010. *J Epidemiol*. 2020;30(2):98. doi:10.2188/JEA.JE20180156

158. Li J, Lee DH, Hu J, et al. Dietary Inflammatory Potential and Risk of Cardiovascular Disease Among Men and Women in the U.S. *J Am Coll Cardiol*.

2020;76(19):2181-2193. doi:10.1016/J.JACC.2020.09.535/SUPPL_FILE/MMC1.DOCX

159. S Eid NM, Albadri AR, Alshobragi K, Sharqawi N, Albar R, Altaf A. Saudi Arabia in the year 2017. *Journal of Food and Nutrition Research*. 2018;6(3):137-145. doi:10.12691/jfnr-6-3-1

160. Shamshirgardi E, Najafitirehshabankareh F, Haghighat N, et al. Correlation between Dietary Inflammatory Index (DII) and Neck Circumference (NC) in Coronary Artery Disease Patients. *J Health Sci Surveill Syst*. 2022;10(2):197-202. doi:10.30476/JHSSS.2021.92877.1397

161. Shivappa N, Godos J, Hébert JR, et al. Dietary Inflammatory Index and Cardiovascular Risk and Mortality-A Meta-Analysis. doi:10.3390/nu10020200

162. Hodge AM, Bassett JK, Dugué PA, et al. Dietary inflammatory index or Mediterranean diet score as risk factors for total and cardiovascular mortality. *Nutrition, Metabolism and Cardiovascular Diseases*. 2018;28(5):461-469. doi:10.1016/J.NUMECD.2018.01.010

163. Ramallal R, Toledo E, Martínez-González MA, et al. Dietary Inflammatory Index and Incidence of Cardiovascular Disease in the SUN Cohort. *PLoS One*. 2015;10(9):e0135221. doi:10.1371/JOURNAL.PONE.0135221

164. Shivappa N, Hébert JR, Rosato V, Montella M, Serraino D, La Vecchia C. Association between the dietary inflammatory index and breast cancer in a large Italian case-control study. *Mol Nutr Food Res*. 2017;61(3). doi:10.1002/MNFR.201600500

165. Shivappa N, Schoenaker DAJM, Hebert JR, Mishra GD. Association between inflammatory potential of diet and risk of depression in middle-aged women: the Australian Longitudinal Study on Women's Health. *Br J Nutr*. 2016;116(6):1077-1086. doi:10.1017/S0007114516002853

166. Park SY, Kang M, Wilkens LR, et al. The Dietary Inflammatory Index and All-Cause, Cardiovascular Disease, and Cancer Mortality in the Multiethnic Cohort Study. *Nutrients*. 2018;10(12):1844. doi:10.3390/NU10121844

167. Nikniaz L, Nikniaz Z, Shivappa N, Hébert JR. The association between dietary inflammatory index and metabolic syndrome components in Iranian adults. *Prim Care Diabetes*. 2018;12(5):467-472. doi:10.1016/J.PCD.2018.07.008

168. Smith DL, Haller JM, Korre M, et al. Pathoanatomic findings associated with duty-related cardiac death in US firefighters: A case-control study. *J Am Heart Assoc*. 2018;7(18). doi:10.1161/JAHA.118.009446

169. Elpidoforos S. Soteriades RHIKDCCSNK. Obesity and risk of job disability in male firefighters. *Occup Med (Lond)*. 2016;1(12):79-82. doi:10.1093/occmed

170. Yang J, Teehan D, Farioli A, Baur DM, Smith D, Kales SN. Sudden Cardiac Death Among Firefighters ≤45 Years of Age in the United States. *Am J Cardiol*. 2013;112(12):1962-1967. doi:10.1016/j.amjcard.2013.08.029

171. Vatandoost A, Azadbakht L, Morvaridi M, Kabir A, Farsani GM. Association between Dietary Inflammatory Index and Risk of Cardiovascular Diseases Among Firefighters. *Int J Prev Med*. 2020;11(1). doi:10.4103/IJPVM.IJPVM_256_19

172. Christodoulou A, Christophi CA, Sotos-Prieto M, Moffatt S, Kales SN. Eating Habits among US Firefighters and Association with Cardiometabolic Outcomes. *Nutrients*. 2022;14(13). doi:10.3390/nu14132762

173. Yang J, Farioli A, Korre M, Kales SN. Dietary preferences and nutritional information needs among career firefighters in the United States. *Glob Adv Health Med*. 2015;4(4):16-23. doi:10.7453/gahmj.2015.050

174. Poston WSC, Haddock CK, Jahnke SA, Jitnarin N, Tuley BC, Kales SN. The prevalence of overweight, obesity, and substandard fitness in a population-based firefighter cohort. *J Occup Environ Med*. 2011;53(3):266-273. doi:10.1097/JOM.0B013E31820AF362,

175. Donahue S, McMorrow C, Almeida AA, Feairheller DL. Feasibility and Perception of a Diet and Exercise Intervention Delivered via Telehealth to Firefighters. *Int J Telerehabil*. 2022;14(1). doi:10.5195/IJT.2022.6458

