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Association between Previously Diagnosed Circulatory Conditions and a Dietary Inflammatory Index

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Abstract

Inflammation is a key contributor to the development or recurrence of circulatory disorders. Diet is a strong modifier of inflammation. It was hypothesized that more pro-inflammatory diets, as indicated by higher Dietary Inflammatory Index (DII) scores, would be associated with self-reported previously diagnosed circulatory disorders using National Health and Nutrition Examination Survey (NHANES) data. This analysis included NHANES respondents from 2005–2010 (n=15,693). The DII was calculated from micro and macronutrients derived from a single 24-hour recall. Logistic regression, stratified by sex and adjusted for important covariates, was used to determine the odds of previous circulatory disorder diagnoses by quartile of DII scores. Excluding hypertension, which had a prevalence of 30%, the prevalence of any circulatory disorder was 8%. Those in DII quartile 4 were 1.30 (95%CI=1.06–1.58) times more likely to have a previous circulatory disorder (excluding hypertension) compared to those in DII quartile 1. Similar findings were observed for specific CVDs including congestive heart failure, stroke, and heart attack. Participants in DII quartile 4 were more likely to have a diagnosis of hypertension compared to those in DII quartile 1 (prevalence odds ratio=1.19, 95%CI=1.05–1.34). Results tended to be stronger among females. Individuals with a previous circulatory disorder diagnosis from NHANES appear to have more pro-inflammatory diets compared to those without a previous diagnosis. Because inflammation is an important factor related to recurrence of circulatory disorders, the DII could be used in treatment programs to monitor dietary modulators of inflammation among individuals with these conditions.

Keywords

Dietary Inflammatory Index; diet; circulatory disorder; inflammation; NHANES

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1. Introduction

Inflammation is a normal biologic process needed for competent immune, vascular, and endothelial response [1]. However, chronic inflammation can result from repeated injuries, including tobacco use, chronic infection, obesity, and others [1]. Chronic inflammation is an underlying pathophysiological process associated with numerous chronic conditions including cancer, diabetes, circulatory disease (e.g., cardiovascular [CVD] or cerebrovascular disease), metabolic syndrome (MetSyn), and both disease-specific and overall mortality [1]. Inflammation is a key component throughout the atherosclerotic process [2], as well as in the triggering of events such as stroke or myocardial infarction [3, 4]. Dietary patterns consistently have been shown to be strong moderators of systemic inflammation [5]. Western-style diets have been associated with increased chronic, systemic inflammation, whereas Mediterranean diets have been associated with lower levels of inflammation [5].

Numerous studies have shown that healthier diets are associated with reduced risk of circulatory disease or CVD risk factors (e.g., body mass index [BMI=kg/m^2], cholesterol, blood pressure) [6, 7]. Additionally, reports indicate that poor dietary habits after diagnosis of circulatory disease are associated with increased risk of recurrence of circulatory events [8, 9]. This is disconcerting considering that some studies have indicated that individuals who had a circulatory disease event continue to eat poorly [10–12].

Dietary indices are typically based on *a priori* approaches using dietary guidelines or a description of a culinary tradition (e.g., the Mediterranean Diet) or *a posteriori* approaches (e.g., factor analysis) [6, 13]. The Dietary Inflammatory Index (DII) was developed to characterize an individual's diet on a continuum from maximally anti- to pro-inflammatory. The DII is grounded in peer-reviewed literature focusing on a specific health outcome (i.e., inflammation) and is standardized to the distribution of dietary intake based on numerous populations from around the world which helps to overcome shortcomings of previous dietary indices [14]. Previously, the DII has predicted C-reactive protein and interleukin-6 levels using 24-hour dietary recalls (24HR) and 7-day recalls, as well as a food frequency questionnaire (FFQ) [15–17]. The DII also has been shown to be associated with the glucose intolerance component of MetSyn, increased odds of asthma, anthropometric measurements, and several cancers [16–25]. It also has been shown that shiftworkers from the National Health and Nutrition Examination Study (NHANES) had statistically significant greater DII values (i.e., more pro-inflammatory) compared to day workers [26].

The DII has yet to be examined among those diagnosed with a circulatory disorder. Ideally, those with a previous circulatory disorder would have, as part of their rehabilitation, received at least some information or nutrition counseling to improve their diet to lower risk of potential future recurrences [27]. However, in actuality, this may not be the case and those with a previous circulatory disorder may continue to expose themselves to unhealthy diets [10–12]. Using NHANES data, this exploratory analysis sought to provide descriptive statistics on mean DII values among those living with a diagnosis of a circulatory condition. Additionally, we hypothesized that those with more pro-inflammatory diets would be more

likely to have a previous diagnosis of a circulatory using the cross-sectional design of NHANES.

2. Methods and materials

2.1 Study Population

Data from NHANES (2005–2010) were utilized in this analysis. NHANES collects information from United States adults and children in two-year cycles using a complex, multistage, probability design to ensure selection of various geographical regions and minority populations. All participants were interviewed in their homes where questionnaire data was obtained for demographic, socioeconomic, diet, medical history, and lifestyle and behavior habits, among others. Participants were invited to a mobile examination center where data from clinical tests, and biological samples were collected. More detailed descriptions of the NHANES methods and protocols have been described and can be found elsewhere (http://www.cdc.gov/nchs/nhanes.htm) [28]. The NHANES population for 2005–2010 was 31,034. This study excluded those <20 years of age (n=13,902), those without dietary information (n=1,431) or any self-report circulatory disorder information (n=2), and those with a total calorie intake of <100 kilocalories, as this may represent some form of reporting bias (n=6). The final sample size for analysis was 15,693. Informed consent was obtained from all participants and data collection is continually reviewed by the National Center for Health Statistics Research and Ethics Review Board.

