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Higher Diet Quality Is Inversely Associated with Mortality in African-American Women[1–4]

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Abstract

Background: Diet quality has been inversely associated with overall mortality in white populations, but the evidence in African-American populations is limited.

Objective: The goal of the present study was to assess diet quality in relation to all-cause mortality in the Black Women's Health Study, a follow-up study of African-American women begun in 1995.

Methods: Data used in this study were obtained via biennial questionnaires from 1995 to 2011. Based on food-frequency questionnaire data collected in 1995 and 2001, we calculated an index-based diet quality score [Dietary Approaches to Stop Hypertension (DASH)] and derived dietary patterns (prudent and Western) with the use of factor analysis. We followed 37,001 women who were aged 30–69 y and free of cancer, cardiovascular disease, and diabetes at baseline for mortality through 2011. Multivariable Cox regression was used to estimate HRs and 95% CIs. Analyses were conducted in 2014.

Results: Based on a total of 1678 deaths during 16 y of follow-up, higher DASH scores were associated with reduced all-cause mortality (HR: 0.75; 95% CI: 0.63, 0.89 for highest vs. lowest quintiles). The DASH components most strongly associated with lower mortality were high intake of whole grains and low intake of red and processed meat. A Western dietary pattern, characterized by high intake of red and processed meat, was associated with increased all-cause mortality rates (HR: 1.37; 95% CI: 1.17, 1.60 for highest vs. lowest quintiles of score); a prudent dietary pattern was not associated with risk.

Conclusion: A DASH-style diet high in intake of whole grains and low in consumption of red meat is associated with reduced mortality rates in healthy African-American women. *J Nutr* 2015;145:547–54.

Keywords: diet quality, all-cause mortality, African Americans, cohort study, women's health

Introduction

Diet is a complex set of correlated exposures. Assessment of dietary patterns in relation to disease outcomes may identify associations that a focus on individual items would miss, and dietary patterns derived from factor or cluster analysis have indeed been found to predict disease risk. It also can be useful to assess whether adherence to particular guidelines is associated with reduced disease risk, especially because it may be easier for the public to understand explicit recommendations about certain food items rather than about a dietary pattern (1, 2). Various measures of high overall diet quality have been inversely associated with all-cause mortality rates in studies of predominantly white populations (3–10). Empirically-derived "prudent" dietary patterns, rich in vegetables and fruit, were associated with lower mortality in several studies (3–6), whereas Western dietary patterns, characterized by intake of red and processed meat and fried foods, were associated with increased mortality in some (3) but not all studies (4, 5). Studies that have evaluated a priori indexes of diet quality based on dietary recommendations have found higher diet quality to be associated with reduced mortality (7–10).

Diet quality is poorer on average among African Americans than among white Americans (11, 12), and mortality rates are higher for American Americans than for other racial groups (13). Yet little data are available on the association between dietary patterns and mortality in African Americans. Because of differences between ethnic groups in comorbidities, modifying factors, and genetic factors, it cannot be assumed that associations observed in one population would necessarily hold among other ethnic groups. In addition, if the same association of

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dietary patterns with mortality is observed in several ethnic groups, this strengthens the credibility of the association.

In the present report, we assess the association of dietary intake with all-cause and cause-specific mortality among African-American women. The data were obtained in the Black Women's Health Study (BWHS)[5] an ongoing follow-up study of black women across the US. We focused on measures of adherence to a diet consistent with the Dietary Approaches to Stop Hypertension (DASH) guidelines (14), and we also evaluated the prudent and Western dietary patterns previously derived in the BWHS by factor analysis (15). These measures were associated with health outcomes in the BWHS: adherence to DASH guidelines was associated with lower incidence of obesity (16); the prudent pattern with lower risks of weight gain (15), estrogen receptor–negative breast cancer (17), and colorectal adenomas (18); and the Western pattern with greater weight gain (15) and higher risk of colorectal adenomas (18). An advantage of index-based measures of diet quality such as the DASH score is the ability to capture components of multiple data-driven dietary patterns in a single score. Another indexed based measure, the Alternative Healthy Eating Index (AHEI) (9), was developed as an improvement on the Healthy Eating Index (19). We judged the DASH score to be preferable for use in the BWHS because it is based on rankings, whereas the AHEI score is based on absolute values; because FFQs underestimate nutrient values [and a reduced FFQ was used in the BWHS (20)], the AHEI likely provides less of a range than DASH across which to compare women. Another measure, the Mediterranean diet score (8), is more applicable to southern European populations than to American populations because of differences in foods eaten, oils used, and meal preparation.