176. Sokol A, Wirth MD, Manczuk M, et al. Association between the dietary inflammatory index, waist-to-hip ratio and metabolic syndrome. *Nutrition Research*. 2016;36(11):1298-1303. doi:10.1016/j.nutres.2016.04.004

177. Nettleton JA, Steffen LM, Mayer-Davis EJ, et al. Dietary patterns are associated with biochemical markers of inflammation and endothelial activation in the Multi-Ethnic Study of Atherosclerosis (MESA). *American Journal of Clinical Nutrition*. 2006;83(6):1369-1379. doi:10.1093/ajcn/83.6.1369

178. Sethi JK, Hotamisligil GS. Metabolic Messengers: tumour necrosis factor. *Nature Metabolism 2021 3:10*. 2021;3(10):1302-1312. doi:10.1038/s42255-021-00470-z

179. Cawthorn WP, Sethi JK. TNF-α and adipocyte biology. *FEBS Lett*. 2007;582(1):117. doi:10.1016/J.FEBSLET.2007.11.051

180. Neufcourt L, Assmann KE, Fezeu LK, et al. Prospective association between the dietary inflammatory index and metabolic syndrome: Findings from the SU.VI.MAX study. *Nutrition, Metabolism and Cardiovascular Diseases*. 2015;25(11):988-996. doi:10.1016/J.NUMECD.2015.09.002

181. Willerson JT, Ridker PM. Inflammation as a cardiovascular risk factor. *Circulation*. 2004;109(21 SUPPL.). doi:10.1161/01.CIR.0000129535.04194.38/ASSET/AA1EDDBB-EDB3-4B73-84C9-1B924A7D2EEF/ASSETS/GRAPHIC/2FF5.JPEG

182. Alfaddagh A, Martin SS, Leucker TM, et al. Inflammation and cardiovascular disease: From mechanisms to therapeutics. *Am J Prev Cardiol*. 2020;4:100130. doi:10.1016/J.AJPC.2020.100130

183. Soteriades ES, Hauser R, Kawachi I, Liarokapis D, Christiani DC, Kales SN. Obesity and cardiovascular disease risk factors in firefighters: A prospective cohort study. *Obes Res*. 2005;13(10):1756-1763. doi:10.1038/oby.2005.214

184. de Ridder D, Kroese F, Evers C, Adriaanse M, Gillebaart M. Healthy diet: Health impact, prevalence, correlates, and interventions. *Psychol Health*. 2017;32(8):907-941. doi:10.1080/08870446.2017.1316849

185. Baghdadi G, Feyzpour M, Shahrokhi SA, Amiri R, Rahimlou M. The association between the Mediterranean Diet and the prime diet quality score and new-

diagnosed irritable bowel syndrome: a matched case-control study. *Front Med (Lausanne)*. 2025;12:1529374. doi:10.3389/FMED.2025.1529374

186. Neuhouser ML. The importance of healthy dietary patterns in chronic disease prevention. *Nutrition Research*. 2019;70:3-6. doi:10.1016/J.NUTRES.2018.06.002

187. Sam-Yellowe TY. Nutritional Barriers to the Adherence to the Mediterranean Diet in Non-Mediterranean Populations. *Foods*. 2024;13(11):1750. doi:10.3390/FOODS13111750

188. Collins AR. Antioxidant intervention as a route to cancer prevention. *Eur J Cancer*. 2005;41(13):1923-1930. doi:10.1016/J.EJCA.2005.06.004

189. Bennett LL, Rojas S, Seefeldt T. Role of Antioxidants in the Prevention of Cancer. *J Exp Clin Med*. 2012;4(4):215-222. doi:10.1016/J.JECM.2012.06.001

190. Gershuni VM. Saturated Fat: Part of a Healthy Diet. *Curr Nutr Rep*. 2018;7(3):85-96. doi:10.1007/S13668-018-0238-X/METRICS

191. Pant A, Chew DP, Mamas MA, Zaman S. Cardiovascular Disease and the Mediterranean Diet: Insights into Sex-Specific Responses. *Nutrients*. 2024;16(4):570. doi:10.3390/NU16040570

192. Widmer RJ, Flammer AJ, Lerman LO, Lerman A. "The Mediterranean Diet, its Components, and Cardiovascular Disease." *Am J Med*. 2014;128(3):229. doi:10.1016/J.AMJMED.2014.10.014

193. Bonaccio M, Costanzo S, Di Castelnuovo A, et al. Increased Adherence to a Mediterranean Diet Is Associated With Reduced Low-Grade Inflammation after a 12.7-Year Period: Results From the Moli-sani Study. *J Acad Nutr Diet*. 2023;123(5):783-795.e7. doi:10.1016/j.jand.2022.12.005

194. Agarwal P, Leurgans SE, Agrawal S, et al. Association of Mediterranean-DASH Intervention for Neurodegenerative Delay and Mediterranean Diets With Alzheimer Disease Pathology. *Neurology*. 2023;100(22):E2259-E2268. doi:10.1212/WNL.0000000000207176

