Eating Habits among US Firefighters and Association with Cardiometabolic Outcomes

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Abstract: Cardiovascular disease is the leading cause of on-duty mortality among firefighters, with obesity as an important risk factor. However, little is known regarding the dietary patterns which are characteristic in this population and how these patterns relate to cardiometabolic outcomes. The aim of this study was to identify the dietary patterns of US firefighters and examine their association with cardiometabolic outcomes. The participants (n = 413) were from the Indianapolis Fire Department, and were recruited for a Federal Emergency Management Agency (FEMA)-sponsored Mediterranean diet intervention study. All of the participants underwent physical and medical examinations, routine laboratory tests, resting electrocardiograms, and maximal treadmill exercise testing. A comprehensive food frequency questionnaire was administered, and dietary patterns were derived using principal component analysis. The mean body mass index (BMI) was 30.0 ± 4.5 kg/m² and the percentage of body fat was 28.1 ± 6.6%. Using principal component analysis, two dietary patterns were identified, namely a Mediterranean diet and a Standard American diet. Following the adjustment for gender, BMI, maximal oxygen consumption (VO₂ max), max metabolic equivalents (METS), age, and body fat percent, the Mediterranean diet was positively associated with high-density lipoprotein (HDL) cholesterol (β = 1.20, p = 0.036) in linear regression models. The Standard American diet was associated with an increase in low-density lipoprotein (LDL) cholesterol (β = −3.76, p = 0.022). In conclusion, the Mediterranean diet was associated with more favorable cardiometabolic profiles, whereas the Standard American diet had an inverse association. These findings could help in providing adequate nutrition recommendations for US firefighters to improve their health.

Keywords: Mediterranean diet; Mediterranean diet scores; dietary patterns; cardiometabolic risk

1. Introduction

Firefighting is a hazardous occupation, and even though one might think that on-duty mortality among firefighters results from burns or smoke inhalation, the most frequent cause is sudden cardiac death (SCD) due to the underlying cardiovascular disease (CVD) [1]. On-duty fatalities in the US fire service account for almost half of all deaths and are due to 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 [2–4].
Therefore, CVD is not only a leading cause of mortality among firefighters, but also a major cause of morbidity and resulting disability. Even though the cardiometabolic health of firefighters is better than the average US citizen, there is a decrease in the cardiometabolic health of male firefighters. Among female firefighters, cardiometabolic health shows a steady decrease, as well [5].

Several risk factors have been associated with the risk of CVD, including obesity, hypertension, and high cholesterol levels [6]. Obesity, which has negative effects on the fitness and performance of firefighters, is also shown to be associated with an increased risk of CVD, blood pressure, glucose metabolism, sleep apnoea, and cardiac enlargement [7].

Several population-based studies among volunteer and career firefighters have shown that the rise in obesity prevalence is not the result of an increase in muscle mass [8], but rather an increase in body fat [8]. This is an issue that affects younger firefighters, as well as middle-aged and older firefighters. Consequently, it is a problem that is not recognized to its full extent [9].

In this paper, we explore the reasons for the increase in obesity rates. A number of recent studies have shown that the difference between obese and non-obese firefighters is the increased consumption of sugary drinks and fast food [10,11]. These findings are consistent with other population-based studies, which suggest that switching the dietary patterns of people will have a large impact on their health. Shift work and uncontrollable mealtimes, which are the norm among firefighters, also tend to increase the consumption of sugary drinks and fast food, with a greater proportion of calories from fat [12,13].

One of the most well-accepted diets in the reduction of CVD risk is the Mediterranean diet. Mediterranean diets, traditionally followed by countries bordering the Mediterranean Sea, are rich in unrefined grains, fruits, vegetables, and olive oil, and contain a lower consumption of red meat and poultry [14]. 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 [15–17]. Based on the clear benefits of the Mediterranean diet, it is recommended as one of the healthiest options in the US and other countries [18].

The first step in a nutritional intervention involves the identification of dietary patterns of the participant 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” [19]. In a survey by Yang et al., obese firefighters were less likely to follow a dietary 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 [20]. Similarly, in a study of 28 Swiss airport firefighters, the participants had an unbalanced diet with low-quality food choices and limited fiber intake [21].