2.2 Outcome Assessment

Primary outcomes included self-reported diagnoses of several circulatory disorders including congestive heart failure, coronary heart disease [CHD]), angina, heart attack, stroke, and high blood pressure. Excluding high blood pressure, these self-reported diagnoses were combined to create a ‘combined circulatory disorders’ outcome measure. Hypertension was not included in the ‘combined circulatory disorders’ measure because the high (i.e., 30%) prevalence of hypertension may wash-out the effect of the DII on more severe previously diagnosed conditions, as hypertension is not an event or necessarily a severe circulatory diagnosis. For each circulatory disorder participants were asked ‘has a doctor or other health professional ever told you that you had X condition’.

2.3 The Dietary Inflammatory Index and Potential Covariates

NHANES dietary assessments included 24HRs. The macro- and micronutrients (known as food parameters) used to calculate the DII included; carbohydrates; protein; fat; grams of alcohol; fiber; cholesterol; saturated, monounsaturated, and polyunsaturated fatty acids; omega3 and omega6 polyunsaturated fatty acids; niacin; vitamins A, B1, B2, B6, B12, C, D, E; iron; magnesium; zinc; selenium; folic acid; beta carotene; and caffeine. Development of the DII is based on findings from 1,943 articles focusing on the effects of dietary components on inflammation, which produced an ‘article score’ for each food parameter [14]. DII calculation is linked to a regionally representative world database, which included food consumption from 11 populations around the world. This database provided a ‘standard mean’ for each food parameter. A z-score is created by subtracting the ‘standard mean’ from the individual’s estimate of intake, then dividing this by its standard deviation, which is

converted to a percentile and centered by doubling the value and subtracting 1. The product of the converted z-score and adjusted article score for each food parameter was summed across all food parameters to create the overall DII score; higher DII scores are more pro-inflammatory and more negative values are more anti-inflammatory [14]. To control for the effect of total energy intake, the DII was calculated per 1,000 calories of food consumed.

Self-reported factors that are potential confounders included age, race, education, marital status, perceived health, health insurance, income, alcohol consumption, tobacco use, clinic-measured BMI, and minutes of moderate-to-vigorous physical activity (MVPA), among others. As a standard procedure, NHANES truncated age to 80 years for the 2007–2008 and 2009–2010 cycles and 85 years for the 2005–2006 cycle. To maintain consistency, age was truncated to 80 years for all cycles by the investigators.

2.4 Statistical Analyses

All analyses were performed using survey design procedures in SAS® (version 9.3, Cary, NC), which control for stratification and clustering effects inherent in NHANES sampling procedures. Six-year sampling weights were calculated by multiplying each of the two-year sampling weights by one-third [28]. Chi-square tests and t-tests were used to compare population characteristics between those with a circulatory condition and those without. Variables selected as potential confounders were identified through a series of bi-variable analyses (i.e., the DII + covariate). If a covariate had a p-value of ≤0.20, it was added to the full model. A backward confounder selection process was then used to develop the final models which included all covariates, that when removed, led to a 10% change in the OR of the DII; statistically significant ($p \leq 0.05$) covariates also were included in the final model. Logistic regression was used to estimate crude and adjusted prevalence odds ratios (PORs) and 95% confidence intervals (95%CIs) for each circulatory disorder and all circulatory disorders combined (minus high blood pressure). The primary comparisons of interest were between DII quartiles 1 and 4. In additional models, the DII was analyzed as a continuous predictor. All analyses were stratified by sex.

3. Results

Those who self-reported a circulatory disorder diagnosis compared to those who did not were more likely to be male (55% vs. 48%, $p<0.01$), non-Hispanic White (77% vs. 70%, $p<0.01$), have served in the military (29% vs. 10%, $p<0.01$), have less than a high school education (29% vs. 18%, $p<0.01$), be unmarried (40% vs. 35%, $p<0.01$), have an income < $35,000 (US dollars: 53% vs. 34%, $p<0.01$), live in a household with a smoker (22% vs. 17%, $p<0.01$), be a current or former cigarette smoker (62% vs. 45%, $p<0.01$), have health insurance (91% vs. 80%, $p<0.01$), have a family history of heart attack (25% vs. 13%, $p<0.01$) and were more likely to be older, have a higher BMI, and spend less time participating in MVPA (Table 1).

The prevalences of each circulatory disorder diagnosis were as follows: 30% with high blood pressure, 2% heart failure, 3% CHD, 2% angina, 3% heart attack, and 3% stroke. Compared to those with no circulatory disorder diagnosis (excluding hypertension) (mean DII=0.75, 95%CI=0.66–0.84), those reporting a diagnosis of any circulatory disorder (mean

DII=0.86, 95%CI=0.73–0.98, p=0.05) or, specifically, stroke (mean DII=1.07, 95%CI=0.90–1.23, p<0.01) had a significantly higher mean DII after adjustment for family history of heart attack, exposure to second-hand smoke, smoking status, sex, age, and BMI. Additionally, those who reported a diagnosis of hypertension (mean DII=0.84, 95%CI=0.75–0.93, p<0.01) had greater DII values compared to those who did not (mean DII=0.71, 95%CI=0.62–0.80). It should be noted that those reporting a diagnosis of coronary artery disease (mean DII=0.63, 95%CI=0.43–0.82, p=0.13) or angina (mean DII=0.54, 95%CI=0.30–0.78, p=0.05) had lower DII scores compared to those with no previous circulatory diagnosis (data not tabulated).