195. MIND and Mediterranean diets linked to fewer signs of Alzheimer's brain pathology | National Institute on Aging. Accessed March 17, 2025.

https://www.nia.nih.gov/news/mind-and-mediterranean-diets-linked-fewer-signs-alzheimers-brain-pathology

196. Guo X, Park Y, Freedman ND, et al. Sweetened beverages, coffee, and tea and depression risk among older US adults. *PLoS One*. 2014;9(4). doi:10.1371/JOURNAL.PONE.0094715

197. Firth J, Gangwisch JE, Gangwisch JE, et al. Food and mood: how do diet and nutrition affect mental wellbeing? *BMJ*. 2020;369. doi:10.1136/BMJ.M2382

198. Allcock L, Mantzioris E, Villani A. Adherence to a Mediterranean Diet is associated with physical and cognitive health: A cross-sectional analysis of community-dwelling older Australians. *Front Public Health*. 2022;10:1017078. doi:10.3389/FPUBH.2022.1017078

199. Lv J, Yu C, Guo Y, et al. Adherence to Healthy Lifestyle and Cardiovascular Diseases in the Chinese Population. *J Am Coll Cardiol*. 2017;69(9):1116-1125. doi:10.1016/J.JACC.2016.11.076

200. Martín Payo R, Suárez Álvarez J, Amieva Fernández ME, Duaso MJ, Álvarez Gómez E. Adherence to healthy diet and physical activity in clinical patients. *Psicothema, 28(4)*. Published online 2016. doi:10.7334/psicothema2016.227

201. Abrignani V, Salvo A, Pacinella G, Tuttolomondo A. The Mediterranean Diet, Its Microbiome Connections, and Cardiovascular Health: A Narrative Review. *Int J Mol Sci*. 2024;25(9):4942. doi:10.3390/IJMS25094942

202. Taylor MK, Sullivan DK, Ellerbeck EF, Gajewski BJ, Gibbs HD. Nutrition literacy predicts adherence to healthy/unhealthy diet patterns in adults with a nutrition-related chronic condition. *Public Health Nutr*. 2019;22(12):2157-2169. doi:10.1017/S1368980019001289

203. Rosato V, Temple NJ, La Vecchia C, Castellan G, Tavani A, Guercio V. Mediterranean diet and cardiovascular disease: a systematic review and meta-analysis of observational studies. *Eur J Nutr*. 2019;58(1):173-191. doi:10.1007/S00394-017-1582-0

204. Taylor RM, Haslam RL, Herbert J, et al. Diet quality and cardiovascular outcomes: A systematic review and meta-analysis of cohort studies. *Nutr Diet*. 2024;81(1):35-50. doi:10.1111/1747-0080.12860

205. Levitan EB, Ahmed A, Arnett DK, et al. Mediterranean diet score and left ventricular structure and function: the Multi-Ethnic Study of Atherosclerosis. *Am J Clin Nutr*. 2016;104(3):595. doi:10.3945/AJCN.115.128579

206. Tryfonos C, Chrysafi M, Papadopoulou SK, et al. Association of Mediterranean diet adherence with disease progression, quality of life and physical activity, sociodemographic and anthropometric parameters, and serum biomarkers in community-dwelling older adults with multiple sclerosis: a cross-sectional study. *Aging Clin Exp Res*. 2024;36(1):73. doi:10.1007/S40520-024-02712-Y

207. Schröder H, Zomeño MD, Martínez-González MA, et al. Validity of the energy-restricted Mediterranean Diet Adherence Screener. *Clinical Nutrition*. 2021;40(8):4971-4979. doi:10.1016/J.CLNU.2021.06.030

208. Papadaki A, Johnson L, Toumpakari Z, et al. Validation of the English Version of the 14-Item Mediterranean Diet Adherence Screener of the PREDIMED Study, in People at High Cardiovascular Risk in the UK. *Nutrients*. 2018;10(2). doi:10.3390/NU10020138

209. Sotos-Prieto M, Ortolá R, Ruiz-Canela M, et al. Association between the Mediterranean lifestyle, metabolic syndrome and mortality: a whole-country cohort in Spain. *Cardiovasc Diabetol*. 2021;20(1):5. doi:10.1186/S12933-020-01195-1

210. Chiriacò M, Tubili C, Bo S, et al. Critical evaluation of the questionnaires assessing adherence to the Mediterranean diet that are based on servings. *Nutrition, Metabolism and Cardiovascular Diseases*. 2023;33(4):724-736. doi:10.1016/J.NUMECD.2023.01.024

211. Finicelli M, Di Salle A, Galderisi U, Peluso G. The Mediterranean Diet: An Update of the Clinical Trials. *Nutrients*. 2022;14(14):2956. doi:10.3390/NU14142956

212. Romagnolo DF, Selmin OI. Mediterranean Diet and Prevention of Chronic Diseases. *Nutr Today*. 2017;52(5):208. doi:10.1097/NT.0000000000000228