Methods

Study population. The BWHS, an ongoing follow-up study of African-American women, was established in 1995 when African-American women from across the US were enrolled through mailed health questionnaires (21). The baseline questionnaire collected information on demographic characteristics, lifestyle factors, and medical history, and usual diet was assessed through an FFQ. A total of 59,000 women aged 21–69 y at baseline were followed through mailed questionnaires every 2 y. Follow-up questionnaires update exposure information and incident medical conditions. Follow-up of the baseline cohort was ~80% through 2011. The Boston University Medical Campus Institutional Review Board approved the protocol.

The present analysis excluded women who at baseline were <30 y of age (n = 12,812); had a history of cancer (except nonmelanoma skin cancer) (n = 1488), myocardial infarction (n = 620), stroke (n = 439), or diabetes (n = 2378); left >10 items blank on the FFQ (n = 1510); had implausible energy intake values (<400 or >3800 kcal) (n = 1783); were pregnant at baseline (n = 482) or were missing height or weight (n = 442); or had an implausible BMI (<15 or ≥60 kg/m^2) (n = 46). The age exclusion was made because there were few deaths in women <30 y old at baseline. The exclusions for cancer, myocardial infarction, stroke, and diabetes were made because these conditions are strong risk factors for mortality and the effect of a weaker risk factor such as dietary pattern might have been difficult to discern in women at high risk of death from those conditions. The exclusions associated with inability to measure BMI at baseline were made because BMI is an important risk factor for mortality in black women (22). After all exclusions, 37,001 women were included in the analysis.

Dietary assessment. Dietary intake in the previous year was assessed in 1995 and 2001 with self-administered modified versions of the reduced Block-National Cancer Institute FFQ (20). In a validation study of the 1995 FFQ among 408 BWHS participants, correlations with responses from 3-d food diaries and 24-h recalls for fat, protein, carbohydrate, fiber, calcium, vitamin C, folate, and β-carotene ranged from 0.5 to 0.8 (23). Diet scores were computed for each participant based on the 1995 and 2001 FFQ data. We evaluated a DASH score created by Fung et al. (14) that ranks participants based on intake of 8 food and nutrient components. Participants were categorized into quintiles for each component. For fruits (including fruit juice), vegetables, nuts and legumes, whole grains, and low-fat dairy, the lowest quintile was assigned 1 point and the highest quintile was assigned 5 points. For sodium, red and processed meats, and sugar-sweetened beverages, scores were reversed such that the lowest quintile was assigned 5 points and the highest quintile was assigned 1 point. DASH scores can range from 8 to 40; in the present study the scores ranged from 8 to 38. We categorized the scores into quintiles (quintiles 1 and 5 represent low and high adherence, respectively).

Prudent and Western dietary patterns were derived with the use of factor analysis of 35 individual foods or food groups, as described previously (15). The SAS function ROTATE = VARIMAX (SAS Institute) was used for rotation of the factors by an orthogonal transformation. Factor scores for each pattern were calculated by summing intakes of each food group weighted by that food group's factor loading. The prudent and Western patterns explained 22% of the variance. The prudent dietary pattern is characterized by high intake of vegetables and fruits, whereas the Western dietary pattern is characterized by high intake of red and processed meat and fried foods. Quintiles 1 and 5 represent low and high adherence, respectively, to each dietary pattern.

The Pearson coefficients for the correlations among the diet scores were as follows: prudent with Western, r = 0.0060 (P = 0.25); prudent with DASH, r = 0.6200 (P < 0001); and Western with DASH, r = −0.4973 (P < 0.0001). Thus, as expected, prudent and Western scores were uncorrelated, which is a function of the statistical methods use to derive them, whereas DASH score was positively correlated with prudent pattern score and inversely correlated with Western pattern score.

The Alternative Healthy Eating Index–2010 (AHEI–2010), another dietary pattern associated with chronic disease (19), is based on 11 constituents, most of which are in the DASH score. Components are scored from 1 to 10, with 10 indicating that dietary recommendations were met. The score is based on absolute amounts of intake. The DASH score and AHEI–2010 score were highly correlated in the BWHS, with r = 0.7433 (P < 0.0001).

Endpoints. Deaths through 31 December 2011 were identified through linkage with the National Death Index for all participants who had not completed the 2011 questionnaire. The International Classification of Diseases, Tenth Revision, was used to classify underlying cause of death as death from cardiovascular disease (I00–I99), cancer (C00–C97), or all other causes [excluding "external" causes of death, S00–Y98 (e.g., accidents and homicides)].