Given that CVD is prevalent among firefighters, it is important to identify the dietary patterns of firefighters. Understanding the quality of different foods in the diet of firefighters can help us in providing scientific advice to improve food intake toward a healthier diet. The aim of this paper is to identify the dietary patterns of US firefighters and establish how these are associated with cardiometabolic outcomes in specific populations. Moreover, this would provide adequate recommendations to improve dietary interventions that target CVD and its related risk factors.

2. Materials and Methods

2.1. Study Participants

In this cross-sectional study, 413 firefighters were recruited from the Indianapolis Fire Department (IFD) (Indianapolis, IN, USA). The participants were enrolled as part of the study “Feeding America’s Bravest: Mediterranean Diet-Based Interventions to change firefighters’ Eating Habits and Improve Cardiovascular Risk Profiles” between November 2016 and April 2018. Recruitment and consent were carried out by the staff of
the National Institute of Public Safety Health. Participants who did not complete baseline anthropometric measurements were excluded from the current analysis. More details on the study methodology and participant recruitment can be found in other literature [22].

2.2. Dietary Assessment

A validated 131-item food frequency questionnaire (FFQ) was administered to the participants [23]. The questionnaire collected information on the average frequency of consumption of each food item over the previous 12 months. Food items included dairy foods, fruits, vegetables, eggs, meat, breads, cereals, starches, beverages, sweets, baked goods, etc. [22].

2.3. Physical Activity

Physical activity was collected in participants’ assessments from the fire department medical examinations at Public Safety Medical (PSM) clinics, which was led by an IFD physician. The examinations included the collection of occupational, smoking, and medical history; a physical examination, including body mass index (BMI) and body fat measurements (using bioelectrical impedance); routine laboratory tests; resting electrocardiograms; and maximal treadmill exercise testing.

2.4. Outcome Assessment

At the initial visit, all of the participants underwent blood pressure and anthropometric assessments. An appropriately sized cuff was used to measure the resting blood pressure while the participants were in a seated position. BMI was recorded for all of the study subjects in kg/m$^2$ and the percentage of body fat was estimated by a Bioelectrical Impedance Analyzer (BIA) [24,25].

The firefighters had their biochemical indices assessed at the medical examinations. We used the measurements collected from the date closest to the date of study consent and within the same 12-month period. Blood samples were collected after an overnight fast. Using ethylenediaminetetraacetic acid (EDTA) collection tubes, 15 mL of blood were collected. Plasma was frozen at $-80\,^\circ\text{C}$ and the blood lipid profiles of the firefighters were determined using an automated high-throughput enzymatic analysis. Moreover, this analysis achieved the following values of the coefficient of variation: $\leq 3\%$ for cholesterol and $\leq 5\%$ for triglycerides, using the cholesterol assay kit and reagent (Ref: 7D62-21) and triglycerides assay kit and reagent (Ref: 7D74-21) by the ARCHITECT c System, Abbott Laboratories, Abbott Park, IL, USA.

2.5. Ethics Statement

The overarching “Feeding America’s Bravest” protocol was approved by the Harvard Institutional Review Board (IRB16-0170) ethics committee and is registered at Clinical Trials (NCT02941757). All of the participants provided signed informed consent for participation. The participants who met the criteria for enrollment were all informed about their right to decline participation or to withdraw at any time as per the Declaration of Helsinki, and the participants who decided to enroll gave full informed consent as per the protocol of the research [25].

2.6. Statistical Analysis

The principal component analysis (PCA) was used to identify the dietary patterns of the firefighters at baseline. A scree test was used to identify the number of factors present. Loading factors were calculated after a varimax rotation to obtain uncorrelated components, which can be more easily interpretable. To obtain a clearer pattern, a cut-off of $\geq 10.21$ in factor loadings was applied. Continuous characteristics were presented as mean $\pm$ standard deviation (SD), whereas categorical variables were reported as frequency (percentage) by tertiles of the identified dietary patterns (low-medium-high) and compared using the ANOVA test or the chi-square test of independence, respectively. Linear regression models
were used to examine the effect of dietary patterns on cardiometabolic outcomes, after adjusting for age, gender, BMI, body fat percent, max metabolic equivalents (METS), and oxygen consumption (VO$_2$) max. The resulting beta coefficients, together with the corresponding standard errors and $p$-values, were presented. As a sensitivity analysis, dietary patterns were used in the models, both as continuous variables as well as in tertiles. All of the statistical analyses were performed using SAS version 9.3 (SAS Institute Inc., Cary, NC, USA). The alpha level of significance was set at 0.05 and all of the tests were two-tailed.

