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Dietary Patterns and Relationship to Obesity-Related Health Outcomes and Mortality in Adults 75 Years of Age or Greater

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Abstract

Background—The prevalence of obesity-related adverse health outcomes is increasing among older adults. Because it is thought that nutrition plays an important role in successful aging, there has been considerable interest in the association between dietary patterns of older adults and obesity-related health outcomes.

Objective—This study examined the association between dietary patterns and mortality and prevalence of obesity-related health outcomes, namely cardiovascular disease (CVD), type 2 diabetes mellitus, hypertension, and metabolic syndrome (MetSyn), over a 5-year follow-up period in adults aged 75 years or greater.

Design—A longitudinal observational study with cross-sectional dietary assessment.

Setting—Rural Central Pennsylvania.

Participants—Community-dwelling older adults (N = 449; 76.5 years old; 57% female).

Measurements—Multiple, unannounced, 24-hour dietary recalls were used to collect dietary intake. Cluster analysis was used to derive dietary patterns. Prevalence of CVD, diabetes mellitus, hypertension, and MetSyn was extracted from outpatient electronic medical records. Logistic regression was used to examine the associations between dietary patterns and health outcomes and mortality.

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Author contributions: The authors' responsibilities were as follows—DCM, TJH, GLJ, and CS were involved in planning the study design. Overall study direction was provided by TJH, CS, and GLJ. Data analysis was the primary responsibility of PYH, with assistance from DCM, TJH, DLC, and GCW. PYH wrote the initial draft of the manuscript. All authors were involved in revisions. PYH was primarily responsible for final content.

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Results—‘Sweets and Dairy’, ‘Health-Conscious’ and ‘Western’ dietary patterns were identified. Compared to the ‘Health-Conscious’ pattern, those in the ‘Sweets and Dairy’ pattern had increased odds of hypertension over the follow-up period; adjusted odds ratio (95% CI) was 2.18 (1.11-4.30). No significant associations were found for CVD, diabetes mellitus, MetSyn or mortality with dietary patterns.

Conclusions—These findings support the potential value of healthy dietary patterns in the management of hypertension in older adults. We did not observe any other strong associations between dietary patterns and health outcomes or mortality in persons ≥ 75 years of age; thus failing to support the use of overly restrictive diet prescriptions for older persons, especially where food intake may be inadequate.

Keywords

Dietary pattern; cluster analysis; older adults; health outcomes; mortality

Introduction

The first of the Baby Boomer generation (adults born between 1946 and 1964) turned 65 years old in 2011. By 2030, 30% of older adults are projected to be obese, and more than 60% will be managing more than one chronic condition (1). Of particular concern are increasing rates of obesity-related chronic diseases, namely cardiovascular disease (CVD), diabetes mellitus, hypertension, and metabolic syndrome (MetSyn).

Longitudinal prospective trials have reported that the consumption of ‘healthy’, ‘prudent’ or ‘Mediterranean-like’ diets are associated with decreased risk of CVD (2, 3), diabetes mellitus (3-5), hypertension (6, 7), and MetSyn (8, 9). These studies were predominately in adult mixed-aged samples (≥ 18 years old). In studies that included mixed-aged samples, results from older adults differed from that of the younger adults (10, 11). Studies of the association between dietary patterns and obesity-related chronic diseases in exclusively older adult populations are fewer (12-14) and have focused mainly on European populations.

The Geisinger Rural Aging Study (GRAS) is a longitudinal cohort that was initiated in 1994 as a nutrition-risk screening study of > 20,000 community-dwelling older adults living in rural Pennsylvania (15). Since the mean age of GRAS participants is 76.5 years old (range: 66-95 years), this cohort provides a unique opportunity to study older persons of advanced age. Therefore, the objectives of this study were twofold: 1) to identify the dietary patterns in a sample of American adults ≥ 75 years of age using cluster analysis; and 2) to examine the association between the derived dietary patterns and prevalence of obesity-related outcomes, namely CVD, diabetes mellitus, hypertension, and MetSyn, and mortality over a 5-year follow-up period.

Subjects and methods

Participants

GRAS participants were enrolled in a Medicare-managed health management organization administered through Geisinger Health System (Danville, PA), which provides services to many individuals living in rural areas (any area with a population of ≤ 2,499 residents) (16). Participants (n = 449; mean age at baseline visit ± SD = 76.5 ± 5.1) for this study were randomly selected from the GRAS cohort. Exclusion criteria included poor cognitive function (Mini Mental State Examination score ≤ 23) or depression (Geriatric Depression Scale score ≥ 6). Additional details about the GRAS cohort selection criteria were described elsewhere (17). Two subgroups of the GRAS cohort were used for these analyses. The first subgroup (GRAS-1997) had in-home baseline measurements from 1997-1998 (n = 81 males, 98 females), while clinic baseline measurements for the second subgroup (GRAS-2004) were taken from 2004-2005 (n = 113 males, 157 females).