213. Bach-Faig A, Berry EM, Lairon D, et al. Mediterranean diet pyramid today. Science and cultural updates. *Public Health Nutr*. 2011;14(12A):2274-2284. doi:10.1017/S1368980011002515,

214. Esposito K, Kastorini CM, Panagiotakos DB, Giugliano D. Mediterranean diet and metabolic syndrome: An updated systematic review. *Rev Endocr Metab Disord*. 2013;14(3):255-263. doi:10.1007/S11154-013-9253-9,

215. Estruch R, Ros E, Salas-Salvadó J, et al. Primary Prevention of Cardiovascular Disease with a Mediterranean Diet Supplemented with Extra-Virgin Olive Oil or Nuts. *New England Journal of Medicine*. 2018;378(25). doi:10.1056/NEJMOA1800389,

216. Salas-Salvadó J, Bulló M, Babio N, et al. Reduction in the incidence of type 2 diabetes with the mediterranean diet: Results of the PREDIMED-Reus nutrition intervention randomized trial. *Diabetes Care*. 2011;34(1):14-19. doi:10.2337/DC10-1288,

217. Neuenschwander M, Hoffmann G, Schwingshackl L, Schlesinger S. Impact of different dietary approaches on blood lipid control in patients with type 2 diabetes mellitus: a systematic review and network meta-analysis. *Eur J Epidemiol*. 2019;34(9):837-852. doi:10.1007/S10654-019-00534-1,

218. Kastorini CM, Milionis HJ, Esposito K, Giugliano D, Goudevenos JA, Panagiotakos DB. The Effect of Mediterranean Diet on Metabolic Syndrome and its Components: A Meta-Analysis of 50 Studies and 534,906 Individuals. *J Am Coll Cardiol*. 2011;57(11):1299-1313. doi:10.1016/J.JACC.2010.09.073

219. Martín-Peláez S, Fito M, Castaner O. Mediterranean Diet Effects on Type 2 Diabetes Prevention, Disease Progression, and Related Mechanisms. A Review. *Nutrients*. 2020;12(8):2236. doi:10.3390/NU12082236

220. Abbate M, Gallardo-Alfaro L, Bibiloni M del M, Tur JA. Efficacy of dietary intervention or in combination with exercise on primary prevention of cardiovascular disease: A systematic review. *Nutrition, Metabolism and*

Cardiovascular Diseases. 2020;30(7):1080-1093. doi:10.1016/j.numecd.2020.02.020

221. Elmskini FZ, Bouh A, Labyad A, et al. Increased nutrition knowledge and adherence to the Mediterranean diet are associated with lower body mass index and better self-rated general health among university students. *Human Nutrition & Metabolism*. 2024;35:200240. doi:10.1016/J.HNM.2024.200240

222. Maltarić M, Ruščić P, Kolak M, et al. Adherence to the Mediterranean Diet Related to the Health Related and Well-Being Outcomes of European Mature Adults and Elderly, with an Additional Reference to Croatia. *International Journal of Environmental Research and Public Health 2023, Vol 20, Page 4893*. 2023;20(6):4893. doi:10.3390/IJERPH20064893

223. Hershey MS, Chang CR, Sotos-Prieto M, et al. Effect of a Nutrition Intervention on Mediterranean Diet Adherence among Firefighters: A Cluster Randomized Clinical Trial. *JAMA Netw Open*. 2023;6(8):E2329147. doi:10.1001/JAMANETWORKOPEN.2023.29147

224. Kyriacou A, Evans JMM, Economides N, Kyriacou A. Adherence to the Mediterranean diet by the Greek and Cypriot population: A systematic review. *Eur J Public Health*. 2015;25(6):1012-1018. doi:10.1093/EURPUB/CKV124,

APPENDIX I

Food Frequency Questionnaire

HARVARD UNIVERSITY — **Dietary Assessment** — DA80 Printed in U.S.A. — Page 1

Please use #2 pencil only.

ID: ☐☐☐☐☐☐ — ☐☐

1. Do you currently take multi-vitamins? (Please report other individual vitamins in the next section.)

◯ No
◯ Yes ➤ a) How many do you take per week? ◯ 2 or less ◯ 3–5 ◯ 6–9 ◯ 10 or more
b) What specific brand (or equivalency) do you usually take?
◯ Centrum Silver ◯ Centrum ◯ Other ➤ e.g., AARP Alphabet II Formula 643 Multivitamins and Minerals
◯ Theragran M ◯ One-A-Day Essential

Not counting multi-vitamins, do you take any of the following preparations?

