See corresponding CME exam on page 1363.

Associations of plant food, dairy product, and meat intakes with 15-y incidence of elevated blood pressure in young black and white adults: the Coronary Artery Risk Development in Young Adults (CARDIA) Study[1–3]

Lyn M Steffen, Candyce H Kroenke, Xinhua Yu, Mark A Pereira, Martha L Slattery, Linda Van Horn, Myron D Gross, and David R Jacobs Jr

ABSTRACT

Background: Consumption of plant foods and dairy and meat products may moderate increases in blood pressure.

Objective: The objective was to evaluate associations of dietary intake with the 15-y incidence of elevated blood pressure (EBP; ie, incident systolic BP ≥ 130 mm Hg, diastolic BP ≥ 85 mm Hg, or use of antihypertensive medication).

Design: Proportional hazards regression was used to evaluate relations of dietary intake at years 0 and 7 with the 15-y incidence of EBP in the Coronary Artery Risk Development in Young Adults (CARDIA) Study of 4304 participants aged 18–30 y at baseline.

Results: EBP incidence varied from 12% in white women to 33% in black men. Plant food intake (whole grains, refined grains, fruit, vegetables, nuts, or legumes) was inversely related to EBP after adjustment for age, sex, race, center, energy intake, cardiovascular disease risk factors, and other potential confounding factors. Compared with quintile 1, the relative hazards of EBP for quintiles 2–5 of plant food intake were 0.83 (95% CI: 0.68, 1.01), 0.83 (0.67, 1.02), 0.82 (0.65, 1.03), and 0.64 (0.53, 0.90), respectively; *P* for trend = 0.01. Dairy intake was not related to EBP (*P* for trend = 0.06), and positive dose-response relations for EBP were observed across increasing quintiles of meat intake (*P* for trend = 0.004). In subgroup analyses, risk of EBP was positively associated with red and processed meat intake, whereas it was inversely associated with intakes of whole grain, fruit, nuts, and milk. Adjustment for intermediary factors in the causal pathway attenuated these relations.

Conclusion: These findings are consistent with a beneficial effect of plant food intake and an adverse effect of meat intake on blood pressure. *Am J Clin Nutr* 2005;82:1169–77.

KEY WORDS Food groups, fruit and vegetables, whole grain, meat, blood pressure

INTRODUCTION

Hypertension is a common and major risk factor for stroke, coronary heart disease, and early mortality (1). Interest in reducing blood pressure grew in the 1970s after studies found that antihypertensive medications reduced the risk of subsequent heart attack and stroke (2). The National High Blood Pressure Education Program was subsequently developed to educate the public about the detection, evaluation, and management of high blood pressure (3, 4). Because 25% of US adults are hypertensive (5), continuing attention to prevention of this disease is needed.

Diet plays an important role in the modulation of blood pressure in hypertensive or normotensive adults (6–18). The DASH (Dietary Approaches to Stop Hypertension) feeding study found that a combination diet rich in fruit, vegetables, and low-fat dairy products and low in saturated fats could substantially lower systolic and diastolic blood pressure levels in 459 moderately hypertensive white and black men and women (6, 15). Numerous studies have shown that vegetarians have a lower blood pressure than do nonvegetarians (16) and that the addition of meat to a vegetarian diet increases blood pressure (17). However, most US adults are not vegetarians. In a recent study of men aged 41–57 y, consumption of 14–42 servings/mo of vegetables compared with <14 servings/mo was associated with a lower increase in blood pressure, whereas consumption of beef, veal, lamb, and poultry was positively related to blood pressure over 7 y of follow-up (18). Few studies have examined the dietary intake of young adults and their risk of developing elevated blood pressure (EBP), especially in young black adults. Therefore, we examined the associations of plant food (fruit, vegetables, whole and refined grains, nuts, and legumes), dairy product (milk, cheese, yogurt, and dairy desserts), and meat (red and processed meat, poultry, fish, and eggs) consumption with 15-y incidence of EBP in young black and white adults. We hypothesized that plant and dairy food intakes are inversely related to EBP, and meat consumption is positively related to EBP.

---

[1] From the Division of Epidemiology and Community Health (LMS, XY, MAP, and DRJ) and the Department of Laboratory Medicine and Pathology (MDG), University of Minnesota, Minneapolis, MN; the Channing Laboratory, Department of Medicine, Brigham & Women's Hospital and Harvard Medical School, Cambridge, MA (CHK); the University of Utah Medical School, Salt Lake City, UT (MLS); the Northwestern University Medical School, Chicago, IL (LVH); and the Department of Nutrition, University of Oslo, Oslo, Norway (DRJ).

[2] The CARDIA Study is supported by National Heart, Lung, and Blood Institute contracts N01-HC-48047, N01-HC-48048, N01-HC-48049, N01-HC-48050, and N01-HC-95095.

[3] Address reprint requests to LM Steffen, University of Minnesota, Division of Epidemiology, School of Public Health, 1300 South 2nd Street, Suite 300, Minneapolis, MN 55454. E-mail: steffen@epi.umn.edu.

Received March 2, 2005.
Accepted for publication June 22, 2005.

SUBJECTS AND METHODS

Subjects

The Coronary Artery Risk Development in Young Adults (CARDIA) Study is a multicenter, population-based, prospective study of cardiovascular disease risk factor evolution in black and white men and women. The 5115 participants were between the ages of 18 and 30 y at baseline (1985–1986). There have been 6 clinic exams at years 0, 2, 5, 7, 10, and 15, including a dietary assessment at years 0 and 7. Clinical centers are located in Birmingham, AL; Chicago, IL; Minneapolis, MN; and Oakland, CA. A detailed description of the CARDIA Study design and participants was previously reported (19, 20).

