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Dietary Patterns and Long-Term Survival: A Retrospective Study of Healthy Primary Care Patients

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ABSTRACT

BACKGROUND: Dietary patterns are related to mortality in selected populations with comorbidities. We studied whether dietary patterns are associated with long-term survival in a middle-aged, healthy population.

METHODS: In this observational cohort study at the Cooper Clinic preventive medicine center (Dallas, Tex), a volunteer sample of 11,376 men and women with no history of myocardial infarction or stroke completed a baseline dietary assessment between 1987 and 1999 and were observed for an average of 18 years. Proportional hazard regressions, including a tree-augmented model, were used to assess the association of the Dietary Approaches to Stop Hypertension (DASH) dietary pattern, Mediterranean dietary pattern, and individual dietary components with mortality. The primary outcome was all-cause mortality. The secondary outcome was cardiovascular mortality.

RESULTS: Mean baseline age was 47 years. Each quintile increase in the DASH diet score was associated with a 6% lower adjusted risk for all-cause mortality ($P < .02$). The Mediterranean diet was not independently associated with all-cause or cardiovascular mortality. Solid fats and added sugars were the most predictive of mortality. Individuals who consumed >34% of their daily calories as solid fats had the highest risk for all-cause mortality.

CONCLUSIONS: The DASH dietary pattern was associated with significantly lower all-cause mortality over approximately 2 decades of follow-up in a middle-aged, generally healthy population. Added solid fat and added sugar intake were the most predictive of all-cause mortality. These results suggest that promotion of a healthy dietary pattern should begin in middle age, before the development of comorbid risk factors.
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KEYWORDS: Cardiovascular disease mortality; Dietary intake; Dietary patterns; Mortality

INTRODUCTION

Dietary pattern is a known modifiable risk factor for chronic diseases, including cardiovascular disease[1] and cancer.[2] Dietary patterns have also been linked to chronic disease risk factors, such as lipids,[1] blood pressure,[3] diabetes,[4] body mass index (BMI),[5] and atherosclerosis and inflammation.[1] However, the relationship between dietary pattern and mortality outcomes has been inconsistent.[1,6]

The Dietary Approaches to Stop Hypertension (DASH) diet, originally designed to reduce hypertension,[3] has been shown to reduce overall mortality in select populations, such as adults with hypertension[7] and women with heart failure[8] over approximately 5 to 8 years of follow-up. Also, the DASH diet was associated with an approximately 17% decrease in the risk for all-cause and cardiovascular disease mortality in adults aged more than 60 years.[9] The Mediterranean dietary pattern has shown an inconsistent relationship with

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mortality.[8,10-12] Individual foods and food groups, for example, fruits,[13-15] vegetables,[13-15] dairy,[13,16] sugars,[17,18] and fats,[19-21] have similarly demonstrated an inconsistent association with mortality outcomes. In a population of generally healthy, middle-aged individuals, we sought to assess the relationship of dietary patterns and food group intake at midlife with the long-term risk of all-cause and cardiovascular disease mortality.

CLINICAL SIGNIFICANCE

- In this observational study, the DASH diet was associated with decreased risk for all-cause mortality.
- Vegetable intake in the DASH diet pattern was associated with decreased risk for all-cause mortality, and fruit/nut and grain intake in the Mediterranean diet pattern was associated with a decreased risk for cardiovascular mortality.
- Solid fat and added sugar intake were the most predictive of all-cause mortality.
- Dietary patterns were associated with all-cause mortality an average of 18 years after dietary assessment.

MATERIALS AND METHODS

Design and Participants

The Cooper Center Longitudinal Study is a prospective study of predominantly non-Hispanic white patients at the Cooper Clinic in Dallas, Texas.[22] The current study included men and women aged 20 years or older who completed a 3-day dietary record from 1987 to 1999 (n = 15,517). Participants were excluded if they were missing data on covariates (n = 3507), they reported prevalent cardiovascular disease (n = 466), their discretionary fat intake was recorded greater than total fat intake (n = 107), their total daily calorie intake was less than 500 kcal (n = 5) or greater than 5000 kcal (n = 31), or their physical activity exceeded 140 metabolic equivalent of task hours/week (n = 25). After exclusions, 11,376 individuals remained for primary analysis.