3. Results

3.1. Baseline Characteristics

A sample of 413 firefighters had complete data for analysis in the current study. Firefighters’ baseline characteristics are shown in Table 1. The vast majority of the participants were males (94%), with a mean age of 47.2 ± 8.2 years. The average BMI in the study population was 30.0 ± 4.5 kg/m$^2$. The average METS score was 11.6 ± 5.5 and the mean total cholesterol was 196.9 ± 38.3 (mg/dL). The participation rate of the study was 95%.

Table 1. Baseline characteristics.

| Characteristics          | Overall     |
|--------------------------|-------------|
| Males                    | 390 (94%)   |
| Age (years)              | 47.2 (8.2)  |
| Smoking                  | 10 (3.9%)   |
| Alcohol (units per week) | 12.81 (20.18) |
| 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)  |
| Max METS                 | 11.6 (5.5)  |
| Est. VO$_2$ max          | 42.1 (4.97) |
| Diastolic BP (mmHg)      | 78.3 (6.1)  |
| Systolic BP (mmHg)       | 123.4 (8.8) |
| 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 (75.65) |
| Glucose (mg/dL)          | 100.0 (20.5) |

BMI, body mass index; METS, metabolic equivalents; Est. VO$_2$, estimated oxygen consumption; BP, blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

3.2. Dietary Patterns

Scree tests of the PCAs indicated two distinct factors—a Standard American diet (SAD) and a Mediterranean diet (MD). In the analysis, the total number of food items was 148, out of which 96 had a loading factor above the pre-set cut-off of ≥ 0.21. The Mediterranean diet included 57 of these items, and consisted of vegetables (raw spinach (0.673), romaine lettuce (0.601), fruits (peaches, apple), wine, nuts (walnuts), and rice, as shown in Table 2.
Table 2. Dietary Patterns.

| 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 Calorie 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          |
Table 2. Cont.

Dietary Patterns-Mediterranean Diet

| Food Item             | Loading Factor |
|-----------------------|----------------|
| 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          |

Dietary patterns-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          |
| Chichen 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          |
Thirty-nine items scored loading factors above 0.21 in the Standard American diet, and those included red meat (hamburger, pork), pasta, and sweets (brownies), as shown in Table 2.

### 3.3. Categorization of Participants in Accordance with the Dietary Pattern

The cross-tabulation of the 413 participants in tertiles of MD and SAD are shown in Table 3. Several participants had both MD and SAD scores low as well as both MD and SAD high.

### Table 3. Different dietary patterns of participants.

| Standard American Diet | Mediterranean Diet | Total |
|------------------------|--------------------|-------|
| **Low**                | **Medium**         | **High**         |       |
| **Low**                | 76                 | 45               | 15    | 136 |
| **Medium**             | 44                 | 54               | 39    | 137 |
| **High**               | 17                 | 37               | 86    | 140 |
| **Total**              | 137                | 136              | 140   | 413 |

### 3.4. Association of Dietary Patterns with Cardiometabolic Outcomes

Participants in the highest tertile of Western diet were significantly worse in terms of weight, HDL cholesterol, cholesterol ratio, and triglycerides scores (Table 4). However, no significant differences were observed among the tertiles of Mediterranean diet.
Table 4. Cardiometabolic characteristics.