Those participants who reported extreme caloric intakes at years 0 or 7 (<800 and >8000 kcal/d for men and <600 and >6000 kcal/d for women; $n = 119$), women who were lactating or reported being pregnant at the year 0 exam ($n = 54$) or the year 7 exam ($n = 134$), participants with EBP (defined below; $n = 443$) or diabetes ($n = 34$) at baseline, and participants with a nonfasting blood sample ($n = 147$) were excluded. Blood pressure measurements taken during pregnancy were treated as missing ($n = 218$). After these overlapping exclusions were accounted for, the sample size was 4304 ($n = 883$ black men, 1249 black women, 989 white men, and 1183 white women). All participants provided written consent, and the study was approved by the institutional review boards of the participating field centers.

Clinical measurements

Before each CARDIA exam, the participants fasted for ≥8 h and were asked to avoid smoking and heavy physical activity for the final 2 h. Blood was drawn by venipuncture according to a standard protocol (19). Blood antioxidant concentrations were measured in the Molecular Epidemiology and Biomarker Laboratory (University of Minnesota, Minneapolis, MN). Plasma concentrations of ascorbic acid were measured with an HPLC-based method as described previously (21). Specimens were collected at year 10 in vials containing metaphosphoric acid and were frozen for ≤1 y at −70 °C. Concentrations of serum carotenoids were assayed in baseline and year 7 samples stored at −70 °C with an HPLC-based method (22–24).

Blood pressure was measured at each exam on the right arm with a Hawksley random zero sphygmomanometer (WA Baum Company, Copaigue, NY) with the participant seated and after a 5-min rest. Three measurements were taken at 1-min intervals. Systolic and diastolic blood pressures were recorded as phase I and phase V Korotkov sounds (25). The average of the second and third measurements was used in the analyses. EBP was defined as a systolic BP ≥ 130 mm Hg, a diastolic BP ≥ 85 mm Hg, or the use of antihypertensive medications (26).

Body weight was measured to the nearest 0.2 kg with a calibrated balance-beam scale. Height was measured with a vertical ruler to the nearest 0.5 cm. Body mass index (BMI) was computed as weight in kilograms divided by height in meters squared. Waist was measured with a tape in duplicate to the nearest 0.5 cm around the minimal abdominal girth.

CARDIA diet history

The CARDIA diet history was interviewer-administered and was previously described (27, 28). Reported foods were grouped as plant, dairy, and meat as well as by type of food, including fruit, vegetable, whole and refined grain, nuts, legumes, milk, yogurt, cheese, dairy dessert, red and processed meat, poultry, fish, and eggs. Intake of each food group was calculated as the sum of the number of times a food in each food group was eaten per day or per week. Other dietary measures from the CARDIA diet history used in the present analyses as potential confounders or mediators of our hypotheses included energy intake (kcal/d), alcohol intake (mL/d), dietary fiber (g/d), magnesium (mg/d), calcium (mg/d), sodium (mg/d), potassium (mg/d), saturated fat (g/d), and protein (g/d).

The analyses were conducted by using the average of year 0 and year 7 dietary data, because the cumulative average of dietary intake at ≥2 time points was found to be a more accurate measure of habitual diet than only one measure (29). Year 7 data were based on an updated and more extensive version of the food database. Specifically, whole-grain breakfast cereal was coded more completely at year 7. In addition, dietary fiber data were available only at year 7. Race- and sex-adjusted Spearman correlations between year 0 and year 7 intakes were $r = 0.39$ for fruit, $r = 0.36$ for whole grains, $r = 0.31$ for refined grains, $r = 0.43$ for vegetables, $r = 0.29$ for nuts, $r = 0.32$ for legumes, $r = 0.41$ for the combined group of plant foods, $r = 0.38$ for dairy foods, and $r = 0.40$ for the meat, poultry, and fish group. These correlation coefficients were similar across race and sex groups (data not shown).

Other measures

Standard questionnaires were used to maintain consistency in the assessment of demographic (age, sex, race, and education) and behavioral (physical activity and cigarette smoking) information across CARDIA examination visits. The CARDIA Physical Activity History questionnaire queries the amount of time per week spent in 13 categories of leisure, occupational, and household physical activities over the past 12 mo (30). Physical activity level is summarized as units of moderate intensity, high intensity, and total activity. Education is represented as years of schooling achieved by exam year 15 and represents complete schooling for most participants. Cigarette smoking status at year 0 was dichotomized as current smoker or nonsmoker.

Statistical analysis

PC-SAS software (version 8; SAS Institute, Cary, NC) was used for all statistical analyses (31). Fifteen-year incidence of EBP is defined as the first occurrence of EBP at years 2, 5, 7, 10, or 15. EBP incidence was evaluated by race and sex. The average food intake was computed within quintiles of each food group for plant foods and dairy and meat products by using linear regression, adjusted for sex, age, race, center, education, and energy intake.

Cox proportional hazards regression analysis was used to evaluate associations of the average of year 0 and 7 food group consumption with 15-y incidence of EBP. Hazard ratios were computed for quintiles 2–5 of the respective food groups with quintile 1 (lowest intake) as the referent group. A linear trend across quintiles was tested with contrast statements by using orthogonal polynomial coefficients. Given low intakes of nuts, legumes, and yogurt, these foods were categorized into tertiles. The relation of continuous plant, dairy, and meat intakes with blood pressure was also examined.