a) Vitamin A	◯ No	◯ Yes, seasonal only ◯ Yes, most months	If Yes,	Dose per day:	◯ Less than 10,000 IU	◯ 10,000 to 15,000 IU	◯ 16,000 to 22,000 IU	◯ 23,000 IU or more	◯ Don't know
b) Potassium	◯ No	◯ Yes	If Yes,	Dose per day:	◯ Less than 2.5 mEq (100 mg)	◯ 3 to 10 mEq	◯ 11 to 20 mEq	◯ 21 mEq or more	◯ Don't know
c) Vitamin C	◯ No	◯ Yes, seasonal only ◯ Yes, most months	If Yes,	Dose per day:	◯ Less than 400 mg	◯ 400 to 700 mg	◯ 750 to 1250 mg	◯ 1300 mg or more	◯ Don't know
d) Vitamin B_6	◯ No	◯ Yes	If Yes,	Dose per day:	◯ Less than 50 mg	◯ 50 to 99 mg	◯ 100 to 149 mg	◯ 150 mg or more	◯ Don't know
e) Vitamin E	◯ No	◯ Yes	If Yes,	Dose per day:	◯ Less than 100 IU	◯ 100 to 250 IU	◯ 300 to 500 IU	◯ 600 IU or more	◯ Don't know
				Type: ◯ Natural	◯ Regular (dl)	◯ Unknown			
f) Calcium (Include Calcium in Tums, etc.)	◯ No	◯ Yes	If Yes,	Dose per day (elemental calcium):	◯ Less than 600 mg	◯ 600 to 900 mg	◯ 901 to 1500 mg	◯ 1501 mg or more	◯ Don't know
g) Selenium	◯ No	◯ Yes	If Yes,	Dose per day:	◯ Less than 80 mcg	◯ 80 to 130 mcg	◯ 140 to 250 mcg	◯ 260 mcg or more	◯ Don't know
h) Vitamin D (In calcium supplement or separately)	◯ No	◯ Yes, seasonal only ◯ Yes, most months	If Yes,	Dose per day:	◯ Less than 300 IU	◯ 300 to 500 IU	◯ 600 to 900 IU	◯ 1000 IU or more	◯ Don't know
i) Zinc	◯ No	◯ Yes	If Yes,	Dose per day:	◯ Less than 25 mg	◯ 25 to 74 mg	◯ 75 to 100 mg	◯ 101 mg or more	◯ Don't know

2. Are there other supplements that you take on a regular basis?

◯ Metamucil/Citrucel ◯ Flax Seed ◯ Niacin ◯ Choline ◯ DHEA
◯ Cod Liver Oil ◯ Beta-carotene ◯ Chromium ◯ Folic Acid ◯ Iron ◯ Other (Please specify)
◯ Vitamin B_{12} ◯ Magnesium ◯ Lecithin ◯ B-Complex
◯ Flax Seed Oil ◯ Fish oil ◯ Coenzyme Q_{10} ◯ Lycopene

3. How many teaspoons of sugar do you add to your beverages or food each day? ➤ ____ tsp.

4. What brand and type of cold breakfast cereal do you usually eat? ➤ Specify cereal brand & type (e.g., Kellogg's Raisin Bran)

◯ Don't eat cold breakfast cereal.

5. What form of margarine or spread do you usually use (exclude pure butter)? ➤ What specific brand & type of margarine (e.g., Shedd's Country Crock plus calcium and vitamins)

◯ None **Form?** ◯ Stick ◯ Tub ◯ Spray ◯ Squeeze (liquid)
Type? ◯ Reg ◯ Light ◯ Nonfat

6. For each food listed, fill in the circle indicating how often on average you have used the amount specified during the past year.

DAIRY FOODS		Never, or less than once per month	1–3 per month	1 per week	2–4 per week	5–6 per week	1 per day	2–3 per day	4–5 per day	6+ per day
Milk (8 oz. glass)	Skim milk	◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
	1 or 2 % milk	◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
	Whole milk	◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
	Soy milk	◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
Cream, e.g., coffee, whipped or sour cream (1 Tbs)		◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
Non-dairy coffee whitener (1 Tbs)		◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
Frozen yogurt, sherbet or low-fat ice cream (1 cup)		◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
Regular ice cream (1 cup)		◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
Yogurt (1 cup)	Low-carb, artificially sweetened or plain	◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
	Sweetened–with fruit or other flavoring	◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
Spreads added to food or bread; exclude use in cooking	Margarine	◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
	Pure Butter	◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
Cottage or ricotta cheese (1/2 cup)		◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
Cream cheese (1 oz.)		◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯
Other cheese, e.g., American, cheddar, etc., plain or as part of a dish (1 slice or 1 oz. serving)		◯	◯	Ⓦ	◯	◯	Ⓓ	◯	◯	◯

➤ **What type of cheese do you usually eat?** ◯ Soy ◯ Regular ◯ Low fat or Lite ◯ Nonfat ◯ None

6. ***(continued)*** **For each food listed, fill in the circle indicating how often on average you have used the amount specified during the past year.**

Please try to average your seasonal use of foods over the entire year. For example, if a food such as cantaloupe is eaten 4 times a week during the approximate 3 months that it is in season, then the average use would be once per week.