When circulatory disorders were combined, the odds of a diagnosis among those in DII quartile 4 was 1.30 (95%CI=1.06–1.58) times greater than those in DII quartile 1. When comparing quartile 4 to quartile 1, the odds of congestive heart failure (POR=1.38, 95%CI=1.09–1.74), heart attack (POR=1.48, 95%CI=1.12–1.97), stroke (POR=1.56, 95%CI=1.21–2.01) and high blood pressure (POR=1.19, 95%CI=1.05–1.34) were all elevated. No statistically significant findings were observed for CHD or angina (Table 2). When analyzing the DII continuously, a one-unit increase (corresponding to ≈7% of its global range) in the DII led to statistically significantly greater PORs for combined circulatory disorders (POR=1.05, 95%CI=1.01–1.08), heart failure (POR=1.06, 95%CI=1.02–1.10), heart attack (POR=1.06, 95%CI=1.01–1.12), stroke (POR=1.09, 95%CI=1.04–1.15), and high blood pressure (POR=1.04, 95%CI=1.01–1.06; data not tabulated).

Sex modified the relationship between the DII and circulatory disorder diagnoses (interaction term: p<0.01). Although several elevated PORs were observed among males, there were no statistically significant associations between any of the reported circulatory conditions and the DII. Among women, statistically significant PORs for combined circulatory disorders, congestive heart failure, heart attack, stroke, and high BP were observed among quartile 4 (Table 3). *Post-hoc* analyses additionally adjusted for presence of any self-reported sleep disorder diagnoses and results remained unchanged (data not shown).

4. Discussion

The hypothesis was accepted in that those with more pro-inflammatory diets (i.e., DII quartile 4) were more likely to have a previous circulatory disorder diagnosis (including congestive heart failure, heart attack, and stroke, as well as hypertension diagnoses) compared to those with more anti-inflammatory diets (i.e., DII quartile 1). However, these results tended to only apply to women, not men. The DII incorporates numerous micro and macronutrients which has several advantages over analyzing individual dietary components. Dietary patterns take into account the fact that foods are eaten in combination. It may be difficult to separate the effects of individual nutrients. The effect of any single nutrient may be too small to detect or a large number of individual micro- or macronutrients may lead to chance findings. The effect of a single nutrient may be confounded by dietary habits and patterns [13, 29].

Other dietary patterns or foods have been associated with previous diagnoses of circulatory disorders or acute circulatory events [10–12, 30, 31]. Many of these papers have focused primarily or exclusively on hypertension [30, 31]. Understanding current dietary patterns among those diagnosed with a circulatory disorder is important considering that diet is a strong predictor of primary circulatory disease, as well as recurrence [32]. For example, the Mediterranean diet has repeatedly been shown to be protective against CVD recurrence [9, 27, 33, 34].

It was not possible to determine the extent of recurrence using NHANES data. However, the DII is a tool that measures the inflammatory potential of diet. Inflammation is a substrate for a number of primary mechanisms through which circulatory disorders develop and progress [1–3]. Additionally, the DII has been associated with 'less healthy' (e.g., Western) diets in previous simulation analyses [35]. These, 'less healthy' diets, in turn, have been associated with increased circulatory disease risk and recurrence, as well as elevated levels of triglycerides and cholesterol [7, 27, 33], which are strong contributors to circulatory disease. Although more research is needed investigating the relationship between circulatory disorders and the DII, if individuals with a previously diagnosed circulatory disease have less healthy, more pro-inflammatory diets, they could be putting themselves at increased risk for recurrence. Additionally, it is not clear why results were stronger among females than males. It is possible that education and treatment after diagnosis differs between males and females.

The primary strength of this analysis was the use of the novel DII to examine the relationship between self-reported history of circulatory disorders and dietary inflammatory potential. The scientific rigor through which the DII was developed offers advantages over other dietary indices [14, 15]. Also, the use of NHANES data allows for generalization to the US public due to the complex sampling design. Limitations include the cross-sectional nature of NHANES and therefore this study cannot infer causation. Previously, the DII was associated with increased risk of CVD in the Prevención con Dieta Mediterránea (PREDIMED) study (hazard ratio for DII quartile 4 compared to 1 = 1.73, 95%CI= 1.15–2.60) [36]. However, showing that individuals with a previous diagnosis of a circulatory condition have pro-inflammatory diets still has public health significance from a recurrence standpoint. Use of self-report diagnoses does not allow for confirmation through medical records or time between circulatory disorder diagnoses and participation in NHANES. Only one 24HR was utilized to calculate the DII. Estimates of dietary intake are subject to day-to-day variability and dietary information on a single day may provide imprecise estimates of usual dietary intake [37]. Lastly, there were large age differences between those reporting a diagnosis and those not; however, all models were adjusted for age.