The Cooper Center Longitudinal Study is reviewed annually by the Institutional Review Board at the Cooper Institute, and the present analysis was determined not to require review by the Stanford University Institutional Review Board.

Dietary Variables. Participants completed a 3-day diet record for which recording methods have been described.[23,24] Briefly, participants recorded their food intake and portion sizes on 1 weekend day and 2 weekdays. Clinic dietitians provided written instructions and photographs of serving sizes to assist in accurately recording food intake and portion sizes. Nutrient analysis was performed with the Food Intake Analysis System (University of Texas-Houston School of Public Health) using the US Agricultural Department (USDA) Survey Nutrient Database to supply nutrient intake information. Adjusted standard portion sizes were used when portion sizes were missing.[25] Diet record data were linked to the USDA Pyramid Servings database,[26] which provided USDA food pyramid servings data and complete nutrient intakes for the diet records.

To calculate the DASH diet score, average daily intakes of fruits, vegetables, nuts and legumes, dairy, whole grains, red meat, and added sugars were computed from the 3-day dietary record and converted to My Pyramid serving equivalents, similar to prior analyses.[8,27] These items, along with sodium intake, were ranked into quintiles. Participants were categorized by quintile of DASH diet score.

To calculate the Mediterranean diet score, average daily intakes of vegetables (except potatoes), fruits and nuts, legumes, grains, fish, dairy, and meat (except fish) were computed from the 3-day dietary record and converted to My Pyramid equivalents.[28] Quintiles of Mediterranean diet score categories were used in analysis.

Outcome Measurements. All-cause mortality was assessed via National Death Index records through December 31, 2010. Cardiovascular disease deaths were identified using the International Classification of Diseases, 9th Revision (codes 410.0-414.9 and 429.2) for deaths occurring before 1999 and 10th Revision (codes 120-126) for deaths between 1999 and 2010.

Covariates. Covariates were assessed at the baseline visit. Family history was defined as positive if a first-degree relative had cardiovascular disease before age 50 years. Alcohol use was measured as the number of drinks per week when not included in the diet exposure score. Smoking status was categorized as current versus nonsmokers. BMI was calculated as weight in kilograms divided by height in meters squared. Physical activity levels were defined by metabolic equivalent of task hours per week. Resting systolic and diastolic blood pressures were recorded in millimeters of mercury at the baseline visit. Fasting low-density lipoprotein (LDL) cholesterol and glucose levels were measured in milligrams/deciliter.

Statistical Analysis

Characteristics of participants at baseline were summarized in aggregate and within quintiles of total caloric intake. Trends of characteristics across ordered diet categories were tested using the nonparametric Jonckheere-Terpstra method.[29] To account for the effect of total calorie intake on dietary patterns, the total sample of participants was divided into quintiles of total calorie intake. Within each total calorie intake quintile, the dietary pattern exposure was calculated as described previously. Individuals grouped into the same dietary pattern score were combined into total calorie-adjusted dietary pattern groups for primary analysis.

Hazard ratios (HRs) for all-cause and cardiovascular mortality were estimated using proportional hazards models. Age at baseline was used as an entry time to account for left truncation. Age at follow-up was used as the time scale to control for strong age dependence in mortality. All models included the diet score. Adjusted models included age and sex, or age, sex, family history of premature heart disease, BMI, physical activity, current smoking, alcohol use (except in the Mediterranean diet analysis, which includes alcohol in the score calculation), LDL cholesterol, systolic blood pressure, and glucose. Each aggregate diet score model had a companion model including the score components individually. Proportional hazards assumptions for each covariate included in regression models were confirmed by testing the Pearson correlation between the rank order of the age at follow-up and the corresponding Schoenfeld residuals.[30,31]

We further used a tree-augmented proportional hazards model to explore the relationship between dietary composition and all-cause and cardiovascular mortality controlling for age, sex, smoking, total caloric intake, and physical activity.[32] We initially fit a proportional hazards model of right-censored age at death with entry age at dietary assessment. Deviance residuals reflective of excess deaths were then modeled at the individual level by recursive partitioning[33] on 2 dietary compositions: one giving the allocation of total calories among 13 specific food groups (fruits, vegetables, legumes/nuts/seeds, dairy, poultry/eggs, fish, other meat, added oils, solid fats, added sugar, alcohol, whole grains, other grains) and another giving the allocation of total calories among the 4 macro-nutrients (protein, carbohydrate, fat, alcohol). The resulting tree was pruned back to the size that minimized average square error in 10-fold cross-validation.[34] A categoric variable representing the nodes of the selected tree was then included as an additional covariate in the final proportional hazards model. All analyses were programmed in SAS/STAT, version 9.4 (SAS Institute, Inc, Cary, NC).