| Characteristic | Low    | Medium | High    | p-Value | Low    | Medium | High    | p-Value |
|               | 1.79 (0.07) | 1.79 (0.07) | 1.80 (0.07) | 0.155 | 1.79 ± 0.07 | 1.79 ± 0.07 | 1.80 ± 0.07 | 0.779 |
| Weight (kg)    | 93.3 (16.20) | 96.02 (15.71) | 101.11 (19.18) | <0.001 | 96.00 ± 14.80 | 96.77 ± 19.00 | 97.80 ± 18.33 | 0.698 |
| body fat (%)   | 27.24 ± 6.95 | 27.89 ± 6.17 | 29.03 ± 6.70 | 0.084 | 28.012 ± 5.71 | 28.31 ± 6.87 | 27.4 ± 7.30 | 0.778 |
| Max METS       | 12.16 ± 9.24 | 11.29 ± 1.31 | 11.24 ± 2.43 | 0.318 | 11.96 ± 9.12 | 11.28 ± 1.58 | 11.45 ± 2.44 | 0.578 |
| VO\textsubscript{2} max | 42.58 ± 5.31 | 42.19 ± 4.69 | 41.58 ± 4.89 | 0.258 | 42.19 ± 4.70 | 42.01 ± 5.06 | 42.13 ± 5.18 | 0.960 |
| Diastolic BP (mmHg) | 78.21 ± 5.86 | 78.01 ± 6.08 | 78.80 ± 6.19 | 0.539 | 78.62 ± 5.67 | 78.70 ± 6.08 | 77.72 ± 6.38 | 0.338 |
| Systolic BP (mmHg) | 123.05 ± 8.86 | 123.17 ± 8.72 | 123.98 ± 8.93 | 0.639 | 123.32 ± 8.38 | 123.41 ± 9.14 | 123.49 ± 9.01 | 0.987 |
| Cholesterol (mg/dL) | 193.15 ± 38.28 | 199.59 ± 39.99 | 197.55 ± 37.22 | 0.363 | 196.84 ± 39.51 | 194.77 ± 36.96 | 198.69 ± 39.06 | 0.700 |
| HDL cholesterol (mg/dL) | 51.52 ± 12.00 | 48.84 ± 11.19 | 47.29 ± 10.66 | 0.008 | 48.54 ± 10.64 | 49.10 ± 12.14 | 49.90 ± 11.37 | 0.612 |
| LDL cholesterol (mg/dL) | 119.03 ± 31.70 | 126.90 ± 33.73 | 122.15 ± 33.43 | 0.150 | 122.83 ± 31.67 | 122.01 ± 33.96 | 123.32 ± 33.67 | 0.947 |
| Cholesterol Ratio | 3.95 ± 1.52 | 4.24 ± 1.08 | 4.37 ± 1.25 | 0.023 | 4.27 ± 1.63 | 4.16 ± 1.16 | 4.14 ± 1.06 | 0.647 |
| Triglycerides (mg/dL) | 106.79 ± 59.75 | 120.64 ± 64.14 | 145.20 ± 93.08 | <0.001 | 124.80 ± 87.07 | 119.56 ± 64.83 | 129.11 ± 76.01 | 0.581 |
| Glucose (mg/dL) | 97.82 ± 18.02 | 102.44 ± 27.60 | 99.77 ± 13.20 | 0.180 | 101.20 ± 20.46 | 98.19 ± 19.10 | 100.64 ± 21.78 | 0.440 |

The associations of dietary patterns with cardiometabolic outcomes are shown in Table 5. In unadjusted regression models, a unitary increase in SAD was significantly associated with increases in total cholesterol (β = 4.58, p = 0.014), LDL cholesterol (β = 3.88, p = 0.017), whereas it was associated with a decrease in HDL cholesterol (β = −0.59, p = 0.292). Moreover, there was a significant association between MD and HDL cholesterol levels (β = 1.14, p = 0.045). After adjusting for age, gender, VO\textsubscript{2} max, max METS, BMI, and body fat percent, SAD was significantly associated with a higher body fat percent (β = 0.02, p = 0.922) and cholesterol ratio (β = 0.12, p = 0.026), whereas it was associated with a decrease in HDL cholesterol (β = −0.292, p = 0.578). Furthermore, we observed an increase in cholesterol (β = 4.49, p = 0.015) and triglycerides (β = 5.83, p = 0.090), although the results were not statistically significant. Finally, MD was significantly associated with an increase in HDL cholesterol (β = 1.20, p = 0.036) in the adjusted analysis, whereas it was associated with a decrease in cholesterol ratio (β = −0.05, p = 0.358).
Table 5. Association of dietary patterns with cardiometabolic outcomes.