Covariate assessment. Information on self-reported height (feet and inches) and current weight (pounds) was collected at baseline. In a validation study among 115 participants, Spearman correlations for self-reported vs. technician-measured height and weight were 0.93 and 0.97, respectively (24, 25). BMI was calculated as weight in kilograms divided by height in meters squared. Information on years of education was ascertained on the 1995 and 2003 questionnaires. Data on marital status, vigorous exercise, television watching, smoking status, and alcohol intake were obtained at baseline and were updated on biennial follow-up questionnaires. In a validation study of physical activity, participants wore actigraphs (activity monitors) during their waking hours for 7 d; the correlation between BWHS questionnaire data and actigraph measurements was 0.40 (P < 0.001) for vigorous activity (24).

Statistical analysis. Cox proportional hazards models were used to estimate HRs and 95% CIs for the association between diet quality and mortality. Participants contributed to the analysis from 1995 until death, loss to follow-up, or the end of follow-up in 2011, whichever occurred first. Time-varying covariates were updated with the use of the

[5]Abbreviations used: AHEI, Alternative Healthy Eating Index; BWHS, Black Women's Health Study; DASH, Dietary Approaches to Stop Hypertension.

TABLE 1 Age-standardized baseline characteristics according to diet scores, Black Women's Health Study, 1995[1]

Characteristic	DASH score		Prudent dietary pattern		Western dietary pattern	
	Quintile 1	Quintile 5	Quintile 1	Quintile 5	Quintile 1	Quintile 5
Participants, *n*	6995	6284	7400	7400	7400	7400
Age, y	39.0 ± 7.1	45.1 ± 9.6	39.2 ± 7.2	44.7 ± 9.2	42.8 ± 9.4	41.6 ± 8.2
BMI, kg/m^2	28.9 ± 7.0	27.0 ± 5.5	28.9 ± 6.9	27.1 ± 5.7	27.2 ± 5.7	28.5 ± 6.7
BMI ≥30	36.3	22.9	36.0	23.7	24.4	33.1
Education ≥16 y	34.6	58.8	38.3	53.6	55.6	37.1
Married or living as married	42.9	43.1	42.1	42.4	43.1	41.7
Vigorous activity ≥5 h/wk	7.0	22.9	7.0	21.6	19.4	8.9
Television watching ≥5 h/d	23.5	7.0	21.2	8.9	9.2	19.1
Current smoker	28.9	9.1	23.1	15.3	9.1	29.5
Alcohol use ≥7/wk	8.8	4.2	3.5	9.6	1.3	16.6
Total energy intake, kcal/d	1537 ± 682	1453 ± 610	1593 ± 735	1275 ± 574	1377 ± 616	1409 ± 677

[1]Values are means ± SDs or percentages standardized to the age distribution of the study population at the start of follow-up. DASH, Dietary Approaches to Stop Hypertension.

Andersen-Gill data structure (26); this structure creates a new record for each follow-up cycle in which a participant is at risk, and assigns the covariate value for that cycle.

Diet scores at baseline in 1995 were assessed in relation to mortality from 1995 to 2001. To better represent long-term intake, the mean of diet scores in 1995 and 2001 was assessed in relation to mortality from 2001 to 2011. We also created cumulative means of vigorous exercise and television watching every 2 y. Multivariable models, stratified by age and questionnaire cycle, were adjusted for total energy intake (quintiles), education (≤12, 13–15, or ≥16 y), marital status (married or living as married, divorced or separated, widowed, or single), vigorous exercise (<1, 1–2, or ≥3 h/wk), television watching (<3, 3–4, or ≥5 h/d), smoking (never; former; current, <15 cigarettes/d; or current, ≥15 cigarettes/d), and alcohol intake (never; former; current, 1–6/wk; or current, ≥7/wk). The proportion of missing data was <1% for all covariates; missing data for covariates were modeled as indicator variables. The primary analyses did not adjust for BMI, which is considered to be an intermediate between dietary pattern and illness/death. However, in analyses that controlled for BMI, whether at baseline or as time-varying, results were unchanged. Additional control for health insurance status and visits to a physician did not materially alter the estimates. Tests for linear trend were conducted by modeling diet quality index scores as continuous variables with the use of the median value for each quintile. We conducted subgroup analyses within strata of BMI, age, smoking, vigorous exercise, and years of education. Tests for interaction were performed by using the likelihood ratio test comparing models with and without crossproduct terms between the variable of interest (e.g., BMI) and the diet quality score. All statistical analyses were performed with the use of SAS version 9.3.