RESULTS

Participant Characteristics

Baseline participant characteristics in aggregate and by quintile of daily calorie intake are reported in **Table 1**. As baseline calorie intake increased, mean participant age decreased; alcohol use, LDL cholesterol, blood pressure, fasting glucose, smoking rates, and BMI increased; and participants were more predominantly men ($P < .001$ for all characteristics across calorie quintile).

Dietary Pattern, Dietary Components, and Mortality

All-Cause Mortality. There were 841 deaths from all causes over a mean of 18.0 years of follow-up. The relationship among baseline dietary pattern, dietary components, and all-cause mortality is shown in **Tables 2 and 3**. After adjustment for all covariates, the DASH diet score was associated with a lower risk of all-cause mortality (HR, 0.94 per quintile; 95% confidence interval [CI], 0.89-0.99). A 1-quintile increase in vegetable intake, as defined in the DASH diet score, was associated with a 7% lower risk for all-cause mortality (HR, 0.93; 95% CI, 0.88-0.98). Neither the Mediterranean diet score nor the dietary components in the Mediterranean diet score calculation were associated with all-cause mortality.

Cardiovascular Mortality. There were 249 cardiovascular deaths over a mean 18 years of follow-up. Assessment of dietary pattern, dietary components, and risk for cardiovascular mortality is reported in **Tables 2 and 3**. After adjustment for all covariates, neither the DASH diet score nor the DASH diet score components were associated with cardiovascular mortality. Although the Mediterranean diet score was also not associated with risk of cardiovascular mortality, greater than median intake of fruits and nuts (HR, 0.70; 95% CI,

Table 1 Participant Characteristics at Baseline Visit, by Total, and by Quintiles of Average Daily Calorie Intake

	Total	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P*
N	11,376	2275	2275	2276	2275	2275	–
Energy, kcal (SD)	2155 (641)	1354 (214)	1783 (92)	2092 (89)	2433 (113)	3114 (445)	<.001
Age, y (SD)	46.5 (10.0)	47.7 (9.8)	47.3 (10.2)	46.8 (10.0)	46.0 (9.9)	44.5 (9.9)	<.001
Sex (% female)	2799 (24.6)	1125 (49.5)	756 (33.2)	497 (21.8)	279 (12.3)	142 (6.2)	<.001
Family history cardiovascular disease (%)	2155 (18.6)	430 (18.9)	424 (18.6)	447 (19.6)	399 (17.5)	415 (18.2)	.349
Alcohol use (drinks/wk)	5.9 (7.2)	4.7 (6.0)	5.5 (6.5)	6.0 (6.7)	6.5 (8.1)	6.9 (8.4)	<.001
LDL cholesterol (mg/dL)	131.4 (36.3)	127.6 (37.2)	131.4 (37.5)	131.5 (35.0)	133.1 (35.7)	133.3 (35.9)	<.001
SBP (mm Hg)	119.8 (14.3)	118.1 (15.2)	119.4 (14.9)	119.6 (13.9)	120.6 (13.9)	121.4 (13.4)	<.001
DBP (mm Hg)	80.2 (9.9)	79.3 (10.4)	79.8 (10.0)	80.2 (9.8)	80.7 (9.8)	81.0 (9.4)	<.001
Fasting glucose (mg/dL)	99.1 (15.9)	98.4 (15.6)	99.3 (18.3)	99.0 (16.1)	99.1 (12.3)	99.7 (16.8)	<.001
Smoking (% current)	1349 (11.9)	248 (10.9)	257 (11.3)	271 (11.9)	293 (12.9)	280 (12.3)	.04
BMI (kg/m^2)	25.8 (4.1)	25.2 (3.9)	25.4 (3.9)	25.7 (4.0)	26.1 (4.0)	26.4 (4.3)	<.001
Physical activity (MET-h/wk)	17.5 (19.5)	16.6 (18.8)	16.8 (18.5)	17.7 (19.0)	18.1 (20.1)	18.6 (21.0)	.002

BMI = body mass index; DBP = diastolic blood pressure; LDL = low-density lipoprotein; MET = metabolic equivalent of task; SBP = systolic blood pressure; SD = standard deviation.

