# Dietary Approaches to Stop Hypertension, Mediterranean, and Alternative Healthy Eating indices are associated with bone health among Puerto Rican adults from the Boston Puerto Rican Osteoporosis Study

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**ABSTRACT**

**Background:** Conflicting results on associations between dietary quality and bone have been noted across populations, and this has been understudied in Puerto Ricans, a population at higher risk of osteoporosis than previously appreciated.

**Objective:** To compare cross-sectional associations between 3 dietary quality indices [Dietary Approaches to Stop Hypertension (DASH), Alternative Health Eating Index (AHEI-2010), and Mediterranean Diet Score (MeDS)] with bone outcomes.

**Method:** Participants ($n$ = 865–896) from the Boston Puerto Rican Osteoporosis Study (BPROS) with complete bone and dietary data were included. Indices were calculated from validated food frequency data. Bone mineral density (BMD) was measured using DXA. Associations between dietary indices (z-scores) and their individual components with BMD and osteoporosis were tested with ANCOVA and logistic regression, respectively, at the lumbar spine and femoral neck, stratified by male, premenopausal women, and postmenopausal women.

**Results:** Participants were 59.9 y ± 7.6 y and mostly female (71%). Among postmenopausal women not taking estrogen, DASH (score: 11–38) was associated with higher trochanter (0.026 ± 0.006 g/cm$^2$, $P$ <0.001), femoral neck (0.022 ± 0.006 g/cm$^2$, $P$ <0.001), total hip (0.029 ± 0.006 g/cm$^2$, $P$ <0.001), and lumbar spine BMD (0.025 ± 0.007 g/cm$^2$, $P = 0.001$). AHEI (score: 25–86) was also associated with spine and all hip sites ($P$ <0.02), whereas MeDS (0–9) was associated only with total hip ($P = 0.01$) and trochanter BMD ($P = 0.007$) in postmenopausal women. All indices were associated with a lower likelihood of osteoporosis (OR from 0.54 to 0.75). None of the results were significant for men or premenopausal women.

**Conclusions:** Although all appeared protective, DASH was more positively associated with BMD than AHEI or MeDS in postmenopausal women not taking estrogen. Methodological differences across scores suggest that a bone-specific index that builds on existing indices and that can be used to address dietary differences across cultural and ethnic minority populations should be considered. *Am J Clin Nutr* 2020;111:1267–1277.

**Keywords:** osteoporosis, dietary quality, Hispanic/Latino, nutrition, bone

## Introduction

Osteoporosis is an emerging public health problem among Puerto Rican adults living on the US mainland. Recent evidence suggests a similar and/or higher prevalence of osteoporosis in this population, compared with non-Hispanic white adults (1). The age-adjusted prevalence of osteoporosis was 8.6% for Puerto Rican men compared with 2.3% for non-Hispanic white men, and 10.7% for Puerto Rican women compared with 10.1% for non-Hispanic white women based on data from the Boston Puerto Rican Osteoporosis Study (BPROS) and NHANES 2005–2010

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Abbreviations used: AHEI-2010, Alternative Healthy Eating Index-2010; BMD, bone mineral density; BPROS, Boston Puerto Rican Osteoporosis Study; BPRHS, Boston Puerto Rican Health Study; DASH, Dietary Approaches to Stop Hypertension; HNRCA, Human Nutrition Research Center on Aging; MeDS, Mediterranean Diet Score; RIA, radioimmunoassay.

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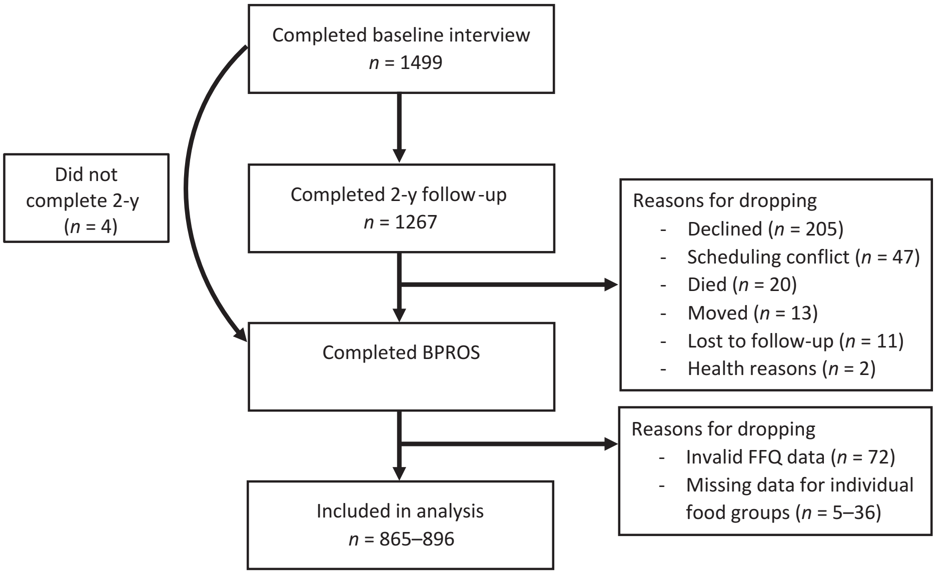

**FIGURE 1** Flow chart of participation from the BPRHS and BPROS. BPROS, Boston Puerto Rican Osteoporosis Study; BPRHS, Boston Puerto Rican Health Study.

(1). Osteoporosis increases the risk of fracture and subsequent morbidity, mortality, and reduced quality of life (2); thus, it is imperative to identify factors associated with the prevention of osteoporosis to enhance public health messaging to reduce the prevalence and burden of this disease. Diet is a known major modifiable risk factor for bone health (3, 4) and may, in part, explain disparities in bone outcomes across populations. Few studies have investigated the dietary risk factors for osteoporosis among Puerto Rican adults living on the US mainland (5, 6).

The extant literature on nutrition and osteoporosis suggests that overall dietary quality is critical for bone health (7–11). Dietary indices have been developed to characterize overall dietary quality based on existing nutrition knowledge and/or dietary recommendations for disease prevention (12). The Mediterranean Diet Score (MeDS) and Alternative Health Eating Index (AHEI) are widely used indices, as higher adherence to these dietary patterns has been associated with reduced chronic disease risk and mortality (13–18). Several population-based studies have examined relations between various dietary quality indices, including the MeDS (19–26) and AHEI (22, 26–28) and bone health, with mixed results. Some reported protective findings with higher adherence to dietary indices (19, 20, 22, 26, 27), 1 found a negative association (21), whereas others showed no association with bone mineral density (BMD) or fracture (23–25, 28). Most studies on dietary indices and bone health have been conducted in non-Hispanic populations (19, 20, 22, 23, 25–27, 29–31) and few have focused on Puerto Ricans (5). A limited number of studies have examined Dietary Approaches to Stop Hypertension (DASH) in relation to bone, despite the unique inclusion of foods that are beneficial for bone health. It is currently unclear which dietary pattern would be most beneficial for bone in this population.