After experiencing a major circulatory event, one would expect there to be no, or a weaker, association between the DII and previous circulatory disorders due to changes in diet that are a part of secondary prevention protocols [38]. It should be noted that those with a previous diagnosis of angina or coronary artery disease had lower mean DII scores compared to those with no prior diagnosis. However, it was not possible using NHANES data to determine whether these values were lower due to changes in dietary patterns after diagnosis, some other unexplained reason, or chance. Changing diet after a circulatory

disorder diagnosis or event can lead to a lower risk of recurrence. For example, adherence to the Mediterranean diet has been shown to improve lipid profiles, arrhythmias, blood pressure, obesity, and inflammation [39]. Previously, we showed, in a diet-modification randomized control trial, that a switch from a more western diet to vegan or vegetarian diets lowers the DII [40]. It would be interesting to determine if diet modification among those previously diagnosed with a circulatory condition lowers the DII and, in turn, risk of recurrence.

In conclusion, this study indicated that women with a previous diagnosis of a circulatory disorder have more pro-inflammatory diets than those without a previous circulatory diagnosis. Recently, the Nutrition Society has urged the use of dietary pattern analyses for CVD risk and recurrence [29]. The rationale for their statements includes the fact that circulatory disorder progression entails multi-factorial processes that involve complex relationships between many components of dietary intake, not just a single nutrient [29]. They further urge researchers to create studies involving whole-diet interventions. However, to most effectively examine whole-diet changes, dietary tools need to be created to measure these changes. The DII was designed specifically to measure the inflammatory potential of diet. Considering inflammation is involved in the development of various circulatory conditions, the DII may serve as an excellent dietary index for monitoring dietary changes after diagnoses of circulatory conditions to reduce the risk of recurrence.

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Abbreviations

DII	Dietary Inflammatory Index
NHANES	National Health and Nutrition Examination Survey
CVD	cardiovascular disease
MetSyn	metabolic syndrome
BMI	body mass index
24HR	24-hour dietary recall
FFQ	food frequency questionnaire
CHD	coronary heart disease
MVPA	moderate-to-vigorous physical activity
POR	prevalence odds ratio
95%CI	95% confidence interval

Literature Cited

1. Libby P. Inflammatory mechanisms: the molecular basis of inflammation and disease. Nutr Rev. 2007; 65:S140–6. [PubMed: 18240538]
2. Libby P. Inflammation and cardiovascular disease mechanisms. Am J Clin Nutr. 2006; 83:456S–60S. [PubMed: 16470012]
3. Smith CJ, Lawrence CB, Rodriguez-Grande B, Kovacs KJ, Pradillo JM, Denes A. The Immune System in Stroke: Clinical Challenges and Their Translation to Experimental Research. J Neuroimmune Pharmacol. 2013; 8:867–87. [PubMed: 23673977]
4. Trzos E, Uznanska B, Rechcinski T, Krzeminska-Pakula M, Bugala M, Kurpesa M. Myocardial infarction in young people. Cardiol J. 2009; 16:307–11. [PubMed: 19653171]
5. Ahluwalia N, Andreeva VA, Kesse-Guyot E, Hercberg S. Dietary patterns, inflammation and the metabolic syndrome. Diabetes Metab. 2013; 39:99–110. [PubMed: 23062863]
6. Martinez-Gonzalez MA, Bes-Rastrollo M. Dietary patterns, Mediterranean diet, and cardiovascular disease. Curr Opin Lipidol. 2014; 25:20–6. [PubMed: 24370845]
7. Cuenca-Garcia M, Artero EG, Sui X, Lee DC, Hebert JR, Blair SN. Dietary indices, cardiovascular risk factors and mortality in middle-aged adults: findings from the Aerobics Center Longitudinal Study. Ann Epidemiol. 2014; 24:297–303. e2. [PubMed: 24529647]
8. Cole JA, Smith SM, Hart N, Cupples ME. Systematic review of the effect of diet and exercise lifestyle interventions in the secondary prevention of coronary heart disease. Cardiol Res Pract. 2011; 2011:232351. [PubMed: 21197445]
9. de Lorgeril M, Salen P. Mediterranean diet in secondary prevention of CHD. Public Health Nutr. 2011; 14:2333–7. [PubMed: 22166192]
10. Mangat A, Grewal D, Kaur P, Jyotsna R, Singh R, Pandian JD. Dietary patterns in stroke patients in Northwest India. Nutr Neurosci. 2013; 16:288–92. [PubMed: 23433119]
11. Lim H, Choue R. Dietary pattern, nutritional density, and dietary quality were low in patients with cerebral infarction in Korea. Nutr Res. 2011; 31:601–7. [PubMed: 21925345]
12. Baltali M, Kiziltan HT, Korkmaz ME, Topcu S, Demirtas M, Metin M, et al. Prevalence of modifiable cardiovascular risk factors remain high after coronary bypass graft surgery: a multicentre study among Turkish patients. J Cardiovasc Risk. 2002; 9:207–14. [PubMed: 12394329]
13. Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. Curr Opin Lipidol. 2002; 13:3–9. [PubMed: 11790957]
14. Shivappa N, Steck SE, Hurley TG, Hussey JR, Hebert JR. Designing and developing a literature-derived, population-based dietary inflammatory index. Public Health Nutr. 2014; 17:1689–96. [PubMed: 23941862]
15. Shivappa N, Steck SE, Hurley TG, Hussey JR, Ma Y, Ockene IS, et al. A population-based dietary inflammatory index predicts levels of C-reactive protein in the Seasonal Variation of Blood Cholesterol Study (SEASONS). Public Health Nutr. 2014; 17:1825–33. [PubMed: 24107546]
16. Wirth MD, Burch J, Shivappa N, Violanti JM, Burchfiel CM, Fekedulegn D, et al. Association of a dietary inflammatory index with inflammatory indices and metabolic syndrome among police officers. J Occup Environ Med. 2014; 56:986–9. [PubMed: 25046320]
17. Wood LG, Shivappa N, Berthon BS, Gibson PG, Hebert JR. Dietary inflammatory index is related to asthma risk, lung function and systemic inflammation in asthma. Clin Exp Allergy. 2015; 45:177–83. [PubMed: 24708388]
18. Shivappa N, Prizment AE, Blair CK, Jacobs DR Jr, Steck SE, Hebert JR. Dietary inflammatory index and risk of colorectal cancer in the Iowa Women's Health Study. Cancer Epidemiol Biomarkers Prev. 2014; 23:2383–92. [PubMed: 25155761]
19. Zamora-Ros R, Shivappa N, Steck SE, Canzian F, Landi S, Alonso MH, et al. Dietary inflammatory index and inflammatory gene interactions in relation to colorectal cancer risk in the Bellvitge colorectal cancer case-control study. Genes Nutr. 2015; 10:447. [PubMed: 25488145]
20. Shivappa N, Bosetti C, Zucchetto A, Montella M, Serraino D, La Vecchia C, et al. Association between dietary inflammatory index and prostate cancer among Italian men. Br J Nutr. 2015; 113:278–83.