*P for trend of characteristic across diet category. Continuous data presented as mean (standard deviation). Frequency data presented as N (percent).

Table 2 Mortality Hazard Ratios for Dietary Approaches to Stop Hypertension Dietary Pattern Score and Components

	Basic Adjustment*	Full Adjustment†
All-cause mortality		
DASH diet score	0.89 (0.85-0.94)‡	0.94 (0.89-0.99)‡
DASH score components		
Fruit	0.97 (0.91-1.02)	1.00 (0.94-1.06)
Vegetable	0.92 (0.88-0.97)‡	0.93 (0.88-0.98)‡
Nuts and legumes	0.98 (0.93-1.02)	0.98 (0.94-1.03)
Dairy	0.96 (0.91-1.01)	0.96 (0.92-1.01)
Whole grain	0.94 (0.90-0.99)‡	0.97 (0.92-1.02)
Sodium	1.00 (0.95-1.05)	1.00 (0.95-1.05)
Red and processed meats	1.02 (0.97-1.08)	1.00 (0.95-1.06)
Added sugar	1.01 (0.96-1.06)	1.02 (0.97-1.07)
Cardiovascular mortality		
DASH diet score	0.90 (0.82-0.99)‡	0.96 (0.86-1.06)
DASH score components		
Fruit	0.94 (0.85-1.04)	0.97 (0.88-1.08)
Vegetable	0.93 (0.85-1.02)	0.94 (0.85-1.03)
Nuts and legumes	0.97 (0.89-1.06)	0.98 (0.90-1.07)
Dairy	1.02 (0.93-1.12)	1.03 (0.94-1.13)
Whole grain	0.90 (0.82-0.99)‡	0.94 (0.85-1.03)
Sodium	1.02 (0.93-1.12)	1.02 (0.93-1.13)
Red and processed meats	1.00 (0.91-1.10)	0.98 (0.89-1.08)
Added sugar	1.04 (0.95-1.14)	1.05 (0.96-1.15)

DASH = Dietary Approaches to Stop Hypertension.

DASH diet score data represent the HR (95% CI) for each 1 quintile increase in the DASH diet score. DASH diet components are scored by quintile. Component HRs represent 1 quintile increase in each respective component.

*Adjusted for sex and age.

†Adjusted for sex, age, smoking, calorie intake, physical activity, BMI, family history, cardiovascular disease, and baseline glucose, LDL, and SBP.

‡$P < .05$.

Table 3 Mortality Hazard Ratios for Mediterranean Dietary Pattern Score and Components

	Basic Adjustment*	Full Adjustment†
All-cause mortality		
Mediterranean diet score	0.96 (0.91-1.01)	0.99 (0.94-1.04)
Mediterranean score components		
Vegetable	0.86 (0.74-0.98)‡	0.88 (0.77-1.02)
Fruits and nuts	0.81 (0.70-0.94)‡	0.88 (0.75-1.02)
Legumes	1.04 (0.91-1.19)	1.06 (0.92-1.21)
Grains	0.90 (0.78-1.03)	0.92 (0.80-1.06)
Fish	0.92 (0.90-1.06)	0.92 (0.80-1.06)
MUFA:SFA	1.02 (0.88-1.18)	1.03 (0.89-1.19)
Dairy	0.84 (0.73-0.97)‡	0.86 (0.75-1.00)
Meat	0.98 (0.85-1.14)	0.92 (0.79-1.07)
Alcohol	0.95 (0.83-1.10)	0.93 (0.81-1.08)
Cardiovascular mortality		
Mediterranean diet score	0.92 (0.84-1.01)	0.93 (0.85-1.02)
Mediterranean score components		
Vegetable	1.02 (0.78-1.31)	1.05 (0.81-1.37)
Fruits and nuts	0.65 (0.50-0.86)‡	0.70 (0.52-0.93)‡
Legumes	1.24 (0.96-1.59)	1.24 (0.96-1.60)
Grains	0.59 (0.45-0.77)‡	0.62 (0.48-0.82)‡
Fish	0.91 (0.70-1.19)	0.91 (0.70-1.18)
MUFA:SFA	0.97 (0.74-1.27)	0.97 (0.74-1.27)
Dairy	0.96 (0.73-1.25)	1.00 (0.76-1.30)

MUFA = mono-unsaturated fatty acids; SFA = saturated fatty acids.