Results

Among 37,001 women followed for ≤16 y, 1678 deaths were identified; 428 (26%) were due to cardiovascular disease, 742 (44%) were due to cancer, and 508 (30%) were due to other causes. Among the latter, there were a large number of causes, with most accounting for just a few deaths. The largest categories were chronic obstructive pulmonary disorder (*n* = 37), diabetes (*n* = 29), HIV-related (*n* = 28), and sarcoidosis (*n* = 26). At baseline, women with higher DASH or prudent diet

TABLE 2 Diet scores and risk of all-cause mortality in the Black Women's Health Study, 1995–2011[1]

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	*P*-trend[2]
DASH						
Deaths, *n*	336	433	357	285	267	
Person-years	98,484	138,660	114,839	93,839	82,665	
Age-adjusted HR (95% CI)	1.00 (ref)	0.76 (0.66, 0.87)	0.64 (0.55, 0.75)	0.55 (0.46, 0.64)	0.49 (0.42, 0.58)	<0.001
Multivariable HR (95% CI)	1.00 (ref)	0.86 (0.75, 1.00)	0.83 (0.71, 0.97)	0.75 (0.63, 0.89)	0.75 (0.63, 0.89)	<0.001
Prudent						
Deaths, *n*	301	334	310	357	376	
Person-years	105,726	105,678	105,750	105,687	105,646	
Age-adjusted HR (95% CI)	1.00 (ref)	0.93 (0.80, 1.09)	0.77 (0.65, 0.90)	0.79 (0.68, 0.93)	0.75 (0.64, 0.88)	<0.001
Multivariable HR (95% CI)	1.00 (ref)	1.05 (0.90, 1.23)	0.92 (0.78, 1.08)	0.99 (0.85, 1.17)	1.01 (0.86, 1.20)	0.98
Western						
Deaths, *n*	283	311	329	335	420	
Person-years	105,760	105,737	105,724	105,656	105,611	
Age-adjusted HR (95% CI)	1.00 (ref)	1.14 (0.97, 1.34)	1.27 (1.08, 1.49)	1.36 (1.16, 1.60)	1.77 (1.52, 2.06)	<0.001
Multivariable HR (95% CI)	1.00 (ref)	1.10 (0.93, 1.29)	1.16 (0.99, 1.37)	1.18 (1.00, 1.39)	1.37 (1.17, 1.60)	<0.001

[1]Age-adjusted HR is adjusted for age and total energy intake. Multivariable HR is adjusted for age, total energy intake, education, marital status, vigorous exercise, television watching, smoking, and alcohol intake. DASH, Dietary Approaches to Stop Hypertension; ref, reference.

[2]Derived from test for linear trend, modeling the median value for each quintile as a continuous variable.

TABLE 3 DASH and Western diet scores and risk of all-cause mortality in strata of BMI, smoking, vigorous exercise, age, and education in the Black Women's Health Study, 1995–2011[1]