All study procedures were approved by the human Institutional Review Board (IRB) at the Geisinger Health System and an IRB-approved Data Sharing Agreement was in place with The Pennsylvania State University. Additional study details have been published elsewhere (17).

Study measures

At the baseline visit, height, weight (light clothing, no shoes), and waist circumference measurements were taken. Body mass index (BMI) was calculated as (weight in kg)/(height in m)^2 and categorized as < 18.5 = underweight; 18.5-24.9 = normal weight; 25-29.9 = overweight; and ≥ 30 = obese. Cognitive impairment and depression were assessed using the Mini-Mental State Examination (MMSE) (18) and the Geriatric Depression Scale (GDS) (19), respectively. Cigarette smoking was categorized as 'current smoker' or 'non-current smoker'. Education was coded as 'elementary school, 'some high school', 'graduated from high school or general education development (GED)', or 'some college or more'. Marital status was collapsed into 'married' or 'not married'. Self-reported number of prescribed medications was queried. Participants also completed health questionnaires, including the Physical Activity Score for the Elderly (PASE) (20) (only GRAS-2004) to determine level of activity. The PASE measures self-reported weekly household, occupational, and leisure activities, with a higher score indicative of a higher level of physical activity.

Dietary intake assessment

At baseline, four (GRAS-2004) or five (GRAS-1997) 24-hour dietary recalls were collected via telephone by trained interviewers at The Pennsylvania State University Diet Assessment Center (University Park, PA) using the Nutrition Data System for Research (NDS-R 403.31, NDSR 2005, and NDSR 2010, Nutrition Coordinating Center, Minneapolis, MN). Dietary recalls were collected over a 10-month period to reduce seasonal bias (21). Energy cut-offs of > 5000 kilocalories (kcal) and < 500 kcal were used to exclude implausible energy reporting. Averages of the food and nutrient variables were used in these analyses. Foods were categorized into 29 food groups based on similarity of nutrient composition (Appendix 1). The percentages of total energy from each food subgroup were calculated for each participant using NDSR summary files. Energy density was calculated for each participant as kcal per gram of food weight (22).

Health outcomes and mortality

For a subset of the sample, health outcome data were available (n = 260 from GRAS-2004). A validated electronic data extraction (EDE) process was used to obtain prevalence data on CVD, diabetes, hypertension and MetSyn from the electronic medical records (EMR) of participants maintained through the Geisinger Health System. To validate the electronic data extraction process, the EMRs of 48 participants (24 males, 24 females) from GRAS-2004 were randomly selected for review. Only outpatient visits were accessed for data extraction. A manual chart review (CR) of the EMRs was completed by a trained auditor starting at date of study entry (CR process). The CR process included an audit of demographics, diagnoses codes, laboratory data, past medical history, medications, progress notes, and physician comments.

For the EDE of EMRs, data available electronically were extracted and stored in Statistical Analysis System (SAS) version 9.2 data files (EDE process). A combination of international Classification of Diseases (ICD)-9 codes, current medication use, as well as biochemical measures (hemoglobin A1C, triglycerides, HDL-cholesterol, and glucose) and clinic-measured anthropometrics (heights and weights) were used to define these outcomes (Appendix 2). The EDE process and the CR process were independently used to identify individuals with criteria for the outcomes of interest. Disagreements between results from each method were reviewed to identify and correct human error. Cohen's Kappa was calculated to assess statistical agreement and was ≥ 90% for all diagnoses. For the health outcomes analyses, follow-up time was defined as the time period that extended from the baseline visit until the date of the 'first mention' of the outcome of interest in the EMR, the end of the follow-up period (July 31, 2011), or death. Deaths were identified using EMR and the Social Security Death Index data through July 2011. Mortality status was available for all but three participants (n = 446).

Determination of dietary patterns

Dietary patterns were derived using cluster analysis (PROC FASTCLUS using the SAS version 9.2, SAS Institute, Inc., Cary, NC). Briefly, K-means cluster analysis utilizes Euclidean distances between observations to estimate a user-specified number of mutually-exclusive clusters (K). The objective is to aggregate groups of individuals together on the basis of shared dietary characteristics. Since cluster analysis is sensitive to outliers, data were standardized (PROC STANDARD; mean = 0, SD = 1) and outliers were winsorized (i.e., observations ≥ 5 standard deviations were assigned to the next highest observation) (23, 24). Eighty-seven data points in 28 food subgroups were winsorized, which represents less than 0.7% of data. PROC FASTCLUS requires that the number of clusters be specified in advance. To determine the number of clusters, solutions testing 2 – 6 clusters were examined. Examination of each cluster solution, including inspection of canonical plots (to visually examine separation of clusters), cluster size for statistical power for subsequent health outcome analysis, comparison of the between-cluster versus within-cluster ratios (25), and ease of interpretation of the clustered dietary characteristics, pointed to a 3-cluster solution (i.e., 3 dietary patterns).