Mediterranean diet score data represent the HR (95% CI) for each 1 quintile increase in the Mediterranean diet score. Mediterranean diet components are scored as being above/below median or for alcohol intake above/below a range of intake (see "Materials and Methods"). For all except alcohol intake, data presented as the HR (95% CI) for being above median intake, compared with below median intake, in each respective component. For alcohol intake, the referent group is low alcohol intake.

*Adjusted for sex and age.

†Adjusted for sex, age, smoking, calorie intake, physical activity, BMI, family history cardiovascular disease, and baseline glucose, LDL, and SBP.

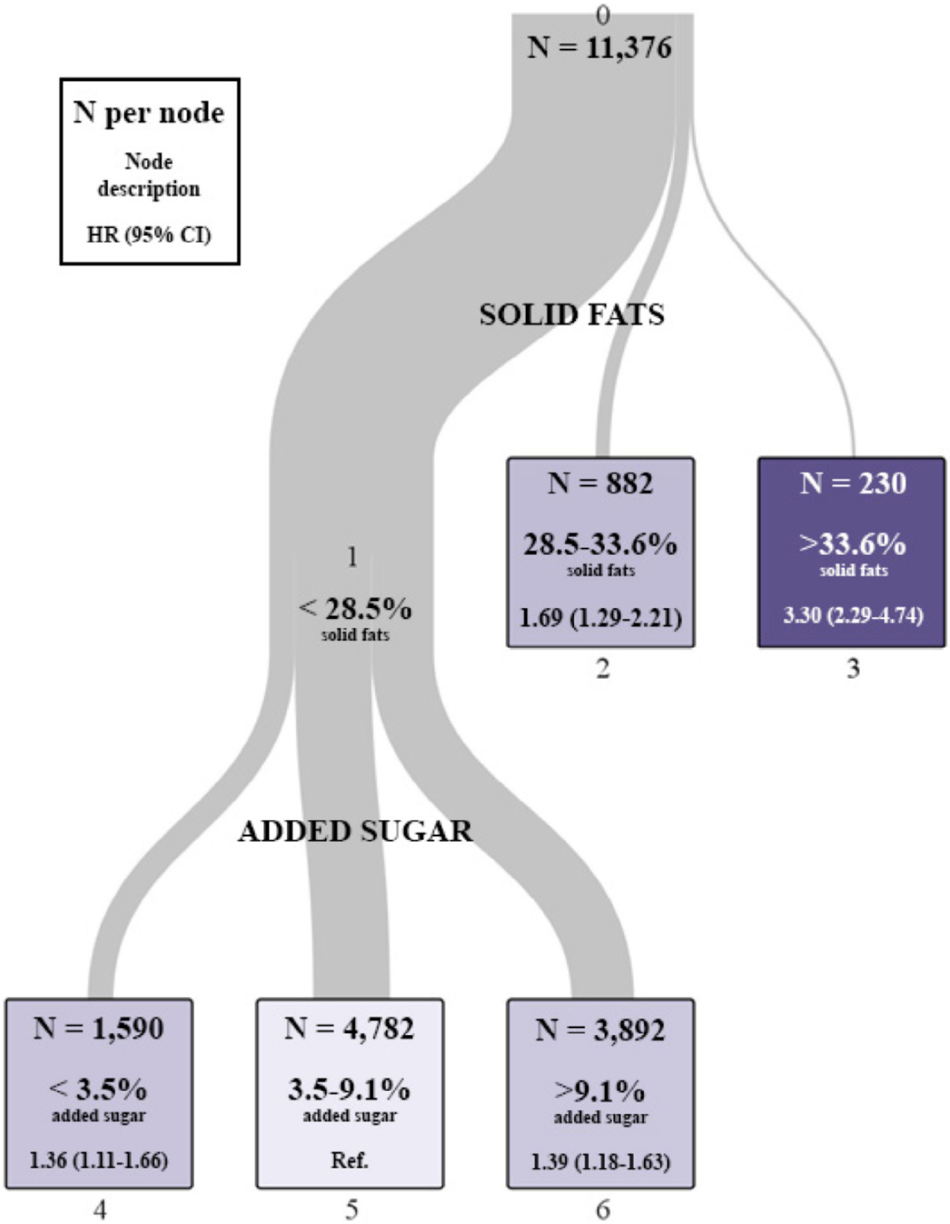
‡$P < .05$.