The objective of this study was to compare the relation between 3 dietary quality indices (DASH, AHEI-2010, and MeDS) with BMD at the hip and spine, and the prevalence of osteoporosis at the lumbar spine (L2–L4) and/or the femoral neck among Puerto Rican adults aged 47–77 y. To our knowledge, this is the first study to compare widely used dietary quality indices and bone in this population. Understanding how dietary quality relates to bone health is a key strategy for prevention, as osteoporosis is a silent chronic health condition until fracture occurs.

## Methods

### Study population

BPROS is an ancillary study to the Boston Puerto Rican Health Study (BPRHS), a longitudinal investigation of genetic, sociological, health, and environmental factors associated with health disparities experienced by Puerto Rican adults living in the Greater Boston area (32). Participants in the BPRHS completed a baseline interview ($n = 1499$) and a 2-y follow-up ($n = 1267$) interview (**Figure 1**). Participants were eligible to participate if they self-identified as Puerto Rican, were between the ages of 45–75 y, and lived within the Greater Boston area. Individuals who planned to move from the area within 2 y, had a Mini-Mental State Examination Score $\leq$10, or were unable to answer questions due to a serious health condition were excluded (32). After the 2-y interview, participants were invited and, if interested, were reconsented to participate in the BPROS ($n = 973$). A total of 298 BPRHS participants did not participate in the BPROS for the following reasons: 205 declined, 13 moved from the area, 47 had difficulty scheduling the interview, 11 were lost to follow-up, 2 did not participate for health reasons, and 20 had died since their 2-y interview. Four participants did not complete the 2-y interview but were consented for the BPROS. Those who declined to participate in the BPROS were older (60.9 y compared with 58.7 y, $P < 0.001$) and were more likely to have type 2 diabetes (47.8% compared with 40.4%, $P = 0.03$) compared with those who participated.

Participants enrolled in the BPROS visited the Metabolic Research Unit at the Jean Mayer USDA Human Nutrition Research Center on Aging (HNRCA) at Tufts University to complete an interview, BMD measures, and a blood draw. A

**TABLE 1** Scoring methodology for the DASH, AHEI-2010, and MeDS dietary indices

| DASH | | | MeDS | | | AHEI-2010 | | |
|---|---|---|---|---|---|---|---|---|
| | Min score | Max score | | Median cut-off | | | Min score | Max score |
| | Q1 | Q5 | | Men | Women | | Mean intake | |
| Vegetables, serv/d | 0.64 | 4.25 | Vegetables, serv/d | 1.56 | 1.47 | Vegetables, serv/d | 0 | ≥5 |
| Fruit, serv/d | 0.22 | 2.96 | Fruit, serv/d | 1.07 | 1.07 | Fruit, serv/d | 0 | ≥4 |
| Whole grain, serv/d | 0.08 | 2.43 | Whole grain, serv/d | 0.64 | 0.66 | Whole grain, g/d | | |
| | | | | | | Men | 0 | 75 |
| | | | | | | Women | 0 | 90 |
| Low-fat dairy, serv/d | 0.09 | 2.27 | Dairy, serv/d | 1.76 | 1.56 | | | |
| Nuts, serv/d | 0.1 | 1.37 | Nuts and legumes, serv/d | 0.77 | 0.65 | Nuts and legumes, serv/d | 0 | ≥1 |
| SS beverages, serv/d | 0.01 | 1.61 | Fish, serv/d | 0.95 | 0.81 | SS beverages, serv/d (including fruit juice) | ≥1 | 0 |
| Red/processed meat, serv/d | 0.17 | 1.97 | Meat, serv/d | 4.70 | 4.01 | Red/processed meat, serv/d | ≥1.5 | 0 |
| Sodium, mg/d | 2172 | 8107 | MUFA:SFA ratio | 1.16 | 1.18 | Sodium, mg/d | Highest decile | Lowest decile |
| | | | Alcohol, drinks/d | ≤ 2 | ≤ 1 | Alcohol, drinks/d | | |
| | | | | | | Men | ≥3.5 | 0.5–2.0 |
| | | | | | | Women | ≥2.5 | 0.5–1.5 |
| | | | | | | PUFA, % energy | ≤2 | ≥10 |
| | | | | | | EPA + DHA, mg/dL | 0 | 250 |
| | | | | | | Trans fat, % energy | ≥4 | ≤0.05 |

AHEI-2010, Alternative Health Eating Index-2010; DASH, Dietary Approaches to Stop Hypertension; MeDS, Mediterranean Diet Score; SS, sugar-sweetened beverages.

trained bilingual phlebotomist collected a fasting blood sample in the participants' home on the morning after the interview, or as soon as possible thereafter, for biochemical analysis. All participants provided written informed consent. The Institutional Review Boards at Tufts Medical Center, Tufts University, Northeastern University, and the University of Massachusetts Lowell approved this study.

### Dietary assessment and dietary pattern methodology

Usual dietary intake over the past year was assessed at baseline, using a semi-quantitative FFQ adapted and validated for use in this population (33). Food intakes, in grams, were collapsed into food groups and mixed dishes were disaggregated and assigned to the appropriate food groups. Average daily nutrient intakes were estimated using the Nutrition Data System for Research software version 2007 (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN, USA). Participants with energy intakes <600 kcal or >4800 kcal/d or with >10 questions blank in the FFQ were excluded ($n = 72$).

Three dietary quality indices were used in this analysis and defined as follows (**Table 1**):

1) DASH was defined following methods by Fung et al. (34). Participants received 1 point for those in the lowest quintile and 5 points for those in the highest quintile of intakes of fruit, vegetables, nuts and legumes, low-fat dairy products, and whole grains, according to quintile rankings. Those with the lowest quintile of intake of sodium, sugar-sweetened beverages, and red and processed meats received a score of 5 and those in the highest quintile received a score of 1. Scores were totaled with a possible score range from 8 (lowest adherence) to 40 (greatest adherence).
2) AHEI-2010 was defined from 11 food groups or nutrients, with higher intakes of 6 components [vegetables, fruit, whole grains, nuts and legumes, long-chain (n–3) fat (EPA + DHA), and PUFAs], moderate intake of 1 component (alcohol), and lower intakes of 4 components (sugar-sweetened beverages, red and processed meat, *trans* fat, and sodium) and has been shown to be protective of chronic health conditions (13). Participants received a score between 0 (minimal adherence) and 10 points (maximal adherence) for each component, based on dietary intakes. A sum of all components was calculated and ranged from 0 (poorest dietary quality) to 110 (highest dietary quality), with a higher score representing better adherence.
3) MeDS was defined following methods by Trichopoulou et al. (35). The score was modified to include whole grains instead of total grains, due to the high intake of refined grains in this population, as described by Mattei et al. (36). The MeDS included 9 food group and nutrient components that were scored using the sex-specific population median adjusted for total energy calculated using the residual method. These included vegetables, fruit, whole grains, nuts and legumes, meat, fish, dairy, MUFA:SFA ratio, and alcoholic beverages. Participants consuming below the median for healthful components received a score of 0 and a score of 1 for above the sex-specific median. For unfavorable components, a score of 0 was assigned for those consuming above the median and a score of 1 for those consuming below the sex-specific median intake. A total score was calculated and ranged from 0 (poorest adherence) to 9 (highest adherence).