FRUITS	Never, or less than once per month	1–3 per month	1 per week	2–4 per week	5–6 per week	1 per day	2–3 per day	4–5 per day	6+ per day	P
Raisins (1 oz. or small pack) or grapes (1/2 cup)			W			D				
Prunes or dried plums (6 prunes or 1/4 cup)			W			D				
Prune juice (small glass)			W			D				
Bananas (1)			W			D				
Cantaloupe (1/4 melon)			W			D				
Avocado (1/2 fruit or 1/2 cup)			W			D				
Fresh apples or pears (1)			W			D				
Apple juice or cider (small glass)			W			D				
Oranges (1)			W			D				
Orange juice (small glass) – Calcium fortified			W			D				
Orange juice (small glass) – Regular (not calcium fortified)			W			D				
Grapefruit (1/2) or grapefruit juice (small glass)			W			D				
Other fruit juices (small glass)			W			D				
Strawberries, fresh, frozen or canned (1/2 cup)			W			D				
Blueberries, fresh, frozen or canned (1/2 cup)			W			D				
Peaches or plums (1 fresh or 1/2 cup canned)			W			D				
Apricots (1 fresh, 1/2 cup canned or 5 dried)			W			D				

VEGETABLES	Never, or less than once per month	1–3 per month	1 per week	2–4 per week	5–6 per week	1 per day	2–3 per day	4–5 per day	6+ per day	P
Tomatoes (2 slices)			W			D				
Tomato or V-8 juice (small glass)			W			D				
Tomato sauce (1/2 cup) e.g., spaghetti sauce			W			D				
Salsa, picante or taco sauce (1/4 cup)			W			D				
String beans (1/2 cup)			W			D				
Beans or lentils, baked, dried or soup (1/2 cup)			W			D				
Tofu, soy burger, soybeans, miso or other soy protein			W			D				
Peas or lima beans (1/2 cup fresh, frozen, canned)			W			D				
Broccoli (1/2 cup)			W			D				
Cauliflower (1/2 cup)			W			D				
Cabbage or coleslaw (1/2 cup)			W			D				
Brussels sprouts (1/2 cup)			W			D				
Carrots, raw (1/2 carrot or 2–4 sticks)			W			D				
Carrots, cooked (1/2 cup) or carrot juice (2–3 oz.)			W			D				
Corn (1 ear or 1/2 cup frozen or canned)			W			D				
Mixed or stir-fry vegetables (1/2 cup), veg. soup (1 cup)			W			D				
Yams or sweet potatoes (1/2 cup)			W			D				
Dark orange (winter) squash (1/2 cup)			W			D				
Eggplant, zucchini or other summer squash (1/2 cup)			W			D				
Kale, mustard greens or chard (1/2 cup)			W			D				
Spinach, cooked (1/2 cup)			W			D				
Spinach, raw as in salad (1 cup)			W			D				
Iceberg or head lettuce (1 serving)			W			D				
Romaine or leaf lettuce (1 serving)			W			D				
Celery (2–3 sticks)			W			D				
Peppers: green, yellow or red (3 slices)			W			D				
Onions as a garnish or in salad (1 slice)			W			D				
Onions as a cooked vegetable, rings or soup (1/2 cup)			W			D				

EGGS, MEAT, ETC.	Never, or less than once per month	1–3 per month	1 per week	2–4 per week	5–6 per week	1 per day	2–3 per day	4–5 per day	6+ per day	P
Eggs (1) – Omega-3 fortified including yolk			W			D				
Eggs (1) – Regular eggs including yolk			W			D				
Beef or pork hot dogs (1)			W			D				
Chicken or turkey hot dogs or sausage (1)			W			D				
Chicken/turkey sandwich or frozen dinner			W			D				
Other chicken or turkey, with skin (3 oz.)			W			D				
Other chicken or turkey, without skin (3 oz.)- including ground			W			D				
Bacon (2 slices)			W			D				

6. ***(continued)*** **For each food listed, fill in the circle indicating how often on average you have used the amount specified during the past year.**

EGGS, MEAT, ETC.	Never, or less than once per month	1–3 per month	1 per week	2–4 per week	5–6 per week	1 per day	2–3 per day	4–5 per day	6+ per day
Salami, bologna, or other processed meat sandwiches			W			D			
Other processed meats, e.g., sausage, kielbasa, etc. (2 oz. or 2 small links)			W			D			
Hamburger (1 patty): Lean or extra lean			W			D			
Hamburger (1 patty): Regular			W			D			
Beef, pork, or lamb as a sandwich or mixed dish, e.g., stew, casserole, lasagna, frozen dinners, etc.			W			D			
Pork as a main dish, e.g., ham or chops (4–6 oz.)			W			D			
Beef or lamb as a main dish, e.g., steak, roast (4–6 oz.)			W			D			
Canned tuna fish (3–4 oz.)			W			D			
Breaded fish cakes, pieces, or fish sticks (1 serving, store bought)			W			D			
Shrimp, lobster, scallops as a main dish			W			D			
Dark meat fish, e.g., tuna steak, mackerel, salmon, sardines, bluefish, swordfish (3–5 oz.)			W			D			
Other fish, e.g., cod, haddock, halibut (3–5 oz.)			W			D			