0.52-0.93), as well as grains (HR, 0.62; 95% CI, 0.48-0.82), was associated with a reduced risk of cardiovascular mortality ($P < .05$).

Tree-Augmented Analysis of Dietary Components

The optimized regression tree for all-cause mortality is displayed in **Figure**, which depicts a recursive process of identifying the predictor variable and threshold value that divides the sample into maximally disparate subgroups. In this tree, the initial sample of 11,376 participants was initially divided by percent of daily caloric intake from solid fats (node 2 includes individuals whose daily caloric intake was between 28.5% and 33.6% solid fats, and node 3 includes individuals whose daily caloric intake was >33.6% solid fats). The group of individuals who consumed less than 28.5% of their daily caloric intake in solid fats was further divided into 3 groups based on percent of daily intake from added sugars: node 4 (<3.5%), node 5 (between 3.5 and 9.1%), and node 6 (>9.1%).

Individuals in node 5 (solid fats <28.5%, added sugar 3.5%-9.1%) had the lowest risk for all-cause mortality. Relative to individuals in node 5, participants in node 4 had a 36% higher risk for all-cause mortality (HR, 1.36; 95% CI, 1.11-1.66) and those in node 6 had a 39% higher risk for all-cause mortality (HR, 1.39; 95% CI, 1.18-1.63). Individuals in node 2 had a 69% increased risk for all-cause mortality (HR, 1.69; 95% CI, 1.29-2.21), regardless of amount of added sugar intake. Participants whose daily caloric intake was >33.6% added solid fats (node 3), regardless of added sugar intake, had a risk for all-cause mortality more than 3 times higher than people in node 5 (HR, 3.30; 95% CI, 2.29-4.74). A similar regression tree analysis was not pursued for cardiovascular mortality



Node comparison	HR (95% CI)
2 vs. 3	0.51 (0.34 – 0.78)*
2 vs. 4	1.24 (0.92 – 1.67)
2 vs. 5	1.69 (1.29 – 2.21)*
2 vs. 6	1.21 (0.93 – 1.59)
3 vs. 4	2.43 (1.66 – 3.57)*
3 vs. 5	3.90 (2.29 – 4.74)*
3 vs. 6	2.37 (1.65 – 3.42)*
4 vs. 5	1.36 (1.11 – 1.66)*
4 vs. 6	0.98 (0.79 – 1.20)
5 vs. 6	0.72 (0.61 – 0.85)*

Figure Regression tree of dietary components for all-cause mortality. *$P < .05$ for risk of all-cause mortality. CI = confidence interval; HR = hazard ratio.

because the optimized tree had no dietary or macronutrient branches.

DISCUSSION

In this generally healthy middle-aged population, the DASH diet was associated with a lower risk of all-cause mortality, even after adjustment for covariates with which dietary pattern are known to be related (eg, lipids, blood pressure, BMI). The DASH diet score was not associated with risk of cardiovascular mortality after accounting for cardiovascular disease risk factors. The Mediterranean dietary pattern was not associated with all-cause or cardiovascular mortality. In our analysis of dietary components and food groups, we found that solid fat and added sugar intake was most highly predictive of all-cause mortality. People who consumed more than one third of their daily calories as solid fats had more than 3 times the risk of dying from any cause over an average of 18 years of follow-up, compared with individuals who ate <28.5% of calories as solid fats and between 3.5% and 9.1% as added sugars. We found that individuals with the lowest risk were not those who ate the least added sugar, but instead consumed a moderate amount of added sugars (between 3.5% and 9.1% of their total daily caloric intake).

Although the DASH diet has been associated with a lower risk of death in adults with hypertension, women with heart failure, older adults, and African-American women,[7-9,35] to our knowledge this is the first analysis to demonstrate a survival benefit associated with the DASH diet in a healthy middle-aged population. The magnitude of lower mortality risk we observed is similar to that observed in higher-risk populations.[6] Our finding that the DASH diet was associated with a lower risk of all-cause mortality after adjustment for key cardiovascular risk factors suggests that this dietary pattern has health benefits beyond its effect on cardiovascular risk factors, such as blood pressure, lipids, and glucose. These results do not clearly indicate a pathway through which the DASH dietary pattern may reduce all-cause mortality. Detailed analysis revealed modest benefit associated with vegetables within the DASH diet scheme. Existing evidence suggests that lower all-cause mortality associated with the DASH dietary pattern may be due to the influence of nutrients, displacement of other foods,[8] reduced inflammation,[36-38] reduced risk of multiple types of cancers,[38-41] and other unmeasured variables. Given the complexity of dietary intake, a combination of these effects likely underlies the lower risk of all-cause mortality.