TABLE 1
Incidence of elevated blood pressure (BP) in participants in the Coronary Artery Risk Development in Young Adults (CARDIA) Study over 15 y of follow-up[1]

CARDIA participants	Systolic/diastolic BP[2]	High-normal BP[3]	Hypertension[4]	Elevated BP[5]
	mm Hg	*n* (%)	*n* (%)	*n* (%)
All (n = 4304)	111 ± 13/73 ± 11	406 (9.4)	591 (13.7)	997 (23.2)
Black men (n = 883)	116 ± 14/75 ± 12	127 (14.4)	162 (18.3)	289 (32.7)
White men (n = 989)	112 ± 11/74 ± 9	110 (11.1)	104 (10.5)	214 (21.6)
Black women (n = 1249)	113 ± 15/74 ± 12	114 (9.1)	240 (19.2)	354 (28.3)
White women (n = 1183)	105 ± 11/69 ± 9	55 (4.6)	85 (7.2)	140 (11.8)

[1] n = 4304.
[2] All values are $\bar{x}$ ± SD.
[3] Defined as a systolic BP ≥ 130 but < 140 mm Hg or a diastolic BP ≥ 85 but 90 mm Hg.
[4] Defined as a systolic BP ≥ 140 mm Hg, a diastolic BP ≥ 90 mm Hg, or the use of antihypertensive medication.
[5] Defined as a systolic BP ≥ 130 mm Hg, a diastolic BP ≥ 85 mm Hg, or the use of antihypertensive medication.

Three models were developed for each major food group. Model 1 was adjusted for energy intake and demographic factors, including age, race, sex, education, and center. Because food intake may be related to other behaviors, model 2 was adjusted for model 1 plus lifestyle factors, including physical activity, alcohol intake, baseline smoking, vitamin supplement use, and simultaneous adjustment of other food group intakes. To determine whether elevated blood pressure is related to food intake, independent of biologic mechanisms potentially on the causal pathway and selected nutrient composition of foods, model 3 was adjusted for model 2 plus potential explanatory factors, including nutrients (saturated fat, sodium, calcium, magnesium, potassium, and dietary fiber) and physiologic measures (baseline systolic blood pressure, fasting insulin, and BMI). As a measure of validity of the food groups, we regressed the year 10 plasma ascorbic acid concentration and the average of year 0 and year 7 serum β-carotene concentrations on quintiles of plant food intake. Blood antioxidant concentrations reflect several weeks of food intake and may be a more precise measure of intake of fruit and vegetables than is the dietary self-report (32). A food index was created to reflect intake of whole grain, fruit, vegetables, nuts, milk, and meat. An individual was assigned the sum of scores of 0–4 that corresponded to the quintile of intake for whole grain, fruit, vegetables, nuts, and dairy foods (quintile 1 = 0, quintile 2 = 1, quintile 3 = 2, quintile 4 = 3, and quintile 5 = 4), which was reversed for meat intake; for example, a person who was in quintile 1 for meat intake and in quintile 5 for each of whole grain, fruit, vegetable, nut, and dairy foods was assigned a score of 4 for each food group, which totaled 24.

RESULTS

Over 15 y, 23.2% (997/4304) of study participants experienced incident EBP, of whom 591 (13.7%) had hypertension and 406 (9.4%) had high-normal blood pressure. Race- and sex-specific incident EBP rates and average systolic and diastolic blood pressure levels at year 15 are shown in **Table 1**. Of those who developed EBP during 15 y of follow-up, 64% were black men and women. The average number of eating occasions was 9.4 times/d for plant foods, 2.4 times/d for dairy foods, and 2.2 times/d for meat, poultry, fish, and eggs (data not shown). After adjustment for race, sex, center, baseline age, education, and total energy intake, women and whites consumed more plant foods per day than did men and blacks, and older individuals and those with more education consumed more plant foods per day than did those who were younger and had less education (**Table 2**). Furthermore, those who consumed more plant foods were also engaged in a pattern of "healthy" behaviors: they drank less alcohol; exercised more; were less likely to smoke and more likely to take a vitamin supplement; consumed fewer calories as saturated fat and less sodium (not including added table salt); had a lower BMI, waist circumference, and systolic blood pressure; and had higher concentrations of serum β-carotene and plasma ascorbic acid.

Spearman's correlation coefficients of serum β-carotene and plasma ascorbic acid with plant food intake were significantly associated in blacks and whites but were higher in whites than in blacks (data not shown). The means of year 0 and 7 serum β-carotene concentrations were 15.0 μg/dL in blacks and 24.23 μg/dL in whites in quintile 5 of the plant food group compared with lower concentrations in quintile 1: 13.0 μg/dL in blacks and 13.8 μg/dL in whites. Mean concentrations of plasma ascorbic acid were 8.0 mg/L in blacks and 10.0 mg/L in whites in quintile 5 of the plant food group compared with lower concentrations in quintile 1: 7.4 mg/L in blacks and 7.7 mg/L in whites.

Mean food index scores were 9.4 for black men, 13.0 for white men, 10.6 for black women, and 14.7 for white women. All pairwise differences were significantly different from each other ($P < 0.001$), after adjustment for age, center, and energy intake.

Consumption of plant foods was inversely associated with EBP after 15 y of follow-up in model 2 (**Table 3**). With additional adjustment for potentially explanatory lifestyle factors (baseline physical activity, smoking and nutrient intake) in model 2, the association of dairy foods with EBP was attenuated (P for trend = 0.06). Consumption of meat was positively related with the risk of developing EBP, even after adjustment for possible explanatory factors (P for linear trend < 0.001). Results for plant food were consistent across race-sex groups, even though blacks, particularly black men, were disproportionately afflicted with EBP (data not shown). A higher proportion of black men and women were in the highest quintile of meat intake and the lowest quintile of plant food intake (data not shown).