21. Shivappa N, Bosetti C, Zucchetto A, Serraino D, La Vecchia C, Hebert JR. Dietary inflammatory index and risk of pancreatic cancer in an Italian case-control study. Br J Nutr. 2015; 113:292–8.
22. Tabung FK, Steck SE, Ma Y, Liese AD, Zhang J, Caan B, et al. The association between dietary inflammatory index and risk of colorectal cancer among postmenopausal women: results from the Women's Health Initiative. Cancer Causes Control. 2015; 26:399–408. [PubMed: 25549833]
23. Wirth MD, Shivappa N, Steck SE, Hurley TG, Hebert JR. The dietary inflammatory index is associated with colorectal cancer in the National Institutes of Health-American Association of Retired Persons Diet and Health Study. Br J Nutr. 2015; 113:1819–27. [PubMed: 25871645]
24. Shivappa N, Zucchetto A, Montella M, Serraino D, Steck SE, La Vecchia C, et al. Inflammatory potential of diet and risk of colorectal cancer: a case-control study from Italy. Br J Nutr. 2015; 114:152–8. [PubMed: 26050563]
25. Ruiz-Canela M, Zazpe I, Shivappa N, Hebert JR, Sanchez-Tainta A, Corella D, et al. Dietary inflammatory index and anthropometric measures of obesity in a population sample at high cardiovascular risk from the PREDIMED (PREvencion con DIeta MEDiterranea) trial. Br J Nutr. 2015; 113:984–95. [PubMed: 25720588]
26. Wirth MD, Burch J, Shivappa N, Steck SE, Hurley TG, Vena JE, et al. Dietary inflammatory index scores differ by shift work status: NHANES 2005 to 2010. J Occup Environ Med. 2014; 56:145–8. [PubMed: 24451608]
27. Apostolopoulou M, Michalakis K, Miras A, Hatzitolios A, Savopoulos C. Nutrition in the primary and secondary prevention of stroke. Maturitas. 2012; 72:29–34. [PubMed: 22406461]
28. CDC. Centers for Disease Control and Prevention. National Health and Nutrition Examinations Survey data. Hyattsville, MD: National Center for Health Statistics; 2013.
29. Williams CM, Lovegrove JA, Griffin BA. Dietary patterns and cardiovascular disease. Proc Nutr Soc. 2013; 72:407–11. [PubMed: 23953031]
30. Selem SS, Castro MA, Cesar CL, Marchioni DM, Fisberg RM. Associations between dietary patterns and self-reported hypertension among Brazilian adults: a cross-sectional population-based study. J Acad Nutr Diet. 2014; 114:1216–22. [PubMed: 24637242]
31. Wang D, He Y, Li Y, Luan D, Yang X, Zhai F, et al. Dietary patterns and hypertension among Chinese adults: a nationally representative cross-sectional study. BMC Public Health. 2011; 11:925. [PubMed: 22168909]
32. Dehghan M, Mente A, Teo KK, Gao P, Sleight P, Dagenais G, et al. Relationship between healthy diet and risk of cardiovascular disease among patients on drug therapies for secondary prevention: a prospective cohort study of 31 546 high-risk individuals from 40 countries. Circulation. 2012; 126:2705–12. [PubMed: 23212996]
33. Lim H, Choue R. Impact of nutritional status and dietary quality on stroke: do we need specific recommendations? Eur J Clin Nutr. 2013; 67:548–54. [PubMed: 23443833]
34. 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; 99:779–85. [PubMed: 9989963]
35. Steck SE, Shivappa N, Tabung FK, Harmon BE, Wirth MD, Hurley TG, et al. The Dietary Inflammatory Index: A New Tool for Assessing Diet Quality Based on Inflammatory Potential. The Digest: The Research Dietetic Practice Group of the Academy of Nutrition and Dietetics. 2014; 49:1–9.
36. Garcia-Arellano A, Ramallal R, Ruiz-Canela M, Salas-Salvado J, Corella D, Shivappa N, et al. Dietary Inflammatory Index and Incidence of Cardiovascular Disease in the PREDIMED Study. Nutrients. 2015; 7:4124–38. [PubMed: 26035241]
37. Basiotis PP, Welsh SO, Cronin FJ, Kelsay JL, Mertz W. Number of days of food intake records required to estimate individual and group nutrient intakes with defined confidence. J Nutr. 1987; 117:1638–41. [PubMed: 3655942]
38. de Waure C, Lauret GJ, Ricciardi W, Ferket B, Teijink J, Spronk S, et al. Lifestyle interventions in patients with coronary heart disease: a systematic review. Am J Prev Med. 2013; 45:207–16. [PubMed: 23867029]