Mean percent total energy contribution from each food subgroup, selected nutrients, and socio-demographic variables were compared across clusters using chi-square analyses (or Fisher's exact test) and generalized linear models (including pair-wise contrast tests) for categorical and continuous variables, respectively. Clusters were labeled according to representation of food groups contributing a greater proportion of the total energy intake for each pattern.

The association between dietary pattern membership and mortality was assessed using Cox proportional hazards regression models with the PHREG procedure in SAS. Associations between dietary pattern membership and prevalence of health outcomes during the 5-year follow-up period were evaluated using logistic regression, controlling for relevant covariates. Final results were reported as odds ratios (or) and 95% confidence intervals (95% CI). Data were analyzed using the SAS statistical software package, version 9.2 (SAS Institute, Inc., Cary, North Carolina). The Bonferroni adjustment was used to correct the significance level for multiple comparisons.

Results

Baseline participant characteristics are presented in Table 1. Three distinct dietary patterns were derived using cluster analysis and labeled based on the food subgroups which contributed the largest percentage of total energy (Table 2). The ‘Sweets and dairy’ pattern (n = 230; 51.2% of the sample) was characterized by largest proportions of energy from the baked goods, milk, sweetened coffee and tea, and dairy-based desserts food groups and lowest intakes of poultry. The ‘Health-conscious’ group (n = 105; 23.4% of the sample) was characterized by relatively higher intakes of pasta, noodles, rice, whole fruit, poultry, nuts, fish, and vegetables, and lower intakes of fried vegetables, processed meats, and soft drinks. Those in the ‘Western’ pattern (n = 114; 25.4% of the sample) had higher intakes from the bread, eggs, fats, fried vegetables, miscellaneous (sauces, condiments, etc.), alcohol and soft drinks, and lowest intakes of milk and whole fruit.

Mean nutrient intakes differed across the 3 dietary patterns (Table 2). The ‘Health-conscious’ dietary pattern had more favorable nutrient intakes, reporting highest intakes of protein, fiber, vitamins B6, B12, C, D, and calcium, magnesium, and potassium. They also reported lowest intakes of energy; total, saturated, and trans fat; and added sugars. Highest fat (total, saturated, and trans) and lowest fiber, vitamins B6, C, D, folate, calcium, magnesium, potassium, and iron intakes distinguished the ‘Western’ dietary pattern. The ‘Sweets and dairy’ pattern was characterized by significantly higher intakes of energy and added sugar compared to those in the ‘Health-conscious’ dietary pattern. Overall, energy density varied significantly across the dietary patterns ($P < 0.05$) with the ‘Western’ dietary pattern reporting the highest energy density (1.60 ± 0.3 kcal/g) and the ‘Health-conscious’ group reporting the lowest (1.23 ± 0.3 kcal/g). When baseline characteristics were compared across dietary patterns, there were no significant differences for age, gender, education, marital status, BMI, waist circumference, smoking status, PASE, number of self-reported prescribed medications, MMSE or GDS. (Table 1).

Table 3 reports the prevalence of obesity-related health outcomes. During the 5-year follow-up period, the overall prevalence of having CVD, type 2 diabetes mellitus, hypertension, or MetSyn were 26.9%, 29.6%, 76.5%, and 56.2%, respectively. Among the obesity-related disease outcomes investigated, only prevalence of hypertension was significantly different among dietary patterns (P < 0.05).

Table 4 presents adjusted point estimates associated with being in the ‘Sweets and dairy’ or ‘Western’ dietary pattern compared to the ‘Health-conscious’ pattern for CVD, type 2 diabetes mellitus, hypertension, MetSyn and mortality. There were no statistically significant differences among dietary patterns for prevalence of CVD, diabetes mellitus, or MetSyn before or after adjustment for covariates. Compared to the ‘Health-Conscious’ pattern, those in the ‘Sweets and Dairy’ pattern had increased odds of hypertension; odds ratio (OR) (95% CI) for the fully-adjusted model was 2.18 (1.11-4.30). Over the 5-year follow-up period, almost 30% of this aged sample died. No association was found for mortality and dietary pattern, both independently or after adjusting for potential confounders.