Concerning specific plant subgroups, whole grain, fruit, and nuts were inversely associated with EBP (P for trend ≤ 0.05), whereas no association was observed with refined grain, vegetables, or legumes (**Table 4**). In the analyses of dairy product subgroups, we found an inverse association of milk consumption

TABLE 2

Means, SEMs, and percentages by quintile (Q) of plant (fruit, vegetables, and grains) food intake in the Coronary Artery Risk Development in Young Adults (CARDIA) Study[1]

	Total plant food intake (times/d)						
	Q1, <6.2 (n = 860)	Q2, 6.2–8.0 (n = 861)	Q3, 8.0–9.7 (n = 861)	Q4, 9.7–12.1 (n = 861)	Q5, >12.1 (n = 861)	SEM[2]	P for trend[3]
Selected characteristics[4]							
Age, year 0 (y)[5]	24.0	24.7	24.7	25.1	25.4	0.1	< 0.001
Sex (% female)[5]	44	52	52	63	72	2	< 0.001
Race (% black)[5]	69	56	45	41	37	2	< 0.001
Education > HS, year 15 (%)[5]	54	65	72	76	84	2	< 0.001
Alcohol (mL/d)	15.9	12.6	12.1	9.6	6.2	0.6	< 0.001
Physical activity (exercise units)	356	382	405	448	484	9	< 0.001
Smoking, year 0 (% smokers)	38	33	29	27	24	2	< 0.001
Vitamin supplement use (%)	20	25	31	34	40	2	< 0.001
Daily dietary intake[4]							
Total energy (kcal)	1901	2436	2760	3215	3887	29	< 0.001
Total fat (g)	123	120	118	116	113	0.6	< 0.001
Saturated fat (g)	46	45	44	42	40	0.3	< 0.001
Carbohydrate (g)	309	323	329	342	362	1.7	< 0.001
Protein (g)	100	102	102	103	103	0.6	0.006
Dietary fiber, year 7 (g)	18	20	22	25	30	0.5	< 0.001
Sodium (mg)[6]	6095	5917	5505	5243	4512	122	< 0.001
Calcium (mg)	1148	1171	1178	1189	1220	14	0.005
Magnesium (mg)	347	363	377	398	433	3	< 0.001
Potassium (mg)	3187	3412	3577	3891	4332	26	< 0.001
Vitamin C (mg)	112	146	162	202	248	3	< 0.001
β-Carotene (IU)	2432	3402	4250	5455	7891	154	< 0.001
Clinical and physical characteristics[4]							
BMI (kg/m^2)	26.1	25.3	25.1	25.0	24.4	0.2	< 0.001
Waist circumference (cm)	82	80	80	79	77	0.4	< 0.001
Systolic blood pressure (mm Hg)	109	108	108	108	107	0.3	0.01
Diastolic blood pressure (mm Hg)	68	68	68	68	67	0.3	0.06
Fasting blood concentration[4,7]							
β-Carotene (μg/dL)	11.6	14.9	16.3	17.7	22.7	0.5	< 0.001
Ascorbic acid, year 10 (mg/L)	7.4	8.1	8.5	8.7	9.4	0.1	< 0.001
Insulin (μU/mL)	13.7	13.0	12.4	11.8	11.1	0.3	< 0.001
Glucose (mg/dL)	84.7	85.2	85.0	84.2	84.8	0.4	0.59
HDL cholesterol (mg/dL)	53.1	52.1	52.7	53.0	53.3	0.5	0.58
Triacylglycerol (mg/dL)	79.3	80.6	77.8	77.6	72.6	2.1	0.05

[1] n = 4304. HS, high school.
[2] Similar for each cell, given the similar sample size in each category.
[3] Tested with contrast statements by using orthogonal polynomial coefficients.
[4] Except where noted, all variables are the average of year 0 and year 7 measurements and are adjusted for baseline age, sex, race, center, education, and total energy intake.
[5] Baseline age, sex, race, and education are each adjusted by linear regression for center and the other 3 variables.
[6] Does not include salt added in cooking or at the table.
[7] Plasma was used for all blood variables, except serum ascorbic acid.

(P for trend = 0.03) and dairy desserts (P for trend = 0.01), but no association of cheese (P for trend = 0.57) or yogurt (P for trend = 0.14) with EBP. There was no association between poultry (P for trend = 0.19) or fish (P for trend = 0.21) and EBP. However, consumption of red and processed meat was positively associated with EBP (P for trend = 0.006), whereas egg intake (P for trend = 0.05) was inversely associated with EBP. Further adjustment of these foods for BMI attenuated these relations slightly (data not shown).

In the food index analysis, we observed an inverse dose-response relation across increasing quintiles of the food index with risk of developing EBP after adjustment for baseline age, race, sex, education, center, energy intake, physical activity, alcohol intake, baseline smoking, saturated fat intake, sodium intake, and vitamin supplementation. Compared with quintile 1, the hazard ratios (95% CI) across quintiles 2-5 were 0.99 (0.82, 1.20), 0.91 (0.75, 1.11), 0.85 (0.68, 1.06), and 0.59 (0.45, 0.76); P for trend < 0.001.

In linear regression analyses (data not shown), the number of eating occasions of plant foods was inversely associated with systolic and diastolic blood pressure ($P \leq 0.05$), whereas meat intake was positively associated with diastolic blood pressure ($P < 0.05$). Dairy intake was not significantly associated with blood pressure. The food index score was significantly and inversely associated with systolic and diastolic blood pressure ($P < 0.05$).