39. Tourlouki E, Matalas AL, Panagiotakos DB. Dietary habits and cardiovascular disease risk in middle-aged and elderly populations: a review of evidence. Clin Interv Aging. 2009; 4:319–30. [PubMed: 19696896]

40. Turner-McGrievy GM, Wirth MD, Shivappa N, Wingard EE, Fayad R, Wilcox S, et al. Randomization to plant-based dietary approaches leads to larger short-term improvements in Dietary Inflammatory Index scores and macronutrient intake compared with diets that contain meat. Nutr Res. 2015; 35:97–106. [PubMed: 25532675]

Table 1

Population Characteristics by Circulatory Disorder Status

Characteristic	Present[1] (n=1,734)	Absent (n=13,879)	p-value
Sex			
Male	1,002 (55%)	6,564 (48%)	
Female	732 (45%)	7,315 (52%)	<0.01
Race			
Non-Hispanic White	1,030 (77%)	6,539 (70%)	
Non-Hispanic Black	373 (12%)	2,790 (11%)	
Mexican American	184 (4%)	2,696 (9%)	
Other	147 (7%)	1,854 (11%)	<0.01
Military			
Yes	521 (29%)	1,541 (10%)	
No	1,213 (71%)	12,337 (90%)	<0.01
Education			
<High School	646 (29%)	3,846 (18%)	
Completed High School	432 (27%)	3,293 (24%)	
Some College	417 (27%)	3,879 (31%)	
≥College Degree	237 (17%)	2,844 (27%)	<0.01
Marital Status			
Married/Living with Partner	949 (60%)	8,537 (65%)	
Widowed/Divorced/Separated	665 (34%)	2,861 (17%)	
Never Married	120 (6%)	2,475 (18%)	<0.01
Health Insurance			
Yes	1,568 (91%)	10,313 (80%)	
No	164 (9%)	3,558 (20%)	<0.01
Income			
<$20,000	597 (28%)	3,247 (17%)	
$20,000 – $34,999	421 (25%)	2,811 (17%)	
$35,000 – $64,999	362 (24%)	3,351 (26%)	
>$65,000	277 (23%)	3,942 (41%)	<0.01
Smoking Family Member			
Yes	370 (22%)	2,421 (17%)	
No	1,353 (78%)	11,377 (83%)	<0.01
Smoking Status			
Current	349 (21%)	3,052 (22%)	
Former	730 (41%)	3,178 (23%)	
Never	655 (38%)	7,646 (55%)	<0.01
Family History of Heart Attack			
Yes	368 (25%)	1,612 (13%)	
No	1,276 (75%)	11,928 (87%)	<0.01
Age	64.4 ± 0.46	45.1 ± 0.31	<0.01

Characteristic	Present[1] (n=1,734)	Absent (n=13,879)	p-value
Sleep Duration (Hours)	6.9 ± 0.05	6.9 ± 6.9	0.54
Body Mass Index	30.2 ± 0.17	28.4 ± 0.11	<0.01
Drinks per Week	0.16 ± 0.02	0.24 ± 0.02	0.01
Moderate-Vigorous PA Minutes[3]	107.7 ± 7.9	165.5 ± 4.8	<0.01

Column percentages may not equal 100% due to rounding. Stratum numbers may not equal column totals due to missing data. All categorical variable p-values based on chi-square tests and all continuous p-values based on t-tests.

[1]Present was defined as self-reported diagnosis of congestive heart failure, coronary artery disease, angina pectoris, heart attack, or stroke.

[2]Represents minutes per week.