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	*P*-trend[2]	*P*-interaction
DASH							
BMI <30							
Deaths, *n*	228	262	223	183	192		
HR (95% CI)	1.00 (ref)	0.72 (0.60, 0.86)	0.69 (0.57, 0.84)	0.64 (0.52, 0.79)	0.65 (0.52, 0.80)	<0.001	
BMI ≥30							0.04
Deaths, *n*	108	171	134	102	75		
HR (95% CI)	1.00 (ref)	1.20 (0.94, 1.54)	1.14 (0.88, 1.49)	1.02 (0.76, 1.36)	0.99 (0.72, 1.37)	0.71	
Western							
BMI <30							
Deaths, *n*	200	195	200	209	284		
HR (95% CI)	1.00 (ref)	1.06 (0.87, 1.30)	1.11 (0.91, 1.35)	1.19 (0.98, 1.46)	1.54 (1.27, 1.87)	<0.001	
BMI ≥30							0.05
Deaths, *n*	83	116	129	126	136		
HR (95% CI)	1.00 (ref)	1.16 (0.87, 1.54)	1.24 (0.94, 1.64)	1.15 (0.87, 1.53)	1.10 (0.82, 1.46)	0.74	
DASH							
Never smokers							
Deaths, *n*	111	163	158	130	127		
HR (95% CI)	1.00 (ref)	0.93 (0.73, 1.19)	1.00 (0.78, 1.28)	0.93 (0.71, 1.21)	0.96 (0.72, 1.26)	0.78	
Ever smokers							0.01
Deaths, *n*	225	269	199	153	140		
HR (95% CI)	1.00 (ref)	0.78 (0.65, 0.93)	0.68 (0.56, 0.83)	0.58 (0.47, 0.72)	0.57 (0.45, 0.72)	<0.001	
Western							
Never smokers							
Deaths, *n*	137	152	149	130	121		
HR (95% CI)	1.00 (ref)	1.19 (0.95, 1.51)	1.20 (0.95, 1.52)	1.18 (0.93, 1.52)	1.20 (0.93, 1.55)	0.19	
Ever smokers							0.07
Deaths, *n*	144	158	180	205	299		
HR (95% CI)	1.00 (ref)	1.04 (0.83, 1.31)	1.17 (0.94, 1.46)	1.26 (1.01, 1.57)	1.59 (1.29, 1.96)	<0.001	
DASH							
Vigorous exercise <3 h/wk							
Deaths, *n*	326	416	323	252	232		
HR (95% CI)	1.00 (ref)	0.86 (0.74, 0.99)	0.77 (0.66, 0.91)	0.69 (0.58, 0.82)	0.70 (0.58, 0.84)	<0.001	
Vigorous exercise ≥3 h/wk							0.33
Deaths, *n*	9	15	30	27	33		
HR (95% CI)	1.00 (ref)	0.84 (0.36, 1.94)	1.32 (0.61, 2.86)	1.19 (0.54, 2.62)	0.95 (0.43, 2.10)	0.99	
Western							
Vigorous exercise <3 h/wk							
Deaths, *n*	252	275	306	315	401		
HR (95% CI)	1.00 (ref)	1.06 (0.89, 1.26)	1.17 (0.98, 1.38)	1.20 (1.01, 1.42)	1.41 (1.20, 1.67)	<0.001	
Vigorous exercise ≥3 h/wk							0.43
Deaths, *n*	27	31	23	19	14		
HR (95% CI)	1.00 (ref)	1.56 (0.92, 2.66)	1.43 (0.80, 2.57)	1.42 (0.76, 2.64)	1.20 (0.60, 2.39)	0.53	
DASH							
Age <55 y							
Deaths, *n*	213	212	154	100	65		
HR (95% CI)	1.00 (ref)	0.84 (0.69, 1.02)	0.87 (0.71, 1.08)	0.80 (0.63, 1.03)	0.69 (0.52, 0.93)	0.01	
Age ≥55 y							0.44
Deaths, *n*	123	221	203	185	202		
HR (95% CI)	1.00 (ref)	0.88 (0.70, 1.10)	0.79 (0.63, 1.00)	0.72 (0.57, 0.91)	0.75 (0.59, 0.96)	0.01	
Western							
Age <55 y							
Deaths, *n*	89	121	151	171	212		
HR (95% CI)	1.00 (ref)	1.20 (0.91, 1.58)	1.36 (1.04, 1.77)	1.40 (1.08, 1.82)	1.55 (1.20, 2.01)	<0.001	
Age ≥55 y							0.22
Deaths, *n*	194	190	178	164	208		
HR (95% CI)	1.00 (ref)	1.07 (0.87, 1.30)	1.07 (0.87, 1.32)	1.07 (0.87, 1.33)	1.28 (1.04, 1.57)	0.03	

(Continued)

TABLE 3 *Continued*

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	*P*-trend[2]	*P*-interaction
DASH							
Education <16 y							
Deaths, *n*	236	255	216	157	117		
HR (95% CI)	1.00 (ref)	0.79 (0.66, 0.95)	0.85 (0.70, 1.04)	0.75 (0.61, 0.93)	0.67 (0.53, 0.86)	0.002	
Education ≥16 y							0.19
Deaths, *n*	98	177	141	125	150		
HR (95% CI)	1.00 (ref)	1.01 (0.79, 1.30)	0.82 (0.63, 1.07)	0.75 (0.57, 1.00)	0.86 (0.65, 1.13)	0.06	
Western							
Education <16 y							
Deaths, *n*	148	156	195	203	279		
HR (95% CI)	1.00 (ref)	1.02 (0.82, 1.28)	1.13 (0.91, 1.41)	1.14 (0.92, 1.42)	1.33 (1.08, 1.64)	0.003	
Education ≥16 y							0.93
Deaths, *n*	135	153	133	131	139		
HR (95% CI)	1.00 (ref)	1.18 (0.94, 1.49)	1.18 (0.93, 1.51)	1.27 (0.99, 1.63)	1.43 (1.11, 1.84)	0.006	

[1] DASH, Dietary Approaches to Stop Hypertension; ref, reference.
[2] Derived from test for linear trend, modeling the median value for each quintile as a continuous variable.

scores or lower Western diet scores were older, leaner, more highly educated, more physically active, less sedentary, less likely to smoke, and consumed fewer calories each day (**Table 1**). Those with a high DASH score, a low prudent diet score, or a low Western score were less likely to drink alcohol.