TABLE 3
Hazard ratios (HRs) for 15-y elevated blood pressure incidence according to quintile (Q) of food group intake in the Coronary Artery Risk Development in Young Adults (CARDIA) Study[1]

	Food group intake					
	Q1	Q2	Q3	Q4	Q5	*P* for trend[2]
All plant foods, including fruit, vegetables, nuts, legumes, and whole- and refined-grain products						
Intake (times/d)	< 6.2	6.2–8.0	8.0–9.7	9.7–12.1	> 12.1	
No. of cases	244	201	192	192	168	
HR model 1 (95% CI)[3]	1.00	0.84 (0.69, 1.02)	0.82 (0.67, 1.01)	0.80 (0.64, 0.99)	0.64 (0.50, 0.83)	0.002
HR model 2 (95% CI)[4]	1.00	0.83 (0.68, 1.01)	0.83 (0.67, 1.02)	0.82 (0.65, 1.03)	0.69 (0.53, 0.90)	0.01
HR model 3 (95% CI)[5]	1.00	0.87 (0.70, 1.09)	0.84 (0.66, 1.07)	0.84 (0.64, 1.10)	0.77 (0.55, 1.07)	0.14
Dairy foods, including milk, cheese, yogurt, and dairy desserts						
Intake (times/d)	< 1.1	1.1–1.7	1.7–2.4	2.4–3.4	> 3.4	
No. of cases	259	227	181	170	160	
HR model 1 (95% CI)[3]	1.00	0.95 (0.79, 1.14)	0.79 (0.64, 0.96)	0.75 (0.61, 0.93)	0.78 (0.62, 0.99)	0.008
HR model 2 (95% CI)[4]	1.00	0.97 (0.80, 1.16)	0.81 (0.66, 0.99)	0.80 (0.64, 0.99)	0.85 (0.67, 1.08)	0.06
HR model 3 (95% CI)[5]	1.00	1.02 (0.83, 1.25)	0.82 (0.65, 1.04)	0.85 (0.66, 1.11)	0.82 (0.59, 1.14)	0.14
Meat, poultry, eggs, fish, and seafood						
Intake (times/d)	< 1.3	1.3–1.8	1.8–2.3	2.3–3.0	> 3.0	
No. of cases	130	186	201	228	252	
HR model 1 (95% CI)[3]	1.00	1.30 (1.03, 1.62)	1.32 (1.06, 1.66)	1.44 (1.14, 1.81)	1.49 (1.13, 1.95)	0.005
HR model 2 (95% CI)[4]	1.00	1.27 (1.01, 1.60)	1.31 (1.04, 1.64)	1.46 (1.14, 1.85)	1.50 (1.14, 1.98)	0.004
HR model 3 (95% CI)[5]	1.00	1.29 (0.97, 1.61)	1.26 (0.98, 1.63)	1.35 (1.03, 1.77)	1.67 (1.21, 2.30)	0.003

[1] $n = 4304$. Elevated blood pressure was defined as a systolic blood pressure ≥ 130 mm Hg, a diastolic blood pressure ≥ 85 mm Hg, or the use of antihypertensive medication. All independent variables are based on information from years 0 and 7, except where noted.
[2] Linear trend across quintiles was tested with contrast statements by using orthogonal polynomial coefficients.
[3] Adjusted for baseline age, sex, race, education, center, and energy intake.
[4] Adjusted as for model 1 and for physical activity, alcohol intake, baseline smoking, vitamin supplement use, and simultaneous adjustment of all food groups.
[5] Adjusted as for model 2 and for potentially explanatory nutrients (sodium, saturated fat, calcium, magnesium, potassium, and dietary fiber) and physiological measurements (baseline systolic blood pressure, BMI, and fasting insulin).

DISCUSSION

Consumption of plant foods—especially whole grains, fruit, and nuts—was inversely associated and consumption of red and processed meat was positively associated with 15-y cumulative incidence of EBP in black and white men and women. Consumption of milk and dairy desserts were inversely related to EBP. These study findings are supported by an inverse dose-response relation between risk of developing EBP and the food index score (a larger score represents greater plant and dairy intake and lower meat intake). Plant foods and milk may confer beneficial effects on blood pressure control through their rich array of nutrients and constituents (eg, fiber, magnesium, potassium, calcium, and other food components) and on satiety, body mass, and insulin sensitivity. Compared with plant-based foods, red and processed meat may contain higher amounts of saturated fat, sodium, nitrates, or other food compounds that are detrimental to blood pressure. These associations in young black and white men and women are biologically plausible, graded, and independent.

Few studies have examined food consumption patterns in relation to blood pressure. In the current study, the relation between plant foods and EBP was significant after adjustment for demographic and lifestyle factors potentially associated with food intake behaviors in model 2, the principal model used to evaluate our hypothesis. In additional analyses to explore mechanisms underlying the relation between dietary intake and blood pressure, we further adjusted for selected nutrients and physiologic factors known to be associated with blood pressure in model 3. Simultaneous adjustment for these potential factors in the causal pathway attenuated the relation of EBP with plant food intake, thereby fully suggesting that plant food intake influenced blood pressure by its action on these nutrient and physiologic factors. Vegetarian diets or diets rich in plant foods have been linked to lower blood pressures and have been shown to reduce blood pressure in both normotensive and moderately hypertensive adults (9, 10, 16, 33–39). Consistent with the findings of our study, the DASH diet demonstrated the clinical efficacy of plant and dairy food intakes for blood pressure control in 459 moderately hypertensive and normotensive men and women (6). The benefits of the DASH diet may be derived from the entire diet, which is low in red meat but rich in fiber and minerals from whole-grain foods, fruit and vegetables, nuts, dairy products, fish, and other unknown food components.