### Bone outcome measures

Primary outcome variables included BMD at the hip and lumbar spine and osteoporosis at the femoral neck and/or lumbar spine. Hip and lumbar spine BMD (g/cm$^2$) was measured using DXA (GE-Lunar Model Prodigy scanner; General Electric) at the Bone Metabolism Laboratory at the HNRCA at Tufts University. All measurements were obtained following standard protocols; the right hip was scanned unless a previous hip fracture or joint replacement in the right hip was self-reported by the participant. The root mean square precision was 1.31% for BMD measures of the femoral neck and 1.04% for the lumbar spine, as reported elsewhere (37). An external standard (aluminum spine phantom: Lunar Radiation Corp) was scanned weekly to assess stability of the DXA measures. After reviewing all scans with T-scores >4.0, 25 participants' lumbar spine (L2–L4) measures and 7 participants' femoral neck measures were excluded, as they were determined to be inaccurate by the study endocrinologist (BD-H).

Osteoporosis was defined as T-score $\leq -2.5$ (2.5 SD or more below peak bone mass) and low bone mass as T-score between $-1.0$ and $-2.5$ (between 1.0 and 2.5 SD below peak bone mass) at the femoral neck or lumbar spine, as defined by criteria from the WHO (38). Lumbar spine T-scores were estimated using a reference group of 30-y-old non-Hispanic white females from the DXA manufacturer's database (39) and femoral neck T-scores from a reference group of 20–29-y-old non-Hispanic white females from NHANES III (40).

### Covariate assessment

Sociodemographic factors including sex and educational attainment were assessed at baseline, through questionnaire. Age was assessed at the BPROS visit. Anthropometric measures, including weight and height, were obtained at the BPROS interview, in duplicate, and an average of the 2 measures was used. BMI was calculated as weight (kg) divided by height ($m^2$). Health behaviors, including smoking and alcohol consumption, were ascertained and categorized as never, past, or current, as assessed at 2-y follow-up. Participants were asked to self-report the use of medication to treat osteoporosis (e.g., Calcitonin, Fosamax, and Didronal) during the BPROS interview. For women only, the use of estrogen preparations either orally or by patch (not including vaginal cream), was obtained and included Premarin, Prempro, Premphase, Estratab, Menest, Estrace, Ogen (Ortho-est), Estraderm (Vivelle), Evista, and/or other medication. Data on menopause (yes or no) and estrogen preparations (yes or no) were used to classify women as estrogenic (premenopausal or currently taking exogenous estrogen) or nonestrogenic (postmenopausal and not taking exogenous estrogen). Serum 25(OH) vitamin D concentration (ng/mL) was measured from fasting blood samples collected during the BPROS interview, and by extraction with radioimmunoassay (RIA) with a 25I RIA Packard Q7 COBRA II Gamma Counter (catalog no. 68100E; DiaSorin, Inc.). The intra-assay and interassay CVs were 10.8% and 9.4%, respectively.

### Statistical analysis

All analyses were conducted using SAS software (version 9.4, SAS Institute). All variables and distributions were examined for normality. Sample size varied across dietary patterns, due to missing data for individual food groups ($n = 865$–896). Means (SEs) and frequencies of sociodemographic factors and health behaviors were calculated by quintile of the DASH, AHEI, and MeDS, using chi-square and ANOVA, for men, premenopausal women (including postmenopausal estrogen users), and postmenopausal women (excluding estrogen users). Dietary quality indices were standardized by converting each score to z-scores. Multivariable linear regression models were used to examine associations between each index and BMD at hip and spine sites in men, and pre- and postmenopausal women. Multivariable logistic regression was used to model relations between dietary quality indices and osteoporosis (yes/no) at the femoral neck and lumbar spine in men and postmenopausal women only, as the number of premenopausal women with osteoporosis was too low ($n = 3$). Multivariable logistic regression models were also used to investigate associations between individual components of each index and the odds of osteoporosis for men and postmenopausal women. An unadjusted model was initially assessed. Model 1 was adjusted for age. Model 2 was adjusted for model 1 plus BMI and height. Model 3 was adjusted for model 2 plus education, smoking status, alcohol use, season of BMD measurement, osteoporosis medication use, calcium intake, and serum vitamin D. DASH and AHEI models were also adjusted for total energy intake (MeDS is based on population medians adjusted for total energy) (36) and alcohol consumption only for DASH, as alcohol is included as a component of the AHEI and MeDS scores.

## Results

Characteristics between the highest compared with lowest quintile of each dietary index were examined for men, and premenopausal (including postmenopausal estrogen users) and postmenopausal women (excluding estrogen users). Results were similar for each dietary index, and therefore, data only for the DASH index are presented in **Table 2**. The prevalence of osteoporosis was 8.8% for Puerto Rican men and 11.2% for Puerto Rican women. Compared with the lowest quintile, men in the highest quintile of the DASH, MeDS, and AHEI (56.7 ± 1.2 y compared with 62.1 ± 1.0 y; 55.4 ± 1.3 y compared with 60.8 ± 0.97 y; 57.8 ± 0.97 y compared with 62.4 ± 1.2 y) and postmenopausal women in the highest quintile of the DASH index (59.5 ± 0.8 y compared with 63.6 ± 0.6 y) were older. A greater percentage of postmenopausal women in the highest quintile of the MeDS had less than an 8th grade education than those in the lowest quintile (57% compared with 38.7%). Premenopausal women in the highest quintile of the DASH index were less likely to be currently smoking, and men and pre- and postmenopausal women in the highest quintile had a higher intake of dietary calcium compared with those in the lowest quintile ($P < 0.05$ for all, Table 2). More men and pre- and postmenopausal women in the highest compared with lowest quintile of the MeDS and AHEI were less likely to be heavy alcohol consumers ($P < 0.01$ for all). Premenopausal women in the highest compared with lowest quintile of the AHEI had a higher intake of dietary calcium (1287 ± 94 mg/d compared with 846 ± 92 mg/d). Postmenopausal women in the highest quintile of the DASH and AHEI had a higher BMD of the trochanter (0.814 ± 0.011 g/cm$^2$ compared with 0.752 ± 0.015 g/cm$^2$; 0.807 ± 0.012 g/cm$^2$ compared with 0.749 ± 0.014 g/cm$^2$, $P < 0.05$) and total hip (1.01 ± 0.012 g/cm$^2$ compared with 0.951 ± 0.017 g/cm$^2$; 1.01 ± 0.014 g/cm$^2$ compared with 0.940 ± 0.016 g/cm$^2$, $P < 0.05$), and a lower prevalence of osteoporosis (5.3% compared with 17.6%; 4.6% compared with 19.3%, $P < 0.05$, respectively) compared with the lowest quintile. There were no differences in postmenopausal status, use of estrogen or osteoporosis medication, total energy intake, or serum 25(OH) vitamin D concentration for the highest compared with lowest quintile of the DASH, AHEI, and MeDS.