| Outcome          | Unadjusted Models | Adjusted Models * |
|------------------|-------------------|-------------------|
|                  | 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 | 0.02 | 0.19 | 0.922 | 0.30 ** | 0.21 | 0.150 |
| Body Fat         | 0.45 | 0.33 | 0.166 | -0.22 | 0.35 | 0.537 | 0.26 | 0.27 | 0.331 | 0.02 ** | 0.20 | 0.943 |
| Cholesterol      | 4.58 | 1.86 | 0.014 | 0.85 | 1.92 | 0.657 | 4.49 | 1.84 | 0.015 | 1.18 | 2.02 | 0.559 |
| HDL cholesterol  | -0.59 | 0.56 | 0.29 | 1.14 | 0.57 | 0.045 | -0.292 | 0.52 | 0.578 | 1.20 | 0.57 | 0.036 |
| LDL cholesterol  | 3.88 | 1.61 | 0.017 | -0.03 | 1.66 | 0.985 | 3.76 | 1.63 | 0.022 | -0.31 | 1.79 | 0.865 |
| Cholesterol ratio| 0.14 | 0.06 | 0.033 | -0.08 | 0.07 | 0.244 | 0.12 | 0.05 | 0.026 | -0.05 | 0.06 | 0.358 |
| Triglycerides    | 7.73 | 3.69 | 0.037 | -0.09 | 3.79 | 0.982 | 5.83 | 3.43 | 0.090 | 1.37 | 3.75 | 0.715 |
| Glucose          | -0.53 | 1.00 | 0.594 | -1.05 | 1.02 | 0.305 | -0.97 | 0.94 | 0.506 | -0.01 | 1.03 | 0.990 |

* Adjusted for gender, max METS, VO2 max, age, BMI, and body fat percent. ** Adjusted for gender, max METS, VO2 max, age. Se, standard error.

When tertiles of dietary patterns were considered, the high SAD tertile compared with the low tertile was associated with a decrease in HDL cholesterol, whereas it was associated with an increase in cholesterol ratio, BMI, and body fat. Similarly, medium vs. low tertile of SAD was associated with an increase in total and LDL cholesterol, cholesterol ratio, and glucose. However, when adjusted for other score (MD diet score for SAD tertiles and SAD diet score for MD tertiles), no statistically significant associations were observed for the tertiles of MD with cardiometabolic outcomes, as shown in Appendix A Table A1.

4. Discussion

Our study identified two major dietary patterns among Indianapolis US firefighters—a Standard American diet and a Mediterranean diet. This was not surprising, given that the Western diet is one of the most common diets among US citizens and the Mediterranean diet is one of the most common diets among people pursuing a healthier lifestyle [20]. 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 [24]. 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 [25]. Furthermore, greater consumption of fruits and vegetables, which is another element of the Mediterranean diet, was linked with higher fiber, folate, and potassium intakes. Dietary fiber may play a protective role against non-communicable diseases. Even though the mechanism for this is not fully understood, higher intakes of fruits and vegetables are strongly associated with lower CVD development [26,27].
In contrast, the Standard American diet was characterized by high consumption of red meat and sugary foods [28]. Meat and meat products were 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 [29]. Meta-analysis studies showed that the greater consumption of processed meat was associated with 42% higher risk of developing coronary heart disease and 19% higher risk of diabetes. In our study, the Standard American diet was associated with an increase in LDL cholesterol and total cholesterol levels [30,31]. These results support the fact that high saturated fat diets were associated with worse cardiometabolic outcomes.

One limitation of this study is its cross-sectional nature, which does not allow us to infer causation. A second limitation concerns the items used in the food frequency questionnaire, which could be considered as common foods of the MD or SAD. In addition, they were included in the PCA analysis and resulted in a relatively low loading factor. Therefore, the pre-set cut-off was 10.21. A third limitation concerns the very low number of female participants (6%). However, this reflects the current demographic of the US career fire service. One of the strengths of the study is that with the help and support of the IFD, the Indianapolis Local 416 fire station, and the recruited participants, we were able to collect all the necessary medical data required for the analysis. Another strength is that all our data were collected from the medical files of the participants with the help of a team of trained physicians, thus ensuring their validity.

5. Conclusions

In conclusion, this is one of the first studies in the US to report on specific dietary patterns among firefighters. These patterns were identified as the Mediterranean diet and the Standard American diet. In addition, the present findings confirmed and further strengthened the current knowledge regarding the positive associations of the Mediterranean diet and the negative associations of the Standard American diet on cardiometabolic outcomes. Further studies should investigate the role of diet in specific populations, as identifying the different diet components can assist in the creation of programs that improve the health of firefighters to save lives.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Harvard Institutional Review Board (IRB16-10170) and is registered at Clinical Trials (NCT029441757).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The authors will make deidentified raw data set available upon reasonable requests.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. 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-Value | β (se) | p-Value | β (se) | p-Value | β (se) | p-Value |
| 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 Dietary 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 Dietary 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 Dietary 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 (4.07) | 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 Dietary 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 (0.16) | 0.882 |
| Adjusted for Dietary 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 Dietary 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 Dietary 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 percent |            |         |        |         |        |         |        |         |
| 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 Dietary 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 |

se, standard error; HDL, high-density lipoprotein; LDL, low-density lipoprotein; BMI, body mass index.
References