Whole grains have been consistently associated with lower blood pressure. The Nurses' Health Study reported that white bread was positively associated and dark bread and grain fiber were inversely associated with blood pressure (8). Whole grain intake may moderate blood pressure through improved insulin sensitivity (35, 40, 41) and endothelial function (42). These beneficial effects of whole grain intake are consistent with many studies that have shown an inverse associations between cereal fiber intake or whole grain intake and risk of coronary heart disease (43–48).

TABLE 4
Hazard ratios (HRs) for incident elevated blood pressure by quintile (Q) of intake of food subgroups in the Coronary Artery Risk Development in Young Adults Study (CARDIA)[1]

	Food subgroup intake					
	Q1	Q2	Q3	Q4	Q5	*P* for trend[2]
Plant food subgroup						
Whole grains						
Intake (times/d)	< 0.4	0.4–0.7	0.7–1.2	1.2–1.9	> 1.9	
No. of cases	247	233	189	162	166	
Hazard ratio (95% CI)	1.00	1.00 (0.83, 1.20)	0.89 (0.73, 1.08)	0.82 (0.66, 1.02)	0.83 (0.67, 1.03)	0.03
Refined grains						
Intake (times/d)	< 1.8	1.8–2.4	2.4–3.1	3.1–4.3	> 4.3	
No. of cases	197	169	197	223	211	
Hazard ratio (95% CI)	1.00	0.84 (0.68, 1.03)	0.96 (0.78, 1.18)	0.98 (0.79, 1.21)	0.87 (0.68, 1.12)	0.70
Fresh, dried, and canned fruit and fruit juice						
Intake (times/d)	< 0.2	0.2–0.5	0.5–0.9	0.9–1.5	> 1.5	
No. of cases	220	223	196	178	179	
Hazard ratio (95% CI)	1.00	0.88 (0.72, 1.06)	0.83 (0.68, 1.01)	0.85 (0.69, 1.04)	0.75 (0.60, 0.94)	0.02
Fresh, frozen, and canned vegetables						
Intake (times/d)	< 1.2	1.2–1.8	1.8–2.4	2.4–3.3	> 3.3	
No. of cases	254	198	201	156	188	
Hazard ratio (95% CI)	1.00	0.83 (0.68, 1.01)	0.94 (0.77, 1.15)	0.78 (0.62, 0.97)	0.94 (0.75, 1.19)	0.49
Legumes						
Intake (times/d)	< 0.1	0.1–0.2	> 0.2			
No. of cases	343	317	337			
Hazard ratio (95% CI)	1.00	0.93 (0.80, 1.09)	0.88 (0.75, 1.03)			0.11
Nuts						
Intake (times/d)	< 0.1	0.1–0.3	> 0.3			
No. of cases	376	322	299			
Hazard ratio (95% CI)	1.00	0.84 (0.73, 0.98)	0.85 (0.72, 0.99)			0.04
Dairy food subgroup						
Milk						
Intake (times/d)	< 0.3	0.3–0.7	0.7–1.2	1.2–2.1	> 2.1	
No. of cases	238	237	182	179	161	
Hazard ratio (95% CI)	1.00	1.04 (0.87, 1.25)	0.79 (0.65, 0.96)	0.81 (0.66, 0.99)	0.87 (0.70, 1.08)	0.03
Cheese						
Intake (times/d)	< 0.3	0.3–0.6	0.6–0.8	0.8–1.2	> 1.2	
No. of cases	253	204	181	172	187	
Hazard ratio (95% CI)	1.00	0.87 (0.72, 1.06)	0.87 (0.71, 1.06)	0.89 (0.73, 1.10)	1.07 (0.85, 1.33)	0.57
Yogurt						
Intake (times/wk)	< 0.1	0.1–0.5	> 0.5			
No. of cases	583	161	253			
Hazard ratio (95% CI)	1.00	1.00 (0.83, 1.20)	0.88 (0.75, 1.04)			0.14
Dairy desserts						
Intake (times/wk)	< 0.3	0.3–0.7	0.7–1.2	1.2–2.2	> 2.2	
No. of cases	233	189	206	189	180	
Hazard ratio (95% CI)	1.00	0.81 (0.67, 0.98)	0.87 (0.71, 1.05)	0.79 (0.65, 0.97)	0.74 (0.60, 0.92)	0.01
Meat subgroup						
Red and processed meat						
Intake (times/d)	< 0.6	0.6–1.0	1.0–1.3	1.3–1.9	> 1.9	
No. of cases	139	173	217	222	246	
Hazard ratio (95% CI)	1.00	1.01 (0.80, 1.26)	1.22 (0.98, 1.53)	1.28 (1.01, 1.62)	1.39 (1.05, 1.82)	0.006
Poultry						
Intake (times/d)	< 0.1	0.1–0.2	0.2–0.4	0.4–0.5	> 0.5	
No. of cases	185	173	192	218	229	
Hazard ratio (95% CI)	1.00	0.96 (0.78–1.18)	1.01 (0.82–1.24)	1.16 (0.94–1.42)	1.07 (0.87–1.31)	0.19
Fish and seafood						
Intake (times/wk)	< 0.6	0.6–1.0	1.0–1.6	1.6–2.5	> 2.5	
No. of cases	192	191	199	215	200	
Hazard ratio (95% CI)	1.00	0.99 (0.81–1.21)	1.08 (0.88–1.32)	1.09 (0.89–1.34)	1.11 (0.90–1.38)	0.21
Eggs						
Intake (times/wk)	< 0.7	0.7–1.3	1.3–2.1	2.1–3.2	> 3.2	
No. of cases	198	167	208	199	225	
Hazard ratio (95% CI)	1.00	0.86 (0.70–1.06)	0.89 (0.73–1.08)	0.83 (0.68–1.02)	0.79 (0.64–0.98)	0.05

[1] $n = 4304$. Elevated blood pressure was defined as a systolic blood pressure ≥ 130 mm Hg, a diastolic blood pressure ≥ 85 mm Hg, or the use of antihypertensive medication. The values were adjusted for baseline age, sex, race, center, energy intake, education, physical activity, alcohol intake, smoking, and vitamin supplement use. Several food groups had <5 categories; legumes, nuts, and yogurt were categorized into tertiles.