Higher adherence to DASH was significantly associated with a higher BMD at the trochanter ($\beta$: 0.026 ± 0.006,

**TABLE 2** Sociodemographic and health factors by highest (Q5) and lowest quintile (Q1) of the DASH for men, and premenopausal and postmenopausal women

| | DASH | | | | | |
|---|---|---|---|---|---|---|
| | Men ($n = 244$) | | Postmenopausal women[1] ($n = 507$) | | Premenopausal women[2] ($n = 139$) | |
| | Q1 (11–19) | Q5 (28–36) | Q1 (12–19) | Q5 (28–38) | Q1 (12–19) | Q5 (28–37) |
| Age, y | 56.7 ± 1.2 | 62.1 ± 1.0$^{**}$ | 59.5 ± 0.8 | 63.6 ± 0.6$^{***}$ | 52.0 ± 0.7 | 54.4 ± 0.8 |
| <8th grade educational level, % | 57.5 | 62.1 | 44.6 | 50.4 | 70.6 | 77.4 |
| Current smoker, % | 40.0 | 19.4 | 24.3 | 11.5 | 41.2 | 6.5$^{**}$ |
| Alcohol consumption, % | | | | | | |
| None within past year | 50.0 | 43.9 | 59.5 | 58.8 | 47.1 | 41.9 |
| Moderate | 42.5 | 45.5 | 35.1 | 40.5 | 44.1 | 51.6 |
| Heavy | 7.5 | 10.6 | 5.4 | 1.0 | 8.8 | 6.5 |
| BMI, kg/m$^2$ | 29.3 ± 0.9 | 31.3 ± 0.7 | 32.9 ± 0.8 | 32.7 ± 0.6 | 30.8 ± 1.1 | 34.6 ± 1.2 |
| Height, cm | 166 ± 1.1 | 167 ± 0.8 | 155 ± 0.7 | 154 ± 0.5 | 156 ± 1.0 | 157 ± 1.2 |
| Postmenopausal, % | — | — | 100 | 100 | 5.9 | 12.9 |
| Use of estrogen medication, % | — | — | 0 | 0 | 5.9 | 16.1 |
| Use of medication to treat osteoporosis, % | 2.5 | 1.5 | 12.2 | 9.2 | 0 | 0 |
| Total energy, kcal | 2230 ± 131 | 2359 ± 101 | 2184 ± 102 | 1874 ± 76 | 2404 ± 135 | 1891 ± 141 |
| Dietary calcium, mg/d | 775 ± 86 | 1198 ± 66$^{**}$ | 948 ± 70 | 1215 ± 52$^{*}$ | 825 ± 81 | 1179 ± 85$^{*}$ |
| Serum 25-OH vitamin D, ng/mL | 18.3 ± 1.1 | 18.6 ± 0.86 | 19.6 ± 0.90 | 20.6 ± 0.68 | 17.6 ± 1.2 | 21.9 ± 1.2 |
| Bone mineral density, g/cm$^2$ | | | | | | |
| Trochanter | 0.874 ± 0.024 | 0.907 ± 0.018 | 0.752 ± 0.015 | 0.814 ± 0.011$^{**}$ | 0.849 ± 0.020 | 0.853 ± 0.020 |
| Femoral neck | 0.963 ± 0.024 | 1.00 ± 0.018 | 0.868 ± 0.015 | 0.911 ± 0.011 | 0.983 ± 0.021 | 0.999 ± 0.022 |
| Total hip | 1.05 ± 0.026 | 1.09 ± 0.020 | 0.951 ± 0.017 | 1.01 ± 0.012$^{*}$ | 1.07 ± 0.022 | 1.07 ± 0.022 |
| Lumbar spine | 1.19 ± 0.030 | 1.23 ± 0.023 | 1.09 ± 0.019 | 1.14 ± 0.015 | 1.25 ± 0.028 | 1.23 ± 0.029 |
| Osteoporosis; femoral neck or lumbar spine, % | 12.5 | 5.9 | 17.6 | 5.3$^{*}$ | 5.9 | 0 |

[1] Postmenopausal women excluding estrogen users.

[2] Premenopausal women, including postmenopausal estrogen users.

ANOVA for continuous and chi-square for categorical variables were used. Means ± SE and frequencies are presented. $^{*}$ $P$ value of <0.05, $^{**}$ $P$ <0.01, and $^{***}$$P$ <0.001 between the lowest and highest quintile of each pattern.

DASH, Dietary Approaches to Stop Hypertension.

$P$ <0.001), femoral neck ($\beta$: 0.022 ± 0.006, $P$ <0.001), total hip ($\beta$: 0.029 ± 0.006, $P$ <0.001), and lumbar spine ($\beta$: 0.025 ± 0.007, $P = 0.001$) for postmenopausal women, after adjusting for sociodemographic, anthropometric, and lifestyle factors, as well as the use of osteoporosis medication and season of BMD measurement (**Table 3**). Higher adherence to MeDS was significantly associated with a higher BMD at the trochanter ($\beta$: 0.015 ± 0.005, $P = 0.007$) and total hip (0.015 ± 0.006, $P = 0.01$, **Table 4**) among postmenopausal women only. Higher adherence to the AHEI was associated with a higher BMD at the trochanter ($\beta$: 0.018 ± 0.006, $P = 0.001$), femoral neck ($\beta$: 0.015 ± 0.006, $P = 0.01$), total hip (0.021 ± 0.006, $P = 0.001$), and lumbar spine ($\beta$: 0.017 ± 0.008, $P = 0.02$, **Table 5**) among postmenopausal women only.