Discussion

The present study used cluster analysis to identify three distinct dietary patterns: ‘Sweets and Dairy’, ‘Health-Conscious’, and ‘Western’. Many studies have previously reported a two dietary pattern solution, consisting of a more prudent pattern and a less healthy pattern, that has often been labeled a ‘Western’ dietary pattern because it reflects dietary practices of more developed nations (e.g., higher fat and energy, etc.). The ‘Health-conscious’ dietary pattern described in this study more closely resembles the Dietary Guidelines for Americans, 2010. In addition to these two common patterns, the current study also characterized a ‘Sweets and dairy’ pattern, that reflects a preference for baked goods, dairy-based desserts, milk products and sweetened beverages. Similar patterns have also been previously reported by others (3, 12, 26-28). A majority of the GRAS sample (51.2%) was characterized by the ‘Sweets and dairy’ pattern. Similar to the present study, a ‘sweets-type’ pattern was the most prevalent (29, 30) or second most prevalent cluster (31, 32) among other studies with derived dietary patterns.

Only the ‘Sweets and Dairy’ dietary pattern was significantly associated with 5-year prevalence of hypertension among this sample of older adults. Results were not appreciably attenuated by adjusting for confounders. Hypertension is a significant risk factor for CVD and coronary heart disease (33). Previous studies have reported an inverse relationship between blood pressure and a healthy or prudent dietary pattern, probably the most notable of which is the Dietary Approaches to Stop Hypertension (DASH) (34). DASH is a therapeutic lifestyle change that includes consumption of a diet that is relatively higher in fruits and vegetables, low-fat dairy products, fish, poultry, and whole grains and lower in red meat, sweets, total and saturated fat, and cholesterol. A clinical trial testing the effects of the DASH diet significantly lowered systolic blood pressure by 11 mm Hg in patients with hypertension compared to a control diet (6). Our findings are consistent with the DASH trial. We might have expected that differences in sodium intake would explain the variance in rates of hypertension (35). Though the lowest mean sodium level was found in the

'Health-conscious' dietary pattern, it was not statistically different from the other dietary patterns. This suggests that sodium intake may only partially explain the association in this older age group and it is likely a combination of nutrient/food interactions (e.g., potassium, magnesium, calcium) that contribute to this association and highlights the importance of emphasizing a total diet approach (e.g., dietary pattern analysis) as opposed to only considering single nutrients. In the present study, the significant association for hypertension and the 'Sweets and dairy' dietary pattern may also be partially explained by lower consumption of fruits, vegetables, nuts and fish in this cluster, which have been shown to have protective effects in other dietary pattern studies. In contrast, Lopez and colleagues (36) found that a 'Sweets' dietary pattern was associated with having normal systolic blood pressure levels. However, this latter study used cross-sectional, nationally representative National Health and Nutrition Examination Survey (NHANES) data only from women ≥ 50 years old.

In longitudinal studies of age-related health outcomes among older populations, there are high rates of attrition due to mortality among older populations. Therefore, in the current study, which focused on an aged cohort, examination of the relationship between dietary patterns and obesity-related health outcomes was repeated examining the relationship between dietary pattern and health outcomes using statistical methods to adjust for a possible survival bias (37). It is especially important to address this potential bias when the selection (e.g., mortality) is influenced by the risk factor (e.g., dietary patterns) and related to the outcome (e.g., CVD). However, after these adjustments, results remained similar. (Data not shown.)

While geriatric medicine practitioners have long suggested that overly restrictive therapeutic diets may not be appropriate for older persons, there has actually been little evidence basis for this recommendation. The present study was not designed to specifically address this issue, but the absence of strong associations between dietary patterns and health outcomes and mortality among persons aged 75 years or older does not support the use of overly restrictive diet prescriptions with the elderly, especially where food intake may be inadequate.

Other potential limitations with this study should be noted. Although GRAS is a longitudinal cohort study, our analyses were limited to the examination of the prevalence of CVD, diabetes mellitus, hypertension, and MetSyn in a smaller subset of persons ≥ 75 years of age over a limited period of follow-up for 260; mortality data was available for 446. Due to the nature of available data, we were unable to examine disease incidence. However, because the mean age of this sample at baseline was 76.5 years old, low rates of incident disease are expected this late in life. Findings from this study can only address the potential relationships between derived dietary patterns and these four obesity-related outcomes of interest. It is possible that there may be relationships between these dietary patterns and other health conditions that were not examined. The consistency of our study participants' dietary patterns was not evaluated in the current study. While it is generally thought that dietary patterns are relatively stable among older persons (38), causality between dietary patterns and health outcomes could not be determined in the present study due to the cross-sectional nature of these diet assessment analyses. While it is possible that some individuals may have changed their dietary patterns as a result of having particular diseases and this could potentially affect the strength of associations, again, we suspect low rates of incident disease diagnoses this late in life. A post-hoc power analysis revealed that, with a significance level set at 0.05, with a sample of n = 260, there was a 80% chance of detecting a significant effect (odds ratio of 2.1). However, to detect a significant effect of odds ratio of 1.5, the power (given our sample size of n = 260 and the prevalence of health outcomes) decreased to 0.25, suggesting that our ability to detect smaller effects of dietary patterns on health outcomes was more limited. Additionally, because the GRAS sample was predominately non-Hispanic white, educated, and relatively independent, our findings may not be generalizable to the older adult population as a whole.