[2] Linear trend across quintiles was tested with contrast statements by using orthogonal polynomial coefficients.

Investigators have reported inverse associations of fruit, vegetable, fiber, and plant protein intakes with hypertension (7, 49, 50), stroke (51, 52), and blood pressure (37, 50). Systolic and diastolic blood pressure were significantly lower in participants randomly assigned to the intervention group than in the control group in the Oxford Fruit and Vegetable Study—a 6-mo controlled trial to test the effectiveness of lowering blood pressure by increasing fruit and vegetable intakes to 5 servings/d in adults (50). In our study, vegetable consumption was not related to EBP, but modest inverse associations of fruit and nut intakes with incidence of EBP were observed. Few studies have addressed associations of legumes or nuts with blood pressure, and those findings have been inconsistent (53–55). As in previous studies, limited consumption of legumes and insufficient statistical power precluded definitive conclusions from being drawn.

Associations of dairy and blood pressure have been inconsistent. Consistent with the current study, prospective observational data from the Nurses' Health Study showed no association with dairy intake (8); however, in subgroup analyses we found inverse associations of milk and dairy dessert intakes with EBP. Whole milk was inversely associated and skim milk was directly associated with systolic blood pressure in the Nine Communities Study (13), whereas intake of calcium from dairy products was inversely associated with blood pressure in the Tromso Study (56). It is plausible that the consumption of moderate amounts of dairy fat may have beneficial effects on blood pressure through a modulation of insulin secretion (57), although evidence is inconsistent (58). Alternatively, dietary calcium may suppress 1,25-dihydroxyvitamin D concentrations, thereby normalizing intracellular calcium (59).

Consistent with the results of other studies (8, 17, 18), our study results showed a significant and positive relation between meat intake and risk of developing EBP, even after adjustment for demographic factors (model 1), lifestyle factors and the other food groups (model 2), and selected nutrient intake and physiologic factors potentially on the causal pathway of developing EBP (model 3). Furthermore, the consumption of red and processed meat $\geq$1–2 times/d was associated with a 20–40% higher risk of developing EBP than was the consumption of red meat <0.6 times/d. Fish intake was not related to EBP in our study, although previous research has reported an inverse relation between fish intake and stroke (60). However, because of the limited consumption of fish, the fish subgroup included both fresh and processed fish in these analyses. It is important to note that the nutrient composition of processed fish may be similar to that of meat, ie, high in saturated fat. Poultry was unrelated to EBP in the current study; however, poultry was inversely associated with blood pressure in the Nurses' Health Study (8) and positively related to blood pressure in men enrolled in the Chicago Western Electric Study (18). Consumption of eggs $\geq$1–3 times/wk was associated with an 11–21% lower risk of developing EBP. The mechanism through which higher meat intake may lead to higher blood pressure is unclear, except that intake of meat replaces other foods, such as whole grains, fruit, and vegetables, through a "substitution effect." In the current study, individuals with food index scores in the highest quintile (a larger score represents a greater plant and dairy food intake and a lower meat intake) had a 40% lower risk of developing EBP than did those in the lowest quintile. Numerous studies have shown that vegetarians have lower blood pressure than nonvegetarians (16).

Limitations of the study include the relative homogeneity of the diet in some subgroups, a limited range of intake of specific foods or narrowly defined food groups, issues with misclassification in self-reported dietary intakes, documentation of frequency compared with quantity, and difficulty in categorizing recipes with multiple food groups and ingredients such as burritos and pizza. It is unclear whether null findings for individual foods, such as yogurt and legumes, were due to the lack of association or limited range in consumption of the specific food group (61). At the other extreme, plant food consumption was defined as the sum of frequencies of several different types of plant food groups. This strategy could mask the influence of some specific plant foods or a few plant foods on EBP. Moreover, it is not known how the measure of eating frequency used in this study reflected individual participants' ideas about serving size and eating occasion irrespective of serving size. Tests of the validity of the plant food group showed that average serum antioxidant concentrations were higher and more widely varied in whites than in blacks. Even after control for vitamin supplement use, correlations of serum β-carotene and plasma ascorbic acid with plant foods were significant in both blacks and whites, which suggests that plant food intake is related to blood antioxidant concentrations in both race groups. Finally, drawing conclusions from observational studies of diet is always difficult because of the potential for residual confounding. However, we adjusted for known confounding factors, including those variables that have been associated with hypertension in other CARDIA research (20). Furthermore, we simultaneously adjusted for several plant and animal food groups, which reduced the likelihood that the associations were due to other dietary components. Additional research to complement the findings of observational epidemiologic studies is needed to determine specific and synergistic hypotensive agents in plant foods.

In summary, we showed that plant food consumption is inversely associated with and that meat consumption is positively associated with the incidence of EBP. Our findings suggest that greater plant food intakes and lower meat intakes may prevent the development of EBP when consumed by free-living black and white men and women as part of a habitual diet.