DASH and AHEI were associated with a lower likelihood of osteoporosis for postmenopausal women only, after adjusting for all covariates. MeDS approached significance after adjusting for all covariates (**Table 6**). Estrogenic women were not included in the analysis, due to the limited number with osteoporosis ($n = 3$). Among postmenopausal women, higher adherence to DASH was associated with 46% lower odds of osteoporosis at the lumbar spine and/or the femoral neck (OR: 0.54, 95% CI: 0.39, 0.75); higher adherence to MeDS and AHEI were also associated with a lower likelihood of osteoporosis (OR: 0.75, 95% CI: 0.56, 1.01 and OR: 0.64, 95% CI: 0.46, 0.88, respectively).

For DASH, MeDS, and AHEI, the whole grains (servings/d) component was associated with a lower likelihood of osteoporosis in postmenopausal women (OR: 0.66, 95% CI: 0.52, 0.83; OR: 0.36, 95% CI: 0.19, 0.67; and OR: 0.77, 95% CI: 0.62, 0.96, **Table 7**). For DASH only, higher low-fat dairy and lower red and processed meat and sodium were also associated with a lower likelihood of osteoporosis in postmenopausal women. For AHEI, higher vegetable score and a lower percentage of energy from *trans* fat were associated with a lower likelihood of osteoporosis in postmenopausal women. No other statistically significant associations were observed between diet score components and prevalence of osteoporosis.

## Discussion

In this population of older Puerto Rican adults, DASH and AHEI-2010 indices were associated with a lower likelihood of osteoporosis among postmenopausal women (not taking estrogen), whereas the MeDS approached significance. No associations were seen among men, and there were too few estrogenic women to evaluate. Higher DASH adherence was associated with a higher BMD at all hip sites and the lumbar spine, and was more strongly associated with a lower likelihood of osteoporosis than the AHEI-2010 or MeDS. Our findings suggest that a DASH diet may be particularly important in maintaining bone health

**TABLE 3** Cross-sectional associations of DASH index z-scores and bone mineral density (g/cm$^2$) for men, and premenopausal and postmenopausal women

| | DASH | | | | | |
|---|---|---|---|---|---|---|
| | Men ($n = 244$) | | Premenopausal women[1] ($n = 139$) | | Postmenopausal women[2] ($n = 507$) | |
| | $\beta \pm$ SE | $P$ | $\beta \pm$ SE | $P$ | $\beta \pm$ SE | $P$ |
| Trochanter | | | | | | |
| Unadjusted | 0.005 ± 0.009 | 0.57 | 0.0007 ± 0.009 | 0.94 | 0.021 ± 0.006 | <0.001 |
| Model 1 | 0.003 ± 0.010 | 0.72 | 0.004 ± 0.010 | 0.65 | 0.027 ± 0.006 | <0.001 |
| Model 2 | – 0.004 ± 0.009 | 0.70 | – 0.003 ± 0.002 | 0.79 | 0.025 ± 0.005 | <0.001 |
| Model 3 | – 0.004 ± 0.010 | 0.65 | – 0.005 ± 0.010 | 0.69 | 0.026 ± 0.006 | <0.001 |
| Femoral neck | | | | | | |
| Unadjusted | 0.004 ± 0.010 | 0.68 | 0.005 ± 0.010 | 0.62 | 0.015 ± 0.006 | 0.01 |
| Model 1 | 0.007 ± 0.010 | 0.50 | 0.010 ± 0.010 | 0.31 | 0.022 ± 0.006 | <0.001 |
| Model 2 | 0.001 ± 0.009 | 0.90 | 0.005 ± 0.010 | 0.63 | 0.021 ± 0.005 | <0.001 |
| Model 3 | 0.006 ± 0.010 | 0.59 | 0.009 ± 0.012 | 0.46 | 0.022 ± 0.006 | <0.001 |
| Total hip | | | | | | |
| Unadjusted | 0.007 ± 0.010 | 0.51 | 0.002 ± 0.011 | 0.83 | 0.022 ± 0.007 | <0.001 |
| Model 1 | 0.007 ± 0.011 | 0.52 | 0.008 ± 0.011 | 0.49 | 0.030 ± 0.006 | <0.001 |
| Model 2 | 0.001 ± 0.010 | 0.90 | – 0.002 ± 0.01 | 0.83 | 0.029 ± 0.006 | <0.001 |
| Model 3 | – 0.001 ± 0.010 | 0.89 | 0.001 ± 0.013 | 0.92 | 0.029 ± 0.006 | <0.001 |
| Lumbar spine | | | | | | |
| Unadjusted | 0.016 ± 0.012 | 0.17 | – 0.011 ± 0.013 | 0.41 | 0.018 ± 0.007 | 0.02 |
| Model 1 | 0.010 ± 0.012 | 0.41 | – 0.004 ± 0.013 | 0.76 | 0.024 ± 0.007 | 0.001 |
| Model 2 | 0.003 ± 0.012 | 0.78 | – 0.010 ± 0.013 | 0.46 | 0.022 ± 0.007 | 0.002 |
| Model 3 | 0.003 ± 0.013 | 0.80 | 0.007 ± 0.016 | 0.67 | 0.025 ± 0.007 | 0.001 |

[1] Premenopausal women, including postmenopausal estrogen users.

[2] Postmenopausal women, excluding estrogen users.

Multivariable linear regression models were used. Unadjusted model includes the dietary quality index only. Model 1 was adjusted for age and sex. Model 2 was adjusted for model 1 plus BMI and height. Model 3 was adjusted for model 2 plus smoking status, season of bone mineral density measurement (fall, winter, spring, summer), osteoporosis medication use (yes/no), and calcium intake (mg/d), total energy intake, alcohol consumption, serum vitamin D status (mg/dL).

DASH, Dietary Approaches to Stop Hypertension.

for postmenopausal women not taking estrogen. Postmenopausal women have lower circulating estrogen, which leads to bone deterioration and progressive bone loss, placing them at increased risk of osteoporosis (41). Thus, it is possible that a healthier dietary pattern, such as DASH, may mitigate bone loss in the environment of lower estrogen among women. In comparison, men and premenopausal women do not appear to experience bone loss at the same accelerated rate and may be less likely to respond to other external stimuli, such as diet. The interaction by estrogen status is corroborated by work from the Aberdeen Prospective Osteoporosis Screening Study, where individual nutrients were associated with bone among peri- and postmenopausal women, but not premenopausal women (42).