1. Kales, S.N.; Soteriades, E.S.; Christophi, C.A.; Christiani, D.C. Emergency duties and deaths from heart disease among firefighters in the United States. *N. Engl. J. Med.* 2007, 356, 1207–1215. [CrossRef]

2. Soteriades, E.S.; Smith, D.L.; Tsismenakis, A.J.; Baur, D.M.; Kales, S.N. Cardiovascular Disease in US Firefighters. *Cardiol. Rev.* 2011, 19, 202–215. [CrossRef]

3. Smith, D.L.; Barr, D.A.; Kales, S.N. Extreme sacrifice: Sudden cardiac death in the US Fire Service. *Extrem. Physiol. Med.* 2013, 2, 6. [CrossRef] [PubMed]

4. Smith, D.L.; Barr, D.A.; Kales, S.N. Extreme sacrifice: Sudden cardiac death in the US Fire Service. *Extrem. Physiol. Med.* 2013, 2, 6. [CrossRef] [PubMed]

5. Smith, D.L.; Barr, D.A.; Kales, S.N. Extreme sacrifice: Sudden cardiac death in the US Fire Service. *Extrem. Physiol. Med.* 2013, 2, 6. [CrossRef] [PubMed]

6. Cardiovascular Diseases (CVDs). Available online: https://www.who.int/en/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds) (accessed on 5 May 2019).

7. Kales, S.N.; Tsismenakis, A.J.; Zhang, C.; Soteriades, E.S. Blood Pressure in Firefighters, Police Officers, and Other Emergency Responders. *Am. J. Hypertens.* 2009, 22, 11–20. [CrossRef] [PubMed]

8. Soteriades, E.S.; Hauser, R.; Kawachi, I.; Liakokapis, D.; Christiani, D.C.; Kales, S.N. Descriptive Epidemiology Obesity and Cardiovascular Disease Risk Factors in Firefighters: A Prospective Cohort Study. *Obes. Res.* 2005, 13, 1756–1763. [CrossRef]

9. Yang, J.; Kales, S.N. Sudden cardiac death among firefighters ≤45 years of age in the United States. *Am. J. Cardiol.* 2013, 112, 1962–1967. [CrossRef]

10. Yang, J.; Farioli, A.; Kales, S.N. Modified Mediterranean Diet Score and Cardiovascular Risk in a North American Working Population. *PLoS ONE* 2014, 9, e87539. [CrossRef]

11. Pereira, M.A.; Kartashov, A.I.; Ebbeling, C.B.; Van Horn, L.; Slattery, M.L.; Jacobs, D.R., Jr.; Ludwig, D.S. Fast-food habits, weight gain, and insulin resistance (the CARDIA study): 15-year prospective analysis. *Lancet* 2005, 365, 36–42. [CrossRef]

12. Lowden, A.; Moreno, C.; Holimbáck, U.; Lennermå, M.; Tucker, P. Eating and shift work—Effects on habits, metabolism, and performance. *Scand. J. Work Environ. Health* 2010, 36, 150–162. [CrossRef]

13. Esquirol, Y.; Bongard, V.; Mabile, J.; Jonnier, B.; Soulat, J.M.; Perret, B. Shift work and metabolic syndrome: Respective impacts of job strain, physical activity, and dietary rhythms. *Chronobiol. Int.* 2009, 26, 544–559. [CrossRef] [PubMed]

14. The Mediterranean Diet: (EUFIC). Available online: https://www.eufic.org/en/healthy-living/article/the-mediterranean-diet?gclid=CjwKCAjw88vxsRBRFEiwApwLevc-P49mYLXkgkJcl1VLxzsvYribBD-OM7vxhDTLd9TLYOrleSoksHRoCeT0QAvD_BwE (accessed on 24 June 2020).