Using cluster analysis to derive dietary patterns is becoming increasingly popular in research. However, cluster analysis, involves a number of subjective decisions. Although a gold standard for deciding the optimal number of clusters has not been established (26), a number of tests were used to evaluate the strength of this cluster solution (e.g., canonical discrimination plots, comparison of the natural log-transformed between-cluster versus within-cluster ratios). Because dietary pattern approaches such as cluster analysis, are exploratory and descriptive in nature (i.e., it has no statistical basis on which to draw statistical inferences about a sample to a population), researchers should take care to employ objectivity where possible when deciding on the final dietary pattern solution (39).

Several strengths exist in the present study. This investigation is one of the very first to look at the associations between obesity-related outcomes and dietary patterns in such an aged cohort. The sample size used in these analyses is relatively large considering that participants were adults of advanced age. Multiple days of dietary data were collected and analyzed using a very systematic approach, which included the use of highly trained interviewers and a random, unannounced, multiple-pass approach to reduce recall bias. Collection of the data over a 10-month period also reduced the possibility of any seasonal bias. The use of high-quality health outcome data abstracted from EMRs (versus self-reported) increases confidence in our ability to determine prevalence of health outcomes of interest since data were not necessarily affected by participant dropout, particularly important with an elderly population.

In conclusion, this study characterized dietary patterns of a sample of adults aged 75 years or greater living in rural Pennsylvania. Although dietary patterns were significantly associated only with hypertension in this study, older adults should still be encouraged to consume balanced diets that enhance quality of life while also providing pleasure from food. There is a need to understand how evidence-based science can be translated into appropriate dietary recommendations for older adults. Future research should seek to prospectively examine stability in food patterns over time, examining earlier life stages, and relationship to incident health outcomes later in life.

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Appendix 1

Description of the 29 food subgroups used in the cluster analysis

Food group	Foods included
Baked goods	Cakes, cookies, pies, pastries, Danish, doughnuts and cobblers
Bread	Loaf bread, buns, bagels, English muffins
Cereal	Ready-to-eat cereals (non-presweetened and sweetened)
Cheese	Cheese—all types (full fat, reduced fat, low-fat and fat-free)
Dairy-based desserts	Frozen dairy dessert (ice cream, frozen yogurt), pudding, sweetened yogurt
Dark-green, deep-yellow vegetables	Broccoli, spinach, salad greens, carrots, sweet potato, yams, squash
Eggs	Eggs and egg substitute
Fats	Cream, shortening, butter and other animal fats, gravy
Fish	Fresh and smoked fish, shellfish
Fried vegetables fried potatoes)	Fried vegetables, fried potatoes (French fries, hash browns, pan-
Juice	Juice, including citrus juice
Legumes	Legumes (cooked dried beans)
Milk	Milk, flavored milk, milk-based beverages
Miscellaneous	Sauces, condiments (e.g., mustard, ketchup, barbeque sauce), pickled foods (e.g., pickles, sauerkraut), soup broth
Nuts	Nuts and seeds, including nut and seed butters
Oils	Margarine, oil, salad dressing
Other vegetables	Tomato, eggplant, green and string beans, peppers, cabbage, asparagus, cauliflower, Brussels sprouts, turnip greens, cucumber, celery, mushrooms, iceberg lettuce, vegetable juice
Pasta, noodles and rice	Pasta (pierogies, ravioli), noodles, rice, oatmeal
Poultry	Poultry (e.g., chicken, turkey), fried chicken
Processed meats	Cured pork, cold cuts and sausage
Red meats	Beef, lamb, pork, game, organ meats (e.g., liver)
Snacks	Chips, crackers, snack bars, pretzels, popcorn
Starchy vegetables	White potatoes, other starchy vegetables
Sweets	Frozen nondairy dessert (popsicles, sorbet), sugar (as an addition), syrup, honey, jam, jelly, preserves, dessert sauces, chocolate candy, non-chocolate candy, frosting or glaze, gelatin-based desserts
Whole fruit	Fruit including citrus fruit, avocado, fried fruits
Alcoholic beverages	Beers and ales, distilled liquor, wine
Soft drinks	Sweetened soft drinks, nondairy-based sweetened meal replacement/ supplements (e.g., Gatorade)
Sweetened fruit drinks	Sweetened fruit drinks (e.g., lemonade, cranberry cocktail, fruit punch)
Sweetened coffee & tea	Sweetened tea, sweetened coffee

Appendix 2

Criteria used to identify health outcomes of interest from electronic medical records using an electronic data extraction process