The DASH, AHEI-2010, and MeDS indices have many similarities in that they emphasize vegetables, fruit, whole grains, nuts, and legumes (13, 34, 35), which are known to be important for bone health (9, 43). The DASH diet also promotes low-fat dairy as beneficial (34) and the DASH and AHEI-2010 include limiting sodium (13, 35). These 2 dietary components may contribute to the DASH being more strongly, positively associated with bone, as dairy is an important component of a dietary quality index for bone, particularly for those with adequate vitamin D status (6). Sodium may also be key, as higher intakes increase urinary calcium excretion, which can lead to poor bone outcomes (44). Several individual low-fat dairy components of the DASH diet were inversely associated with osteoporosis among postmenopausal women in this study. Lower sodium intake represented by the DASH sodium component appeared protective, as did lower red and processed meat consumption. A recent review reported that negative associations between meat consumption and bone health may be due to the fact that it is often consumed as part of a Western dietary pattern (45). A red meat protein pattern was shown to be related to the lowest BMD among adults from the Framingham Osteoporosis Study, compared with other animal sources of protein (46). The implementation of a DASH dietary pattern has been shown to reduce blood pressure and reduce the risk of type 2 diabetes, cancer, and cardiovascular disease (47). This reduction of chronic disease may indirectly benefit bone health. Although few studies have examined DASH directly in relation to bone, those that have suggest beneficial effects. Two dietary interventions with a DASH diet showed improvements in serum bone turnover markers (48) and reduced serum calcitrol (49), and 1 longitudinal cohort study showed an inverse association, although not significant, of hip fracture with a higher DASH diet score (22).

Several studies of dietary quality indices and bone outcomes have focused on the MeDS (19–21, 23), although other dietary quality indices have also been examined (22, 24–26, 28). Overall, findings from studies on dietary quality indices and bone measures (BMD, fracture, bone turnover markers) have been inconsistent, with some showing favorable associations (19, 20, 22, 26, 27, 29, 31), others reporting null associations (23, 24, 28, 30), and 1 study reporting a negative relation (21). Conflicting findings across studies may be due to differences in methodology

**TABLE 4** Cross-sectional associations of MeDS z-scores and bone mineral density (g/cm$^2$) for men, and premenopausal and postmenopausal women

| | MeDS ($n = 865$) | | | | | |
|---|---|---|---|---|---|---|
| | Men ($n = 244$) | | Premenopausal women[1] ($n = 139$) | | Postmenopausal women[2] ($n = 507$) | |
| | $\beta \pm$ SE | $P$ | $\beta \pm$ SE | $P$ | $\beta \pm$ SE | $P$ |
| Trochanter | | | | | | |
| Unadjusted | 0.010 ± 0.009 | 0.27 | −0.005 ± 0.011 | 0.60 | 0.014 ± 0.006 | 0.02 |
| Model 1 | 0.009 ± 0.009 | 0.32 | −0.004 ± 0.010 | 0.67 | 0.014 ± 0.006 | 0.014 |
| Model 2 | 0.005 ± 0.009 | 0.56 | −0.002 ± 0.009 | 0.83 | 0.015 ± 0.005 | 0.004 |
| Model 3 | 0.005 ± 0.009 | 0.58 | −0.005 ± 0.010 | 0.54 | 0.015 ± 0.005 | 0.007 |
| Femoral neck | | | | | | |
| Unadjusted | 0.010 ± 0.009 | 0.31 | −0.006 ± 0.010 | 0.53 | 0.010 ± 0.006 | 0.10 |
| Model 1 | 0.011 ± 0.010 | 0.24 | −0.005 ± 0.010 | 0.61 | 0.011 ± 0.006 | 0.07 |
| Model 2 | 0.007 ± 0.009 | 0.42 | −0.004 ± 0.010 | 0.68 | 0.010 ± 0.005 | 0.08 |
| Model 3 | 0.007 ± 0.009 | 0.46 | −0.007 ± 0.010 | 0.47 | 0.010 ± 0.005 | 0.07 |
| Total hip | | | | | | |
| Unadjusted | 0.012 ± 0.010 | 0.23 | −0.004 ± 0.011 | 0.70 | 0.014 ± 0.007 | 0.044 |
| Model 1 | 0.012 ± 0.010 | 0.23 | −0.003 ± 0.011 | 0.80 | 0.014 ± 0.007 | 0.030 |
| Model 2 | 0.007 ± 0.010 | 0.45 | −0.0003 ± 0.01 | 0.97 | 0.016 ± 0.006 | 0.009 |
| Model 3 | 0.007 ± 0.010 | 0.47 | −0.003 ± 0.011 | 0.76 | 0.015 ± 0.006 | 0.01 |
| Lumbar spine | | | | | | |
| Unadjusted | 0.015 ± 0.012 | 0.21 | −0.006 ± 0.014 | 0.67 | 0.009 ± 0.008 | 0.23 |
| Model 1 | 0.011 ± 0.012 | 0.38 | −0.005 ± 0.013 | 0.74 | 0.009 ± 0.008 | 0.20 |
| Model 2 | 0.006 ± 0.012 | 0.61 | −0.006 ± 0.013 | 0.64 | 0.009 ± 0.007 | 0.19 |
| Model 3 | 0.001 ± 0.012 | 0.90 | −0.008 ± 0.014 | 0.57 | 0.008 ± 0.007 | 0.28 |

[1] Premenopausal women including postmenopausal estrogen users.

[2] Postmenopausal women, excluding estrogen users.

Multivariable linear regression models were used. Unadjusted model includes the dietary quality index only. Model 1 was adjusted for age and sex. Model 2 was adjusted for model 1 plus BMI and height. Model 3 was adjusted for model 2 plus smoking status, season of bone mineral density measurement (fall, winter, spring, summer), osteoporosis medication use (yes/no), and calcium intake (mg/d), serum vitamin D status (mg/dL).

MeDS, Mediterranean Diet Score.

in creating the dietary indices, such as decisions on which foods and beverages to include in food groupings, and criteria used to assess how closely an individual adheres to a specific dietary pattern. Some dietary quality indices, such as MeDS and DASH, are based on population-based cut-offs (sex-specific median intake adjusted for total energy and quintiles) whereas others (e.g., AHEI-2010) are based on existing nutrition knowledge and dietary recommendations. The different methodologies used to define the cut-offs may explain differences in point estimates of the individual components (e.g., whole grain and vegetables) with bone outcomes. For example, the whole grain component of DASH and MeDS, but not for AHEI, was associated with a lower likelihood of osteoporosis in our study. The DASH and MeDS cut-offs are based on the population distribution of intakes, whereas the AHEI is based on an a priori cut-off. Further, some dietary quality indices use dichotomous cut-offs (e.g., MeDS), compared with normative or ordinal cut-offs (AHEI, DASH) for each of the individual components, which impacts the range of scoring. Therefore, the degree to which an individual is classified as below or above the recommended amount for each component of the dietary index may not accurately represent differences in dietary quality.