Table 2

Circulatory Disorder Prevalence by Quartiles of the DII

DII Quartile	Present	Absent	Crude POR (95%CI)	Adjusted POR (95%CI)
Combined Circulatory Disorders				
1	505 (28%)	3,393 (24%)	1.00 (referent)	1.00 (referent)
2	460 (26%)	3,451 (24%)	0.92 (0.80–1.06)	1.16 (1.00–1.36)
3	396 (22%)	3,504 (25%)	0.76 (0.67–0.87)	1.08 (0.93–1.25)
4	373 (23%)	3,531 (27%)	0.74 (0.62–0.87)	1.30 (1.06–1.58)
Congestive Heart Failure				
1	142 (26%)	3,762 (24%)	1.00 (referent)	1.00 (referent)
2	130 (27%)	3,784 (24%)	1.07 (0.80–1.42)	1.36 (1.02–1.82)
3	122 (25%)	3,791 (25%)	0.96 (0.72–1.28)	1.33 (1.00–1.77)
4	107 (22%)	3,804 (26%)	0.78 (0.61–1.00)	1.38 (1.09–1.74)
Coronary Heart Disease				
1	199 (30%)	3,700 (24%)	1.00 (referent)	1.00 (referent)
2	180 (29%)	3,735 (24%)	0.96 (0.75–1.22)	1.21 (0.92–1.59)
3	140 (22%)	3,759 (25%)	0.72 (0.55–0.95)	1.07 (0.82–1.40)
4	115 (18%)	3,795 (26%)	0.55 (0.43–0.70)	0.96 (0.72–1.28)
Angina Pectoris				
1	128 (30%)	3,783 (24%)	1.00 (referent)	1.00 (referent)
2	128 (33%)	3,787 (24%)	1.12 (0.79–1.59)	1.29 (0.90–1.85)
3	83 (19%)	3,828 (25%)	0.61 (0.41–0.89)	0.75 (0.50–1.12)
4	84 (18%)	3,822 (26%)	0.55 (0.36–0.85)	0.83 (0.54–1.28)
Heart Attack				
1	183 (25%)	3,731 (24%)	1.00 (referent)	1.00 (referent)
2	178 (26%)	3,747 (24%)	1.02 (0.81–1.29)	1.25 (0.96–1.63)
3	154 (24%)	3,759 (25%)	0.91 (0.72–1.15)	1.23 (0.99–1.55)
4	170 (25%)	3,742 (26%)	0.92 (0.70–1.21)	1.48 (1.12–1.97)
Stroke				
1	169 (28%)	3,742 (24%)	1.00 (referent)	1.00 (referent)
2	149 (24%)	3,774 (25%)	0.84 (0.66–1.08)	1.05 (0.81–1.35)
3	137 (20%)	3,779 (25%)	0.68 (0.48–0.97)	0.87 (0.60–1.24)
4	149 (29%)	3,767 (26%)	0.98 (0.77–1.26)	1.56 (1.21–2.01)
High Blood Pressure				
1	1578 (27%)	2,334 (23%)	1.00 (referent)	1.00 (referent)
2	1339 (24%)	2,582 (25%)	0.83 (0.74–0.93)	0.94 (0.82–1.07)

DII Quartile	Present	Absent	Crude POR (95%CI)	Adjusted POR (95%CI)
3	1281 (24%)	2,637 (25%)	0.80 (0.71–0.90)	1.04 (0.92–1.18)
4	1210 (25%)	2,705 (27%)	0.78 (0.69–0.88)	1.19 (1.05–1.34)

Column percentages may not equal 100% due to rounding. Column percentages based on weighted frequencies. PORs represent the odds or a diagnosis among DII quartiles 2–4 compared to quartile 1. DII Quartile Ranges: 1 = −5.81 to −0.81; 2 = −0.82 to 0.70; 3 = 0.71 to 1.93; 4 = 1.94 to 4.83. Combined Circulatory Disorders includes congestive heart failure, coronary artery disease, angina pectoris, heart attack, and stroke. Adjustments: All models adjusted for family member smoking status, personal smoking status, age, and body mass index. Abbreviations: DII = Dietary Inflammatory Index; POR = prevalence odds ratio; 95%CI = 95% confidence interval.