The unadjusted association of the DASH diet with cardiovascular disease mortality was significant; however, the association was no longer significant after adjusting for risk factors such as LDL cholesterol, glucose, and blood pressure. This is somewhat surprising, because the DASH diet lowers blood pressure in people with hypertension,[3] but prior studies in different populations had similar findings.[42] Our findings suggest that atherosclerosis risk factors may mediate the pathway from dietary pattern to mortality. The DASH diet was originally developed to treat hypertension, a known cardiovascular disease risk factor, and is also related to other cardiovascular risk factors such as diabetes, cholesterol, and BMI.[1,3-5] This finding supports the importance of primordial prevention or preventing the development of risk factors for cardiovascular disease. In the prevention of fatal cardiovascular events, adoption of a DASH-style diet may prevent progression down the cardiovascular disease pathophysiologic pathway.

Although the DASH diet pattern showed associations with mortality in our population, the Mediterranean dietary pattern did not. The Mediterranean diet has been associated with a lower mortality risk in multiple studies.[43] Mediterranean dietary component analysis in the Cooper Clinic population suggests that fruit and nut intake, as well as grain intake, is protective, which is consistent with prior findings.[14,44,45] The lack of association of the Mediterranean diet score as a whole with mortality in this population may be explained, in part, by the relatively small magnitude of association between score components and mortality, as well as the combination of components associated with both increased and decreased mortality (ie, averaging to no association).

The regression tree analysis suggests that solid fat and added sugar intake are the most predictive of mortality. Both solid fat intake and sugar intake have been linked to mortality in prior studies.[17-20] Of note, in our analysis the participants who consumed a moderate amount of added sugar—not the least amount of added sugar—had the lowest mortality risk. There are multiple potential explanations for this finding. Perhaps participants in the lowest sugar intake group (node 4) were originally in the higher sugar intake groups (nodes 5 or 6), but were instructed to cut their sugar intake because of a poorer health status. These participants' sugar intake would thus be lower, but they may still have had a higher overall mortality risk. Alternatively, it is possible that individuals consuming healthful foods that do contain some added sugar (eg, yogurt) are represented in the lowest-risk category (node 5). A less plausible, but possible, explanation is that our results indicate a physiologic benefit to moderate sugar intake that is not yet well understood.

Study Strengths and Limitations

Strengths of our analysis include a large sample followed over approximately 2 decades. The dietary assessment allowed for calculation of dietary pattern using a validated nutrient analysis. The relatively homogenous baseline sample enhances internal validity of this analysis, but restricts applicability to other groups. However, our analysis was performed on a population who was generally healthy at baseline, unlike many prior studies conducted in older populations or those with comorbidities. As an observational study, our findings are primarily hypothesis generating; however, the tree-augmented model suggests relative contributions of diet components to the overall diet pattern that may influence mortality outcomes. The DASH diet may only be a marker of other healthy behaviors that directly reduce the risk of death. Although the dietary assessment was subject to recall bias, recall errors may be limited because intake was recorded in nearly real-time.

An important limitation to this analysis is that dietary pattern data were only available at baseline. This precluded assessment of changes over time, which have shown associations with mortality.[46] Prior analysis in unrelated populations suggests that dietary patterns may persist for 7 years.[47] Consistent with this observation, our finding of a link between dietary pattern in middle-age and survival after an average of 18 years of follow-up suggest that dietary pattern in midlife is related to long-term outcomes. We also acknowledge that patients seen in a preventive medicine clinic may be more likely to follow a healthful diet, but the range in diet scores seen in our analysis suggests that individuals followed at the Cooper Clinic did not necessarily follow healthful dietary patterns.

CONCLUSIONS

Our results indicate that eating patterns in middle age may influence outcomes decades later, supporting the need for promotion of healthy dietary patterns early in life.

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