BREADS, CEREALS, STARCHES	Never, or less than once per month	1–3 per month	1 per week	2–4 per week	5–6 per week	1 per day	2–3 per day	4–5 per day	6+ per day
Cold breakfast cereal (1 serving)			W			D			
Cooked oatmeal/cooked oat bran (1 cup)			W			D			
Other cooked breakfast cereal (1 cup)			W			D			
Bread (1 slice): White bread, including pita			W			D			
Bread (1 slice): Rye/Pumpernickel			W			D			
Bread (1 slice): Whole wheat, oatmeal, other whole grain			W			D			
Crackers, regular or lowfat e.g., Triscuits, Ritz (6)			W			D			
Bagels, English muffins, or rolls (1)			W			D			
Muffins or biscuits (1)			W			D			
Pancakes or waffles (2 small pieces)			W			D			
Brown rice (1 cup)			W			D			
White rice (1 cup)			W			D			
Pasta, e.g., spaghetti, noodles, couscous, etc. (1 cup)			W			D			
Tortillas (2)			W			D			
French Fries (6 oz. or 1 serving)			W			D			
Potatoes, baked, boiled (1) or mashed (1 cup)			W			D			
Potato chips or corn/tortilla chips (small bag or 1 oz.)			W			D			
Pizza (2 slices)			W			D			

CARBONATED BEVERAGES — Consider the serving size as 1 glass, bottle or can for these carbonated beverages.

BEVERAGES	Never, or less than once per month	1–3 per month	1 per week	2–4 per week	5–6 per week	1 per day	2–3 per day	4–5 per day	6+ per day
CARBONATED BEVERAGES – Low-Calorie (sugar-free) types: Low-calorie beverage with caffeine, e.g., Diet Coke, Diet Mt. Dew			W			D			
CARBONATED BEVERAGES – Low-Calorie (sugar-free) types: Other low-cal bev. without caffeine, e.g., Diet 7-Up			W			D			
CARBONATED BEVERAGES – Regular types (not sugar-free): Carbonated beverage with caffeine & sugar, e.g., Coke, Pepsi, Mt. Dew, Dr. Pepper			W			D			
CARBONATED BEVERAGES – Regular types (not sugar-free): Other carbonated beverage with sugar, e.g., 7-Up, Root Beer, Ginger Ale, Caffeine-Free Coke			W			D			
OTHER BEVERAGES: Other sugared beverages: Punch, lemonade, sports drinks, or sugared ice tea (1 glass, bottle, can)			W			D			
Beer, regular (1 glass, bottle, can)			W			D			
Light Beer, e.g., Bud Light (1 glass, bottle, can)			W			D			
Red wine (5 oz. glass)			W			D			
White wine (5 oz. glass)			W			D			
Liquor, e.g., vodka, gin, etc. (1 drink or shot)			W			D			
Water: bottled, sparkling, or tap (8 oz. cup)			W			D			
Herbal tea or decaffeinated tea (8 oz. cup)			W			D			
Tea with caffeine (8 oz. cup), including green tea			W			D			
Decaffeinated coffee (8 oz. cup)			W			D			
Coffee with caffeine (8 oz. cup)			W			D			
Dairy coffee drink (hot/cold) e.g., Cappuccino (16 oz.)			W			D			

6. ***(continued)*** **For each food listed, fill in the circle indicating how often on average you have used the amount specified during the past year.**

SWEETS, BAKED GOODS, MISCELLANEOUS		Never, or less than once per month	1–3 per month	1 per week	2–4 per week	5–6 per week	1 per day	2–3 per day	4–5 per day	6+ per day
Milk chocolate (bar or pack), e.g., Hershey's, M&M's				W			D			
Dark chocolate, e.g., Hershey's Dark or Dove Dark				W			D			
Candy bars, e.g., Snickers, Milky Way, Reeses				W			D			
Candy without chocolate (1 oz.)				W			D			
Cookies (1)	Fat free or reduced fat			W			D			
	Other			W			D			
Brownies (1)				W			D			
Doughnuts (1)				W			D			
Cake	Fat free or reduced fat			W			D			
	Other			W			D			
Pie, homemade or ready made (slice)				W			D			
Jams, jellies, preserves, syrup, or honey (1 Tbs)				W			D			
Peanut butter (1 Tbs)				W			D			
Popcorn (3 cups)	Fat free or light			W			D			
	Regular			W			D			
Sweet roll, coffee cake or other pastry (serving)	Fat free or reduced fat			W			D			
	Other			W			D			
Breakfast bars, e.g., Nutrigrain, granola, Kashi (1)				W			D			
Energy bars, e.g., Clif, Luna, Glucerna, Powerbar (1)				W			D			
Low carb bars, e.g., Atkins, Zone, South Beach (1)				W			D			
Pretzels (1 small bag or serving)				W			D			
Peanuts (small packet or 1 oz.)				W			D			
Walnuts (1 oz.)				W			D			
Other nuts (small packet or 1 oz.)				W			D			
Oat bran, added to food (1 Tbs)				W			D			
Other bran (wheat, etc.), added to food (1 Tbs)				W			D			
Chowder or cream soup (1 cup)				W			D			
Ketchup or red chili sauce (1 Tbs)				W			D			
Splenda (1 packet)				W			D			
Other artificial sweetener (1 packet)				W			D			
Olive oil added to food or bread (1 Tbs)				W			D			
Low-fat or fat-free mayonnaise (1 Tbs)				W			D			
Regular mayonnaise (1 Tbs)				W			D			
Salad dressing (1-2 Tbs)				W			D			