Outcome	Criteria extracted from outpatient records of EMR using electronic data extraction process
Cardiovascular disease	ICD-9 410: Acute myocardial infarction
	ICD-9 411: Other acute and subacute forms of ischemic heart disease
	ICD-9 412: Old myocardial infarction
	ICD-9 414: Other forms of chronic ischemic heart disease
	Evidence of treatment with statin drugs
Type II diabetes	ICD-9 250: Diabetes mellitus
	ICD-9 362: Diabetic retinopathy
	ICD-9 366.41: Diabetic cataract
	Hemoglobin A1C > 6.0
	Evidence of treatment with antidiabetic drugs (insulin, sulfonylureas, biguanides)
Hypertension	ICD-9 401: Essential hypertension
	2 outpatient visits with hypertension as the diagnosis
	Evidence of treatment with antihypertensive drugs
Metabolic syndrome	ICD-9 277.7: Metabolic syndrome 3 of 5 criteria[1] below:
	a. Triglycerides ≥ 150 mg/dL
	b. HDL-cholesterol: Men < 40 mg/dL; Women < 50 mg/dL
	c. Systolic blood pressure ≥ 130 mm Hg or Diastolic blood pressure ≥ 85 mm Hg
	d. Glucose ≥ 110 mg/dL
	e. BMI > 30 kg/m^2

[1]The ATP III criteria for metabolic syndrome were used with the exception of the waist circumference criteria because waist circumference was less available for this sample.

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Table 1

Selected baseline characteristics by dietary pattern[1]

	Sweets & dairy (n = 230)	Western (n = 114)	Health-conscious (n = 105)	P-value
Age (years)	76.6 ± 5.0	76.0 ± 5.3	76.8 ± 4.9	0.402
Males	45.7 (105)	46.5 (53)	34.3 (36)	0.107
Graduated from high School or greater	82.2 (189)	82.5 (94)	78.1 (82)	0.610
Married	67.4 (155)	70.2 (80)	70.5 (74)	0.798
BMI (kg/m^2)	28.0 ± 4.6	28.4 ± 5.4	28.2 ± 4.8	0.805
BMI category				
Underweight (< 18.5 kg/m^2)	2.2 (5)	0	0	0.346[2]
Normal (18.5-24.9 kg/m^2)	23.5 (54)	27.2 (31)	28.6 (30)	
Overweight (25-29.9 kg/m^2)	44.8 (103)	36.8 (42)	40.0 (42)	
Obese (≥ 30 kg/m^2)	29.6 (68)	36.0 (41)	31.4 (33)	
Waist circumference (cm)				
Female	90.9 ± 13.3	90.6 ± 13.3	91.2 ± 11.9	0.966
Male	102.6 ± 9.9	103.3 ± 14.9	101.1 ± 11.8	0.685
Current smoker	9.1 (21)	7.9 (9)	4.8 (5)	0.384
PASE[3]	129.9 ± 64.8	130.1 ± 59.5	136.9 ± 57.3	0.720
No. of self-reported prescribed medications	3.6 ± 3.0	3.3 ± 3.1	3.8 ± 3.0	0.445
MMSE	28.2 ± 1.5	28.3 ± 1.7	28.3 ± 1.6	0.969
GDS	1.3 ± 1.5	1.3 ± 1.4	1.3 ± 1.4	0.900

[1] Values are means ± SD for continuous variables and percentages (n) for categorical variables;

[2] Fisher's exact test was used;

[3] PASE was only available for n = 270.

Table 2

Mean (± SD) percent energy contribution from food groups, energy-adjusted nutrient intakes (per 1000 kcal), and energy density by dietary pattern