In multivariable models, the DASH score, which assigns higher scores for high intake of vegetables, fruits, whole grains, nuts and legumes, and low-fat dairy and for low intake of red and processed meat, sugar-sweetened beverages, and sodium, was associated with lower all-cause mortality rates (HR: 0.75; 95% CI: 0.63, 0.89 for highest vs. lowest quintiles; *P*-trend < 0.001) (**Table 2**). The prudent dietary pattern, which is characterized by high intake of vegetables and fruits, was not associated with all-cause mortality. In contrast, the Western dietary pattern, characterized by high intake of red and processed meat and fried foods, was associated with increased all-cause mortality (HR: 1.37; 95% CI: 1.17, 1.60 for highest vs. lowest quintiles; *P*-trend < 0.001). Adjustment for baseline BMI did not materially affect the results; the corresponding HRs comparing extreme quintiles were 0.78 (95% CI: 0.65, 0.93) for the DASH score and 1.33 (95% CI: 1.13, 1.56) for the Western dietary pattern. In addition, results were closely similar when only the baseline assessment of diet was evaluated and when deaths occurring in the first 2 y of follow-up were excluded.

In an analysis of AHEI–2010 score in relation to all-cause mortality, there was no association: the multivariable HR for quintile 5 relative to quintile 1 was 0.96 (95% CI: 0.81, 1.13). The corresponding estimates for cardiovascular disease mortality, cancer mortality, and other mortality were 0.86 (95% CI: 0.61, 1.20), 1.11 (95% CI: 0.87, 1.40), and 0.81 (95% CI: 0.60, 1.10), respectively. AHEI–2010 is not considered further.

Associations of DASH and Western scores with all-cause mortality within strata of BMI, smoking, vigorous exercise, age, and education are shown in **Table 3**. The inverse association between DASH scores and all-cause mortality was apparent among the 70% of women who had a BMI <30 kg/m^2 at baseline (*P*-trend < 0.001) but not among obese women (*P*-trend = 0.71) (*P*-interaction = 0.04). Similarly, the Western dietary pattern was associated with mortality among non-obese women (*P*-trend < 0.001) but not among obese women (*P*-trend = 0.74) (*P*-interaction = 0.05). The associations between DASH and Western score and mortality were also apparent among ever smokers but not never smokers and among women who exercised vigorously <3 h/wk but not among more active women. The associations were consistent across age (<55 y and ≥55 y) and strata of education (<16 y and ≥16 y). Prudent pattern was not significantly associated with all-cause mortality in any of the strata considered (data not shown).

Results for each DASH component in relation to all-cause mortality are presented in **Table 4**. Mean values by quintile of each of the components of the DASH score are shown in Table 4. High intake of red and processed meat was associated with increased mortality rates (HR: 1.31; 95% CI: 1.08, 1.60 for highest vs. lowest quintiles; *P*-trend = 0.004), which explains the association observed for the Western dietary pattern (Table 2), given that red meat and processed meat were the foods with the highest factor loadings for this dietary pattern (15). High consumption of whole grains was associated with lower all-cause mortality rates (HR: 0.75; 95% CI: 0.64, 0.89 for highest vs. lowest quintiles; *P*-trend < 0.001). Vegetables and fruits, which were the foods with the highest factor loadings for the prudent dietary pattern, were not significantly associated with mortality risk. None of the other DASH components were significantly associated with all-cause mortality.

Analyses of cause-specific mortality were based on 428 cardiovascular disease deaths, 742 deaths from cancer, and 508 deaths from other causes. Results are given in **Supplemental Table 1** for DASH scores in relation to cardiovascular disease mortality, cancer mortality, and mortality from other causes. DASH scores were most strongly associated with lower mortality from causes other than cardiovascular disease and cancer (HR: 0.57; 95% CI: 0.40, 0.80 for highest vs. lowest quintiles; *P*-trend = 0.002). The most common other causes of death were chronic obstructive pulmonary disorder, diabetes, HIV-related conditions, and sarcoidosis. Higher DASH scores were also associated, but less strongly, with reduced cardiovascular disease mortality (HR: 0.79; 95% CI: 0.55, 1.11 for highest vs. lowest quintiles; *P*-trend = 0.08) and reduced cancer mortality (HR: 0.83; 95% CI: 0.64, 1.09 for highest vs. lowest quintiles; *P*-trend = 0.12). For the Western diet score, there were positive associations with each cause-specific mortality group: *P*-trend = 0.05 for cardiovascular disease mortality, 0.08 for cancer mortality, and 0.001 for other mortality (data not given). For both the DASH and Western diet scores, the associations with cause-specific mortality appeared to be more

TABLE 4 DASH components and risk of all-cause mortality in the Black Women's Health Study, 1995–2011[1]