Due to inconsistent results across populations, few studies have compared commonly recommended indices with BMD and fracture outcomes in adolescents/young adults (24, 25) and older adults (22, 26). In 90,014 postmenopausal women from the Women's Health Initiative cohort study, greater adherence to a Mediterranean diet was associated with a lower risk of hip fracture, and there was a nonsignificant inverse association between higher DASH and AHEI-2010 scores and hip fracture (22). In a case-control study, 4 dietary quality indices [AHEI, HEI-2005, Diet Quality Index-International, and alternate Mediterranean Diet Score (aMed)] were inversely associated with hip fracture in 1452 older Chinese adults; however, the authors note that the aMed was preferable, based on the ability to calculate the score and its interpretability (26). No significant results were observed for studies comparing dietary indices among young adults (24, 25). Many dietary quality indices are designed to assess adherence to dietary recommendations for preventing chronic conditions for the general US population, and do not account for the unique traditional patterns of ethnic and minority populations. This is also true of dietary quality indices that are developed for specific regions, such as the Mediterranean diet, as these scores may not allow for the inclusion of traditional or culturally specific foods (50).

Our analysis demonstrates that, within a US mainland Puerto Rican population using a culturally tailored FFQ to estimate dietary intake, DASH was the strongest predictor of BMD, relative to MeDS or AHEI. This is notable, because the DASH dietary pattern emphasizes nutrients such as potassium and fiber and limits sodium intake (34). Potassium and magnesium in fruit and vegetables may promote lower acid load and positive calcium balance, favoring bone formation over resorption (9, 43). Greater fruit and vegetable variety has been related to lower

**TABLE 5** Cross-sectional associations of AHEI z-scores and bone mineral density (g/cm$^2$) for men, and premenopausal and postmenopausal women

| | AHEI (*n* = 865) | | | | | |
|---|---|---|---|---|---|---|
| | Men (*n* = 237) | | Premenopausal women[1] (*n* = 133) | | Postmenopausal women[2] (*n* = 489) | |
| | β ± SE | *P* | β ± SE | *P* | β ± SE | *P* |
| Trochanter | | | | | | |
| Unadjusted | 0.009 ± 0.010 | 0.35 | – 0.006 ± 0.010 | 0.51 | 0.018 ± 0.006 | 0.003 |
| Model 1 | 0.008 ± 0.010 | 0.42 | – 0.004 ± 0.010 | 0.71 | 0.020 ± 0.006 | <0.001 |
| Model 2 | 0.002 ± 0.009 | 0.83 | – 0.006 ± 0.009 | 0.51 | 0.021 ± 0.005 | <0.001 |
| Model 3 | 0.004 ± 0.010 | 0.67 | – 0.007 ± 0.012 | 0.56 | 0.018 ± 0.006 | 0.001 |
| Femoral neck | | | | | | |
| Unadjusted | 0.005 ± 0.010 | 0.61 | – 0.004 ± 0.010 | 0.66 | 0.013 ± 0.006 | 0.03 |
| Model 1 | 0.008 ± 0.010 | 0.44 | – 0.0004 ± 0.010 | 0.97 | 0.015 ± 0.006 | 0.007 |
| Model 2 | 0.005 ± 0.010 | 0.62 | – 0.004 ± 0.010 | 0.66 | 0.016 ± 0.005 | 0.004 |
| Model 3 | 0.007 ± 0.010 | 0.51 | – 0.002 ± 0.013 | 0.86 | 0.015 ± 0.006 | 0.01 |
| Total hip | | | | | | |
| Unadjusted | 0.011 ± 0.010 | 0.32 | – 0.006 ± 0.011 | 0.59 | 0.020 ± 0.007 | 0.004 |
| Model 1 | 0.011 ± 0.011 | 0.30 | – 0.001 ± 0.011 | 0.90 | 0.022 ± 0.007 | <0.001 |
| Model 2 | 0.005 ± 0.010 | 0.86 | – 0.006 ± 0.011 | 0.59 | 0.024 ± 0.006 | 0.001 |
| Model 3 | 0.007 ± 0.011 | 0.54 | 0.0003 ± 0.014 | 0.98 | 0.021 ± 0.006 | 0.001 |
| Lumbar spine | | | | | | |
| Unadjusted | 0.011 ± 0.013 | 0.39 | – 0.016 ± 0.013 | 0.24 | 0.015 ± 0.008 | 0.05 |
| Model 1 | 0.005 ± 0.013 | 0.67 | – 0.011 ± 0.014 | 0.41 | 0.017 ± 0.007 | 0.02 |
| Model 2 | 0.004 ± 0.013 | 0.77 | – 0.014 ± 0.014 | 0.29 | 0.017 ± 0.008 | 0.03 |
| Model 3 | – 0.007 ± 0.014 | 0.62 | 0.0008 ± 0.018 | 0.96 | 0.017 ± 0.008 | 0.02 |

[1] Premenopausal women, including postmenopausal estrogen users.

[2] Postmenopausal women, excluding estrogen users.

Multivariable logistic regression models were used. Unadjusted model includes the dietary quality index only. Model 1 was adjusted for age and sex. Model 2 was adjusted for model 1 plus BMI and height. Model 3 was adjusted for model 2 plus smoking status, season of bone mineral density measurement (fall, winter, spring, summer), osteoporosis medication use (yes/no), and calcium intake (mg/d), total energy intake, serum vitamin D status (mg/dL).

AHEI, Alternative Health Eating Index-2010.

inflammation, another risk factor for osteoporosis (51), in this population (52).

The strengths of this study include a large cohort of Puerto Rican adults living on the US mainland, a population at high risk of osteoporosis, with comprehensive assessment of sociodemographic, lifestyle, and health factors related to bone. Dietary data were collected using an FFQ that was validated for use in this population. This study is limited by its cross-sectional nature and is subject to possible reverse causation. Further, results were stratified by sex and estrogen status; however, power to detect associations among men and premenopausal estrogenic women was limited, due to the small sample size. Thus, data should be interpreted cautiously, given the unbalanced sample size between men, and estrogenic and nonestrogenic women. Future studies are needed to investigate relations between dietary quality and bone loss in a larger cohort with greater numbers of men, premenopausal women, and postmenopausal women taking estrogen.