	Sweets & dairy (n = 230)	Western (n = 114)	Health-conscious (n = 105)
Food group			
Baked goods[1]	**10.8 ± 0.08[a]**	8.2 ± 0.07[b]	4.6 ± 0.05[c]
Bread[1]	12.2 ± 0.05[a]	**15.0 ± 0.06[b]**	10.4 ± 0.05[c]
Cereal[1]	**4.1 ± 0.04[a]**	1.5 ± 0.05[b]	3.6 ± 0.04
Cheese	3.3 ± 0.03	3.7 ± 0.03	3.4 ± 0.03
Dairy-based desserts[1]	**4.8 ± 0.05[a]**	3.2 ± 0.04[b]	2.7 ± 0.04[b]
Dark green, deep yellow vegetables[1]	0.57 ± 0.01[a]	0.52 ± 0.01[a]	**1.8 ± 0.02[b]**
Eggs[1]	0.98 ± 0.01[a]	**2.8 ± 0.03[b]**	1.2 ± 0.01[a]
Fats[1]	2.7 ± 0.03[a]	**4.1 ± 0.03[b]**	2.1 ± 0.02[c]
Fish[1]	0.71 ± 0.01[a]	0.85 ± 0.02[a]	**2.5 ± 0.03[b]**
Fried vegetables[1]	0.92 ± 0.02[a]	**23 ± 0.03[b]**	0.30 ± 0.01[c]
Juice	2.3 ± 0.03	1.8 ± 0.02	2.8 ± 0.03
Legumes	1.3 ± 0.02	0.77 ± 0.02	1.1 ± 0.02
Milk[1]	**7.2 ± 0.06[a]**	3.3 ± 0.03[c]	5.5 ± 0.04[b]
Miscellaneous[1]	0.53 ± 0.00[a]	**1.0 ± 0.01[b]**	0.56 ± 0.01[a]
Nuts[1]	1.3 ± 0.02[a]	1.3 ± 0.03[a]	**32 ± 0.06[b]**
Oils	5.9 ± 0.03	7.1 ± 0.04	7.2 ± 0.04
Other vegetables[1]	1.5 ± 0.01[a]	1.6 ± 0.01[a]	**2.5 ± 0.02[b]**
Pasta, noodles, rice[1]	6.1 ± 0.05[a]	5.4 ± 0.04[a]	**9.7 ± 0.07[b]**
Poultry[1]	2.0 ± 0.02[a]	3.6 ± 0.03[b]	**4.7 ± 0.04[c]**
Processed meats[1]	4.1 ± 0.04	**4.6 ± 0.04[a]**	1.9 ± 0.02[b]
Red meats	6.0 ± 0.04	6.9 ± 0.05	5.4 ± 0.06
Snacks	2.8 ± 0.04	2.8 ± 0.03	2.4 ± 0.03
Starchy vegetables	3.8 ± 0.03	2.9 ± 0.02	3.9 ± 0.03
Sweets	3.9 ± 0.04	3.7 ± 0.04	3.0 ± 0.04
Whole fruit[1]	5.4 ± 0.04[a]	3.5 ± 0.03[b]	**9.3 ± 0.06[c]**
Alcoholic beverages[1]	0.29 ± 0.01[a]	**3.2 ± 0.06[b]**	0.61 ± 0.02[a]
Soft drinks[1]	0.98 ± 0.02[a]	**2.5 ± 0.04[b]**	0.42 ± 0.01[c]
Sweetened fruit drinks	0.86 ± 0.02	0.40 ± 0.01	0.57 ± 0.02
Sweetened coffee & tea[1]	**0.73 ± 0.02[a]**	0.16 ± 0.01[b]	0.11 ± 0.00[b]
Nutrient[2, 3]			
Energy, kcal	**1590.0 ± 455.3[a]**	1566.6 ± 467.9[a]	1385.7 ± 391.8[b]
Protein, g	39.1 ± 9.6[a]	40.1 ± 11.4[a]	**46.2 ± 11.2[b]**
Fat, g	35.4 ± 8.3[a]	**39.8 ± 11.3[c]**	32.7 ± 10.6[b]

	Sweets & dairy (n = 230)	Western (n = 114)	Health-conscious (n = 105)
Saturated fat, g	12.5 ± 3.8[a]	**13.5 ± 4.6[c]**	10.2 ± 3.9[b]
Trans fat, g	2.5 ± 0.9[a]	**2.8 ± 12[c]**	1.9 ± 1.1[b]
Added sugar, g	**36.2 ± 14.2[a]**	33.9 ± 17.8[a]	28.6 ± 18.7[b]
Fiber, g	10.4 ± 3.6[a]	8.6 ± 2.9[c]	**13.5 ± 4.2[b]**
Vitamin B6, mg	1.1 ± 0.5[a]	0.95 ± 0.5[c]	**13 ± 0.6[b]**
Vitamin B12, mg	3.1 ± 2.1	2.9 ± 2.9	4.1 ± 3.9
Vitamin C, mg	56.0 ± 30.6[a]	46.0 ± 26.0[c]	**81.3 ± 45.7[b]**
Vitamin D, mcg	2.9 ± 1.5[a]	2.0 ± 1.1[b]	**32 ± 2.1[a]**
Folate, mcg	330.2 ± 157.2	282.6 ± 201.9	360.0 ± 166.7
Calcium, mg	491.1 ± 178.4	396.3 ± 243.0[b]	**5203 ± 193.5[a]**
Magnesium, mg	158.1 ± 44.6[a]	138.2 ± 39.7[c]	**190.7 ± 46.4[b]**
Sodium, mg	1696.4 ± 450.7	1756.6 ± 544.9	1667.8 ± 490.8
Potassium, mg	1555.7 ± 415.2[a]	1396.9 ± 381.2[c]	**1901.0 ± 507.6[b]**
Iron, mg	9.3 ± 4.1	8.1 ± 5.1	10.1 ± 3.9
Zinc, mg	6.4 ± 3.6	5.8 ± 3.4	7.3 ± 3.9
Energy density, kcal/g	1.47 ± 0.3[a]	**1.60 ± 03[c]**	1.23 ± 0.3[b]

[1] Overall food group mean significantly different across dietary pattern at P < 0.001. (Significance level corrected for multiple comparisons using Bonferroni adjustment.). Food group means with differing subscripts across rows are significantly different from each other (P < 0.05); Within each row, the dietary pattern with the highest percent energy contributions from each food group is in bold, and the dietary pattern with the lowest percent energy contribution from each food group is underlined.