Type of salad dressing: ◯ Nonfat ◯ Low-fat ◯ Olive oil ◯ Other vegetable oil

7. Liver: (beef, calf or pork 4 oz.) ◯ Never ◯ Less than 1/mo ◯ 1/mo ◯ 2–3/mo ◯ 1/week or more
Liver: (chicken or turkey 1 oz.) ◯ Never ◯ Less than 1/mo ◯ 1/mo ◯ 2–3/mo ◯ 1/week or more

8. How often do you eat fried or sautéed food at home? (Exclude "Pam"-type spray)
◯ Less than once a week ◯ 1–3 times per week ◯ 4–6 times per week ◯ Daily

9. What kind of fat is usually used for frying and sautéing at home? (Exclude "Pam"-type spray)
◯ Real butter ◯ Margarine ◯ Olive oil ◯ Vegetable oil ◯ Veg. shortening ◯ Lard ◯ N/A

10. What kind of fat is usually used for baking at home?
◯ Real butter ◯ Margarine ◯ Olive oil ◯ Vegetable oil ◯ Veg. shortening ◯ Lard ◯ N/A

11. What type of cooking oil is usually used at home? (e.g., Mazola Corn Oil) Specify brand and type ➡

OLV CAN COR SOY VEG

12. How often do you eat deep fried chicken, fish, shrimp, clams or onion rings away from home?
◯ Less than once a week ◯ 1–3 times per week ◯ 4–6 times per week ◯ Daily

13. How often do you eat toasted breads, bagel or English muffin (e.g., slice or 1 half bagel)?
◯ Less than once a week ◯ 1–3 times per week ◯ 4–6 times per week ◯ Daily ◯ 2+ times/day

14. Are there any other important foods that you usually eat at least once per week?

Include for example: Applesauce, mushrooms, bulgur, radish, horseradish, Eggbeaters, dates, figs, rhubarb, mango, mixed dried fruit, papaya, wheat germ, custard, venison, hot peppers, pickles, olives, SlimFast, Ensure (regular or plus), Glucerna Shake.

(Do not include dry spices and do not list something that has been listed in the previous sections.)

	Other foods that you usually eat at least once per week	Servings per week
(a)		
(b)		
(c)		

APPENDIX II

PREDIMED questionnaire

		ANSWER	POINTS
1.	Do you use olive oil as the main source of fat for cooking?	Yes No	
2.	How many tablespoons of olive oil do you use each day? *Include olive oil used in salads, meals eaten away from home, frying etc*	# tablespoons **per day**	
3.	How many servings of vegetables do you eat per day? *One serving is ½ cup raw or cooked vegetables or 1 cup of raw salad greens*	# servings **per day**	
4.	How many servings of whole fruit do you eat per day? *One serving is ½ cup or a medium sized piece of whole fruit*	# serving **per day**	
5.	How many servings of red meat, hamburger or sausages do you eat per week? *One serving is 3 ½ -5 ½ ounces (100-150 grams)*	# servings **per week**	

6.	How many servings of butter, margarine or cream do you consume per day? *One serving is 1 Tablespoon. This does not include soft non-hydrogenated margarines*	# servings **per day**	
7.	How many sugar sweetened beverages do you drink per week? *One serving is 355ml or one can of pop or 12 ounces.* *This includes any drinks with added sugars such as regular pop, fruit drinks, sports drinks, energy drinks, iced tea*	# servings **per week**	
8.	Do you drink wine? How much do you drink per week? *1 glass = 150ml or 5 oz* **If you do not drink wine or alcohol, do not start**	# glasses **per week**	
9.	How many servings of legumes like kidney beans, chick peas, lentils, black beans, split peas do you eat per week? *One serving is 5 ounces or 150 grams or ½ - 2/3 cup*	# servings **per week**	
10.	How many servings of fish or seafood do you eat per week? *One serving of fish is 3 ½ -5 ½ ounces or 100-150 grams One serving of seafood is 4-5 pieces or 7 ounces or 200 grams*	# servings **per week**	

11.	How many times do you eat baked goods such as pie, cookies, cake or doughnuts per week?	# times **per week**	
12.	How many times do you eat nuts per week? *1 serving is 30 grams or 1 ounce*	# times **per week**	
13.	Do you eat chicken or turkey more often than beef, pork, hamburger or sausage?	Yes No	
14.	How many times per week do you eat dishes with a sauce of tomato, garlic, onion/leeks sautéed in olive oil?	# times **per week**	
		TOTAL Points	