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	*P*-trend[2]
Vegetables, serving/d	0.28	0.63	1.04	1.65	3.28	
Deaths/person-years	329/105,701	314/105,667	294/105,826	343/105,653	398/105,641	
Age-adjusted HR (95% CI)	1.00 (ref)	0.87 (0.74, 1.02)	0.77 (0.65, 0.91)	0.84 (0.71, 1.00)	0.95 (0.79, 1.15)	0.56
Multivariable HR (95% CI)	1.00 (ref)	0.90 (0.77, 1.06)	0.82 (0.70, 0.98)	0.91 (0.76, 1.08)	1.04 (0.86, 1.25)	0.17
Fruits, serving/d	0.22	0.66	1.17	1.82	3.43	
Deaths/person-years	326/105,640	301/105,782	301/105,759	353/105,660	397/105,647	
Age-adjusted HR (95% CI)	1.00 (ref)	0.90 (0.76, 1.05)	0.84 (0.71, 0.99)	0.89 (0.75, 1.05)	0.92 (0.78, 1.10)	0.76
Multivariable HR (95% CI)	1.00 (ref)	0.96 (0.82, 1.13)	0.92 (0.78, 1.08)	0.99 (0.84, 1.18)	1.06 (0.89, 1.27)	0.26
Whole grains, serving/d	0.01	0.11	0.32	0.62	1.44	
Deaths/person-years	377/108,101	334/106,662	257/91,614	359/116,192	351/105,919	
Age-adjusted HR (95% CI)	1.00 (ref)	0.92 (0.79, 1.07)	0.77 (0.66, 0.91)	0.79 (0.68, 0.93)	0.71 (0.60, 0.83)	<0.001
Multivariable HR (95% CI)	1.00 (ref)	0.96 (0.83, 1.12)	0.82 (0.70, 0.97)	0.85 (0.73, 0.99)	0.75 (0.64, 0.89)	<0.001
Nuts and legumes, serving/d	0.01	0.06	0.12	0.21	0.67	
Deaths/person-years	326/99,501	326/112,621	332/102,393	332/107,538	362/106,435	
Age-adjusted HR (95% CI)	1.00 (ref)	0.83 (0.71, 0.97)	0.90 (0.77, 1.05)	0.83 (0.70, 0.97)	0.85 (0.72, 1.00)	0.26
Multivariable HR (95% CI)	1.00 (ref)	0.84 (0.72, 0.99)	0.93 (0.79, 1.08)	0.87 (0.74, 1.02)	0.90 (0.76, 1.06)	0.64
Low-fat dairy, serving/d	0	0.03	0.10	0.36	1.43	
Deaths/person-years	607/171,697	298/95,257	245/82,188	261/93,433	267/85,913	
Age-adjusted HR (95% CI)	1.00 (ref)	0.92 (0.80, 1.06)	0.92 (0.79, 1.08)	0.81 (0.70, 0.94)	0.85 (0.72, 0.99)	0.07
Multivariable HR (95% CI)	1.00 (ref)	0.96 (0.83, 1.11)	0.98 (0.84, 1.14)	0.88 (0.76, 1.03)	0.92 (0.79, 1.08)	0.34
Red or processed meat, serving/d	1.70	0.79	0.47	0.24	0.05	
Deaths/person-years	259/105,501	306/106,002	335/105,685	372/105,344	406/105,956	
Age-adjusted HR (95% CI)	1.00 (ref)	1.11 (0.94, 1.31)	1.26 (1.06, 1.49)	1.45 (1.22, 1.72)	1.61 (1.32, 1.95)	<0.001
Multivariable HR (95% CI)	1.00 (ref)	1.06 (0.90, 1.26)	1.15 (0.97, 1.37)	1.29 (1.08, 1.54)	1.31 (1.08, 1.60)	0.004
SSBs,[3] serving/d	3.84	1.44	0.78	0.35	0.05	
Deaths/person-years	360/106,599	332/104,839	303/105,688	301/105,711	382/105,652	
Age-adjusted HR (95% CI)	1.00 (ref)	1.04 (0.89, 1.21)	1.01 (0.86, 1.18)	1.01 (0.86, 1.19)	1.27 (1.07, 1.51)	0.004
Multivariable HR (95% CI)	1.00 (ref)	1.03 (0.89, 1.20)	0.99 (0.85, 1.16)	0.97 (0.82, 1.14)	1.15 (0.97, 1.37)	0.10
Sodium, mg/d	3981	2662	2051	1558	1004	
Deaths/person-years	306/105,721	334/105,712	338/105,693	325/105,699	375/105,662	
Age-adjusted HR (95% CI)	1.00 (ref)	1.17 (0.96, 1.43)	1.16 (0.91, 1.49)	1.05 (0.78, 1.41)	1.09 (0.77, 1.54)	0.91
Multivariable HR (95% CI)	1.00 (ref)	1.18 (0.97, 1.44)	1.21 (0.94, 1.55)	1.12 (0.84, 1.51)	1.17 (0.83, 1.65)	0.64

[1] Age-adjusted HR adjusted for age, each DASH component, and total energy intake. Multivariable HR adjusted for age, each DASH component, total energy intake, education, marital status, vigorous exercise, television watching, smoking, and alcohol intake. DASH, Dietary Approaches to Stop Hypertension; ref, reference; SSB, sugar-sweetened beverage.