[2] With the exception of energy (kcal), nutrient means were energy-adjusted (per 1000 kcal).

[3] Overall means significantly different across dietary patterns for all nutrients (with the exception of vitamin B12, folate, sodium, iron, and zinc) at P < 0.003. (Significance level corrected for multiple comparisons using Bonferroni adjustment.) Means with differing subscripts across rows are significantly different from each other (P < 0.05); Within each row, the dietary pattern with the highest value for each nutrient is in bold, and the dietary pattern with the lowest value for each nutrient is underlined.

Table 3

Prevalence of obesity-related health outcomes and mortality by dietary pattern

Health outcome[1, 2]	Overall	Sweets & dairy	Western	Health-conscious	P-value
Cardiovascular disease (n = 70)	26.9 (70)	50.0 (35)	30.0 (21)	20.0 (14)	0.198
Type 2 diabetes mellitus (n = 77)	29.6 (77)	49.4 (38)	22.1 (17)	28.6 (22)	0.881
Hypertension (n = 199)	76.5 (199)	52.3 (104)	24.6 (49)	23.1 (46)	0.042
Metabolic syndrome (n = 146)	56.2 (146)	52.1 (76)	21.9 (32)	26.0 (38)	0.561
Deceased[3] (n = 131)	29.4 (131)	32.8 (75)	26.8 (30)	24.8 (26)	0.260

[1]Values are percentages (n);

[2]Health outcomes only available for a subset of the sample (n = 260);

[3]Mortality status was unavailable for three participants (n = 446).

Table 4

Point estimates1 and 95% confidence intervals for prevalence of chronic disease by dietary pattern for GRAS-2004

Health outcome	Sweets & dairy[2] (n = 128)	Western[2] (n = 62)	P-value[3]
Cardiovascular disease (n = 70)			
Model 1	1.51 (0.75-3.04)	2.05 (0.93-4.50)	0.203
Model 2	1.43 (0.69-2.93)	2.06 (0.92-4.65)	0.215
Model 3	1.50 (0.72-3.12)	2.28 (1.00-5.23)	0.146
Type 2 diabetes mellitus (n = 77)			
Model 1	0.92 (0.49-1.73)	0.82 (0.39-1.75)	0.881
Model 2	0.81 (0.41-1.57)	0.76 (0.34-1.68)	0.750
Model 3	0.80 (0.41-1.59)	0.79 (0.35-1.80)	0.795
Hypertension (n = 199)			
Model 1	2.17 (1.11-4.27)	1.94 (0.87-4.33)	0.045
Model 2	2.17 (1.11-4.27)	1.94 (0.87-4.33)	0.065
Model 3	2.18 (1.11-4.30)	1.95 (0.87-4.35)	0.065
Metabolic syndrome (n = 146)[4]			
Model 1	1.23 (0.68-2.22)	0.90 (0.45-1.78)	0.561
Model 2	1.24 (0.69-2.25)	0.90 (0.45-1.80)	0.553
Model 3	1.24 (0.69-2.26)	0.92 (0.46-1.85)	0.583
Mortality (n = 131)[5, 6]			
Model 1	1.20 (0.76-1.89)	1.00 (0.59-1.69)	0.594
Model 2	1.03 (0.65-1.64)	0.95 (0.55-1.62)	0.928
Model 3	1.02 (0.64-1.63)	0.95 (0.55-1.63)	0.947

[1] Odds ratios for cardiovascular disease, type 2 diabetes mellitus, hypertension, and metabolic syndrome. Hazard ratios for mortality;

[2] Referent group was the ‘Health-conscious’ dietary pattern (n = 70); Model 1: unadjusted model; Model 2: adjusted for age, gender, physical activity (PASE score), smoking, and waist circumference; Model 3: additionally adjusted for same covariates as model 2 with the addition of marital status and education;

[3] Type 3 P-value;

[4] Analyses for metabolic syndrome were not adjusted for waist circumference as this is included in the diagnosis criteria;

[5] Models 2 and 3 were not adjusted for physical activity as this information was unavailable for n = 179;

[6] Analysis used n = 446.