15. Delgado-Lista, J.; Perez-Caballero, A.I.; Perez-Martinez, P.; Garcia-Rios, A.; Lopez-Miranda, J.; Perez-Jimenez, F. Mediterranean Diet Improves High-Density Lipoprotein Function in High-Cardiovascular-Risk Individuals. *Circulation* 2010, 122, 1979–1988. [CrossRef] [PubMed]

16. Dontas, A.S.; Zerefos, N.S.; Panagiotakos, D.B.; Valis, D.A. Mediterranean diet and prevention of coronary heart disease in the elderly. *Clin. Interv. Aging* 2007, 2, 109–115. [CrossRef] [PubMed]

17. De Lorgeril, M.; Salen, P.; Martin, J.L.; 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, 779–785. [CrossRef] [PubMed] Available online: http://www.ncbi.nlm.nih.gov/published/9989963 (accessed on 26 February 2019).

18. Dietary Health|USDA. Available online: https://www.usda.gov/topics/food-and-nutrition/dietary-health (accessed on 28 April 2022).

19. Dietary Pattern—An Overview | ScienceDirect Topics. Available online: https://www.sciencedirect.com/topics/medicine-and-dentistry/dietary-pattern (accessed on 24 June 2020).

20. Yang, J.; Farioli, A.; Korre, M.; Kales, S.N. Dietary preferences and nutritional information needs among career firefighters in the United States. *Glob. Adv. Health Med.* 2015, 4, 16–23. [CrossRef]

21. 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. *Glob. Adv. Health Med.* 2021, 10, 101492. [CrossRef] [PubMed]

22. Romanidou, M.; Tripsianis, G.; Hershey, M.S.; Sotos-Prieto, M.; Christophi, C.; Moffatt, S.; Muegge, C.; Korre, M.; Mozaffarian, D.; Kales, S.N. Cardiovascular Disease Risk Factors in Firefighters: A Prospective Cohort Study. *Obes. Res.* 2005, 13, 1756–1763. [CrossRef]

23. Romanidou, M.; Tripsianis, G.; Hershey, M.S.; Sotos-Prieto, M.; Christophi, C.; Moffatt, S.; Constantinidis, T.C.; Kales, S.N. Association of the Modified Mediterranean Diet Score (mMDS) with Anthropometric and Biochemical Indices in US Career Firefighters. *Obes. Res.* 2005, 13, 1756–1763. [CrossRef]

24. Romanidou, M.; Tripsianis, G.; Hershey, M.S.; Sotos-Prieto, M.; Christophi, C.; Moffatt, S.; Constantinidis, T.C.; Kales, S.N. Association of the Modified Mediterranean Diet Score (mMDS) with Anthropometric and Biochemical Indices in US Career Firefighters. *Obes. Res.* 2005, 13, 1756–1763. [CrossRef]

25. Romanidou, M.; Tripsianis, G.; Hershey, M.S.; Sotos-Prieto, M.; Christophi, C.; Moffatt, S.; Constantinidis, T.C.; Kales, S.N. Association of the Modified Mediterranean Diet Score (mMDS) with Anthropometric and Biochemical Indices in US Career Firefighters. *Obes. Res.* 2005, 13, 1756–1763. [CrossRef]

26. Widmer, R.J.; Flammer, A.J.; Lerman, L.O.; Lerman, A. The Mediterranean diet, its components, and cardiovascular disease. *Am. J. Med.* 2015, 128, 229–238. [CrossRef]
27. Lăcătusu, C.M.; Grigorescu, E.D.; Floria, M.; Onofriescu, A.; Mihai, B.M. The mediterranean diet: From an environment-driven food culture to an emerging medical prescription. *Int. J. Environ. Res. Public Health* 2019, 16, 942. [CrossRef] [PubMed]

28. Grotto, D.; Zied, E. The standard American diet and its relationship to the health status of Americans. *Nutr. Clin. Pract.* 2010, 25, 603–612. [CrossRef] [PubMed]

29. USDA ERS—Food Availability and Consumption. Available online: https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/food-availability-and-consumption/ (accessed on 24 June 2020).

30. Micha, R.; Wallace, S.K.; 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, 2271–2283. [CrossRef] [PubMed]

31. Aune, D.; Ursin, G.; Veierød, M.B. Meat consumption and the risk of type 2 diabetes: A systematic review and meta-analysis of cohort studies. *Diabetologia* 2009, 52, 2277–2287. [CrossRef]