In conclusion, several dietary quality indices were associated with bone outcomes in a population of older Puerto Rican adults,

**TABLE 6** ORs and 95% CIs for the associations of DASH z-scores and osteoporosis at the lumbar spine and/or femoral neck for men and postmenopausal women[1]

| | DASH | | | | MeDS | | | | AHEI | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Men (*n* = 244) | | Postmenopausal women (*n* = 507) | | Men (*n* = 244) | | Postmenopausal women (*n* = 507) | | Men (*n* = 237) | | Postmenopausal women (*n* = 489) | |
| | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Osteoporosis | | | | | | | | | | | | |
| Unadjusted | 0.82 | 0.52, 1.28 | 0.66 | 0.50, 0.87 | 0.88 | 0.56, 1.37 | 0.77 | 0.58, 1.01 | 0.72 | 0.44, 1.17 | 0.68 | 0.51, 0.90 |
| Model 1 | 0.84 | 0.53, 1.33 | 0.58 | 0.44, 0.78 | 0.90 | 0.58, 1.40 | 0.76 | 0.57, 1.00 | 0.74 | 0.45, 1.21 | 0.65 | 0.49, 0.87 |
| Model 2 | 0.82 | 0.50, 1.35 | 0.60 | 0.45, 0.81 | 0.93 | 0.58, 1.50 | 0.75 | 0.56, 0.99 | 0.72 | 0.42, 1.25 | 0.65 | 0.48, 0.87 |
| Model 3 | 0.71 | 0.40, 1.29 | 0.54 | 0.39, 0.75 | 0.85 | 0.51, 1.42 | 0.75 | 0.56, 1.01 | 0.75 | 0.41, 1.36 | 0.64 | 0.46, 0.88 |

[1] Postmenopausal women excluding estrogen users.

Multivariable logistic regression models were used. Unadjusted model includes the dietary quality index only. Model 1 was adjusted for age. Model 2 was adjusted for model 1 plus BMI and height. Model 3 was adjusted for model 2 plus smoking status, season of bone mineral density measurement (fall, winter, spring, summer), osteoporosis medication use (yes/no), and calcium intake (mg/d), serum vitamin D status (mg/dL).

AHEI, Alternative Health Eating Index-2010; DASH, Dietary Approaches to Stop Hypertension; MeDS, Mediterranean Diet Score.

**TABLE 7** ORs and 95% CIs for the associations of individual components and osteoporosis at the lumbar spine or the femoral neck sites for each dietary index[1,2,3]

| DASH | | | MeDS | | | AHEI | | |
|---|---|---|---|---|---|---|---|---|
| Component | Men OR (95%CI) | Postmenopausal women OR (95% CI) | Component | Men OR (95% CI) | Postmenopausal women OR (95% CI) | Component | Men OR (95% CI) | Postmenopausal women OR (95% CI) |
| Vegetables, servings/d | 0.80 (0.51, 1.2) | 0.82 (0.65, 1.03) | Vegetables, servings/d | 0.57 (0.18, 1.8) | 0.98 (0.55, 1.7) | Vegetables, servings/d | 0.86 (0.63, 1.2) | 0.86 (0.75, 1.0) |
| Fruit, servings/d | 0.81 (0.54, 1.2) | 0.91 (0.73, 1.1) | Fruit, servings/d | 0.64 (0.21, 1.9) | 0.91 (0.51, 1.6) | Fruit, servings/d | 0.94 (0.72, 1.2) | 0.89 (0.76, 1.03) |
| Whole grains, servings/d | 0.97 (0.65, 1.4) | 0.66 (0.52, 0.83) | Whole grains, g/d | 0.73 (0.25, 2.1) | 0.36 (0.19, 0.67) | Whole grains, g/d | 0.98 (0.65, 1.5) | 0.77 (0.62, 0.96) |
| Low-fat dairy, servings/d | 0.79 (0.52, 1.2) | 0.77 (0.61, 0.98) | Dairy, servings/d | 0.62 (0.20, 2.0) | 1.3 (0.68, 2.4) | | | |
| Nuts, servings/d | 1.0 (0.67, 1.6) | 1.0 (0.79, 1.2) | Nuts and legumes, servings/d | 0.99 (0.34, 2.9) | 0.73 (0.41, 1.3) | Nuts and legumes, servings/d | 0.96 (0.78, 1.2) | 0.98 (0.88, 1.1) |
| Sugar-sweetened beverages, servings/d | 0.93 (0.62, 1.4) | 0.87 (0.70, 1.1) | Fish, servings/d | 3.1 (0.92, 10.2) | 0.83 (0.51, 1.3) | Sugar-sweetened beverages, servings/d | 0.93 (0.79, 1.1) | 0.98 (0.89, 1.1) |
| Red and processed meat, servings/d | 1.0 (0.51, 2.0) | 0.69 (0.48, 0.97) | Meat, servings/d | 2.0 (0.62, 6.5) | 0.29 (0.44, 1.4) | Red and processed meat, servings/d | 0.82 (0.65, 1.04) | 0.92 (0.81, 1.04) |
| Sodium, mg/d | 1.0 (0.51, 2.0) | 0.69 (0.48, 0.97) | MUFA:SFA ratio | 0.50 (0.16, 1.6) | 1.2 (0.68, 2.2) | Sodium, mg/d | 1.1 (0.79, 1.6) | 0.81 (0.65, 1.02) |
| | | | Alcohol, drinks/d | 0.81 (0.23, 2.6) | 0.79 (0.42, 1.5) | Alcohol, drinks/d | 0.97 (0.82, 1.2) | 0.94 (0.84, 1.1) |
| | | | | | | PUFA, % of energy Long-chain n–3 fats | 1.2 (0.98, 1.5) | 0.91 (0.81, 1.02) |
| | | | | | | *Trans* fat, % energy | 0.73 (0.47, 1.1) | 0.74 (0.55, 1.0) |

[1] *Denotes significant 95% CI.

[2] Multivariable logistic regressions were used. Models were adjusted for age, education, BMI, height, smoking status, season of bone mineral density measurement (fall, winter, spring, summer), osteoporosis medication use (yes/no), and calcium intake (mg/d), serum vitamin D status (mg/dL). DASH and AHEI were also adjusted for total energy intake. DASH was also adjusted for alcohol consumption.

[3] Postmenopausal women excluding estrogen users.

AHEI, Alternative Health Eating Index-2010; DASH, Dietary Approaches to Stop Hypertension; MeDS, Mediterranean Diet Score.

with DASH more strongly associated than MeDS or AHEI-2010, particularly in postmenopausal women. This contributes to a growing body of literature on dietary quality and bone health, but also highlights limitations of dietary indices for ethnic and minority groups. Given the inconsistent findings among dietary quality indices and bone in the extant literature, there is a need for the development of a bone index that can be used to identify individuals at risk and provide recommendations for dietary improvement across cultural and ethnic minority groups. Further research is needed to examine the impact of these indices on changes in bone measures.

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