Table 3

Circulatory Disorder Prevalence by Quartiles of the DII Stratified by Sex

	Males				Females			
DII Quartile	**Present**	**Absent**	**Crude POR (95%CI)**	**Adjusted POR (95%CI)**	**Present**	**Absent**	**Crude POR (95%CI)**	**Adjusted POR (95%CI)**
Combined Circulatory Disorders								
1	283 (28%)	1,293 (19%)	1.00 (referent)	1.00 (referent)	222 (28%)	2,100 (29%)	1.00 (referent)	1.00 (referent)
2	268 (27%)	1,612 (24%)	0.76 (0.61–0.95)	1.00 (0.77–1.29)	192 (26%)	1,839 (25%)	1.05 (0.80–1.37)	1.27 (0.95–1.69)
3	246 (24%)	1,775 (27%)	0.58 (0.48–0.71)	0.99 (0.78–1.25)	150 (20%)	1,729 (23%)	0.90 (0.72–1.14)	1.07 (0.84–1.37)
4	205 (21%)	1,884 (30%)	0.45 (0.37–0.54)	0.85 (0.66–1.09)	168 (26%)	1,647 (23%)	1.15 (0.90–1.47)	1.84 (1.42–2.40)
Congestive Heart Failure								
1	75 (23%)	1,503 (19%)	1.00 (referent)	1.00 (referent)	67 (29%)	2,259 (29%)	1.00 (referent)	1.00 (referent)
2	82 (29%)	1,798 (24%)	1.02 (0.76–1.37)	1.43 (1.06–1.91)	48 (26%)	1,986 (25%)	1.03 (0.61–1.73)	1.19 (0.67–2.10)
3	80 (28%)	1,947 (27%)	0.88 (0.60–1.31)	1.56 (1.02–2.37)	42 (21%)	1,844 (23%)	0.93 (0.60–1.44)	0.97 (0.62–1.52)
4	58 (20%)	2,033 (30%)	0.56 (0.40–0.79)	1.09 (0.73–1.64)	49 (24%)	1,771 (23%)	1.03 (0.75–1.42)	1.67 (1.21–2.31)
Coronary Heart Disease								
1	136 (29%)	1,439 (19%)	1.00 (referent)	1.00 (referent)	63 (33%)	2,261 (29%)	1.00 (referent)	1.00 (referent)
2	125 (29%)	1,755 (24%)	0.91 (0.59–1.10)	1.03 (0.72–1.45)	55 (29%)	1,980 (25%)	1.03 (0.64–1.64)	1.34 (0.81–2.23)
3	108 (24%)	1,911 (27%)	0.57 (0.41–0.80)	0.99 (0.70–1.42)	32 (19%)	1,848 (23%)	0.74 (0.43–1.28)	0.95 (0.53–1.68)
4	81 (18%)	2,011 (30%)	0.39 (0.27–0.55)	0.70 (0.46–1.07)	34 (19%)	1,784 (23%)	0.72 (0.41–1.26)	1.31 (0.66–2.61)
Angina Pectoris								
1	76 (31%)	1,508 (19%)	1.00 (referent)	1.00 (referent)	52 (29%)	2,275 (29%)	1.00 (referent)	1.00 (referent)
2	70 (34%)	1,813 (24%)	0.90 (0.58–1.40)	1.10 (0.67–1.79)	58 (33%)	1,974 (25%)	1.33 (0.76–2.32)	0.45 (0.81–2.58)
3	47 (18%)	1,977 (27%)	0.41 (0.23–0.73)	0.60 (0.33–1.09)	36 (20%)	1,851 (23%)	0.87 (0.51–1.47)	0.93 (0.52–1.67)
4	49 (17%)	2,043 (30%)	0.36 (0.21–0.60)	0.55 (0.29–1.02)	35 (19%)	1,779 (23%)	0.82 (0.46–1.47)	1.26 (0.69–2.30)
Heart Attack								
1	123 (26%)	1,463 (19%)	1.00 (referent)	1.00 (referent)	60 (24%)	2,268 (29%)	1.00 (referent)	1.00 (referent)

	Males				Females			
DII Quartile	**Present**	**Absent**	**Crude POR (95%CI)**	**Adjusted POR (95%CI)**	**Present**	**Absent**	**Crude POR (95%CI)**	**Adjusted POR (95%CI)**
2	125 (26%)	1,765 (24%)	0.80 (0.63–1.02)	1.07 (0.79–1.45)	53 (26%)	1,982 (25%)	1.25 (0.74–2.10)	1.39 (0.82–2.37)
3	113 (25%)	1,914 (27%)	0.68 (0.54–0.86)	1.21 (0.88–1.64)	41 (21%)	1,845 (23%)	1.13 (0.70–1.80)	1.10 (0.68–1.78)
4	109 (23%)	1,987 (30%)	0.57 (0.45–0.73)	1.10 (0.82–1.47)	61 (29%)	1,755 (23%)	1.51 (0.85–2.67)	1.97 (1.10–3.53)
Stroke								
1	80 (28%)	1,501 (19%)	1.00 (referent)	1.00 (referent)	89 (28%)	2,241 (29%)	1.00 (referent)	1.00 (referent)
2	67 (21%)	1,821 (24%)	0.60 (0.36–1.00)	0.79 (0.46–1.37)	82 (26%)	1,953 (25%)	1.07 (0.78–1.49)	1.28 (0.93–1.76)
3	85 (27%)	1,945 (27%)	0.68 (0.44–1.05)	1.07 (0.62–1.83)	52 (14%)	1,834 (23%)	0.64 (0.42–0.98)	0.68 (0.46–1.03)
4	68 (25%)	2,027 (30%)	0.57 (0.38–0.87)	1.05 (0.64–1.71)	81 (33%)	1,740 (23%)	1.51 (1.07–2.11)	2.11 (1.51–2.95)
High Blood Pressure								
1	650 (23%)	936 (18%)	1.00 (referent)	1.00 (referent)	928 (31%)	1,398 (28%)	1.00 (referent)	1.00 (referent)
2	649 (24%)	1,240 (24%)	0.78 (0.66–0.92)	0.91 (0.75–1.10)	690 (24%)	1,342 (25%)	0.87 (0.75–1.01)	0.97 (0.82–1.15)
3	654 (26%)	1,376 (28%)	0.75 (0.64–0.88)	0.97 (0.80–1.17)	627 (22%)	1,261 (23%)	0.85 (0.72–1.00)	1.11 (0.94–1.30)
4	636 (28%)	1,461 (30%)	0.72 (0.59–0.87)	1.11 (0.89–1.39)	574 (22%)	1,244 (24%)	0.85 (0.73–0.98)	1.25 (1.07–1.45)

Column percentages may not equal 100% due to rounding. Column percentages based on weighted frequencies. PORs represent the odds or a diagnosis among DII quartiles 2–4 compared to quartile 1. DII Quartile Ranges: 1 = −5.81 to −0.81; 2 = −0.82 to 0.70; 3 = 0.71 to 1.93; 4 = 1.94 to 4.83. Combined Circulatory Disorders includes congestive heart failure, coronary artery disease, angina pectoris, heart attack, and stroke. Adjustments: All models adjusted for family member smoking status, personal smoking status, age, and body mass index. Abbreviations: DII = Dietary Inflammatory Index, POR = prevalence odds ratio; 95%CI = 95% confidence interval.