[2] Derived from test for linear trend, modeling the median value for each quintile as a continuous variable.

[3] 1 serving = 8 ounces.

evident among nonobese women, but the estimates were imprecise across subgroups, and there were no significant interactions by BMI (data not given).

Discussion

In the present study of African-American women, a DASH-style diet was associated with lower all-cause mortality, with a 25% reduction in risk for the highest relative to the lowest quintile. The individual components of the DASH score that were most strongly associated with reduced mortality were high consumption of whole grains and low intake of red and processed meat. A Western dietary pattern, derived by factor analysis and characterized by high intake of red and processed meat, was associated with increased mortality. In contrast, a prudent dietary pattern, characterized by high intake of vegetables and fruit, was not significantly associated with mortality risk, and the vegetable and fruit components of the DASH score were not associated with mortality. AHEI scores were not associated with mortality.

Adherence to a DASH-style diet is associated with reductions in blood pressure (27) and lower risk of cardiovascular disease (14), diabetes (28), colorectal cancer (29), and estrogen receptor–negative breast cancer (30). Higher DASH scores also were associated with lower all-cause mortality among adults with hypertension (31) and heart failure (32). To our knowledge, no previous studies have examined DASH scores and risk of overall mortality in a cohort of healthy adults.

Our findings are supported by those from 3 US cohorts in which red and processed meat were associated with increased all-cause mortality (33, 34). This association may operate in part because of dietary effects on chronic conditions including type 2 diabetes (35), cardiovascular disease (36), and several cancers (37). Also consistent with our results, whole grain intake was inversely associated with overall mortality (38, 39), incidence of type 2 diabetes (40), and incidence of cardiovascular disease (41). However, one study that found an inverse association between whole grain intake and all-cause mortality also reported that high fruit and vegetable intake was associated with lower mortality (39), which was not observed in the present study. Fruit and vegetable consumption also was associated with a lower risk of death in one of the largest studies to date, with stronger inverse associations observed for raw vegetables than for cooked vegetables (42). We lacked information in the current study on mode of preparation.

In our primary analyses, we did not adjust for BMI because the causal effect of diet on mortality is hypothesized to operate in part through effects on body weight. We found, however, that the inclusion of BMI as a covariate did not materially affect the results. The association between diet quality and mortality was apparent only among nonobese women. Similar to the present study, we previously found that higher DASH scores were associated with reduced risk of becoming obese only among women who were leaner at baseline (16). The lack of a positive association in the present study between diet quality and mortality among obese women may be due in part to the higher prevalence of comorbidities in this group of women and to the difficulty in discerning a small increase when the underlying risk of mortality is high, or it could be because of reduced statistical power in the smaller group of obese women. Evidence that weighs against the first explanation are the findings that diet quality was not associated with mortality among women at lower risk of dying because of higher levels of vigorous exercise or because of never smoking, whereas associations were clearly present among less active women and ever smokers. Consistent with the second explanation involving statistical power, the numbers of deaths among never smokers and active women were small.

The associations between diet quality and mortality were present across strata of age and education. Although BWHS participants on average have higher levels of education than does the general African-American population, they represent the 83% of women of the same ages nationally who have completed high school or a higher level of education (43). It is therefore plausible that our findings might be generalizable to most healthy African-American women.

Strengths of the present study include the large sample size and long duration of follow-up. Dietary intake was assessed at 2 time points, and cumulative mean scores were used in order to better reflect long-term diet quality. We also used updated data on important covariates such as physical activity, sedentariness, and smoking history. Study limitations include the use of FFQs to estimate dietary intake. Underreporting of dietary intake is more prevalent among obese adults (44, 45), which may have contributed to our inability to detect an association with mortality in this group of women. Because BMI was based on self-reported data on weight and height, there was imprecision in this measure.

In summary, we found that greater adherence to a DASH-style diet, particularly high intake of whole grains and low intake of red and processed meat, was inversely associated with all-cause mortality among African-American women who were free of cancer, cardiovascular disease, and diabetes at the beginning of follow-up. Our findings suggest that reducing red meat intake and increasing whole grain intake may lower mortality rates in healthy populations.

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DAB, JRP, and LR designed the research; DAB and YB analyzed the data; DAB wrote the manuscript; and all authors interpreted the results and critically reviewed the manuscript. All authors read and approved the final manuscript.

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