LMS, CHK, and DRJ designed the study. LMS and XY analyzed the data. MDG performed the biochemical analysis of the antioxidants. LMS and CHK wrote the manuscript. LMS, CHK, XY, MAP, MLS, LVH, MDG, and DRJ interpreted the data, provided advice, and gave final approval for the manuscript. None of the authors had any conflicts of interest

REFERENCES

1. Stokes J III, Kannel WB, Wolf PA, Cupples LA, D'Agostino RB. The relative importance of selected risk factors for various manifestations of cardiovascular disease among men and women from 35 to 64 years old: 30 years of follow-up in the Framingham Study. Circulation 1987;75: V65–73.
2. Freis ED. Reminiscences of the Veterans Administration Trial of the Treatment of Hypertension. Hypertension 1990;16:472–75.
3. Roccella EJ, Horan MJ. The National High Blood Pressure Education Program: measuring progress and assessing its impact. Health Psychol 1988;(suppl):297–303.
4. The Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC VI). Arch Intern Med 1997;157:2413–46.
5. American Heart Association. Heart disease and stroke statistics—2004 update. Dallas, TX: American Heart Association, 2003.
6. Appel LJ, Moore TJ, Obarzanek E, et al, of the DASH Collaborative

Research Group. A clinical trial of the effects of dietary patterns on blood pressure. N Engl J Med 1997;336:1117–24.
7. Ascherio A, Rimm EB, Giovannucci EL, et al. A prospective study of nutritional factors and hypertension among US men. Circulation 1992; 86:1475–84.
8. Ascherio A, Hennekens C, Willett WC, et al. Prospective study of nutritional factors, blood pressure and hypertension among US women. Hypertension 1996;27:1065–72.
9. Beilin LJ, Rouse IL, Armstrong BK, Margetts BM, Vandongen R. Vegetarian diet and blood pressure levels: incidental or causal association? Am J Clin Nutr 1988;48:806–10.
10. Margetts BM, Beilin LJ, Vandongen R, Armstrong BK, Vandongen R. Vegetarian diet in mild hypertension: effects of fat and fiber. Am J Clin Nutr 1988;48:801–5.
11. Sciarrone SE, Strahan MT, Beilin LJ, Burke V, Robers P, Rouse IL. Biochemical and neurohormonal responses to the introduction of a lacto-ovovegetarian diet. J Hypertens 1993;11:849–60.
12. Singh RB, Rastogi SS, Singh NK, Ghosh S, Gupta S, Niaz MA. Can guava fruit intake decrease blood pressure and blood lipids? J Hum Hypertens 1993;7:33–8.
13. Trevisan M, Krogh V, Farinaro E, Panico S, Mancini M. Calcium-rich foods and blood pressure: findings from the Italian National Research Council Study (the Nine Communities Study). Am J Epidemiol 1988; 127:1155–63.
14. The Trials of Hypertension Prevention Collaborative Research Group. Effects of weight loss and sodium reduction intervention on blood pressure and hypertension incidence in overweight people with high-normal blood pressure: The Trials of Hypertension Prevention, phase II. Arch Intern Med 1997;157:657–67.
15. Svetkey LP, Simons-Morton D, Vollmer WM, et al. Effects of dietary patterns on blood pressure: subgroup analysis of the Dietary Approaches to Stop Hypertension (DASH) randomized clinical trial. Arch Intern Med 1999;159:285–93.
16. Fraser GE. Vegetarianism and obesity, hypertension, diabetes, and arthritis. In: Fraser, GE, ed. Diet, life expectancy, and chronic disease: studies of Seventh-day Adventists and other vegetarians. New York, NY: Oxford University Press, Inc, 2003.
17. Sacks FM, Donner A, Castelli WP, et al. Effect of ingestion of meat on plasma cholesterol in vegetarians. JAMA 1981;246:640–4.
18. Miura K, Greenland P, Stamler J, Liu K, Daviglus ML, Makagawa H. Relation of vegetable, fruit, and meat intake to 7-year blood pressure change in middle-aged men: the Chicago Western Electric Study. Am J Epidemiol 2004;159:572–80.
19. Friedman GD, Cutter GR, Donohue RP, et al. CARDIA: study design, recruitment, and some characteristics of the examined subjects. J Clin Epidemiol 1988;41:1105–16.
20. Dyer AR, Liu K, Walsh M, Kiefe C, Jacobs DR, Bild DE. Ten-year incidence of elevated blood pressure and its predictors: the CARDIA Study. J Hum Hypertens 1999;13:13–21.
21. Dharwal KR, Hartzell WO, Levine M. Ascorbic acid and dehydroascorbic acid measurements in human plasma and serum. Am J Clin Nutr 1991;54:1–5.
22. Bieri JG, Brown ED, Smith JC Jr. Determination of individual carotenoids in human plasma by high performance liquid chromatography. J Liquid Chromatogr 1985;8:473–84.
23. Craft NE, Brown ED, Smith Jr JC. Effects of storage and handling conditions of individual carotenoids, retinol, and tocopherol in plasma. Clin Chem 1988;34:4–48.
24. Gross MD, Prouty CB, Jacobs DR. Stability of carotenoids and tocopherol during blood collection and processing procedures. Clin Chem 1995;41:943–4.
25. Korotkov NS. A contribution to the problem of methods for the determination of the blood pressure. In: Ruskin A, ed. Classics in arterial hypertension. Springfield, IL: Charles C Thomas, 1956:127–33.
26. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). Bethesda, MD: NHLBI, 2001. (NIH publication no. 01-3670.)
27. McDonald A, Van Horn L, Slattery M, et al. The CARDIA dietary history: development, implementation, and evaluation. J Am Diet Assoc 1991;91:1103–12.
28. Liu K, Slattery M, Jacobs DR Jr, et al. A study of the reliability and comparative validity of the CARDIA dietary history. Ethn Dis 1994;4: 15–27.
29. Hu FB, Stampfer MJ, Rimm E, et al. Dietary fat and coronary heart disease: a comparison of approaches for adjusting for total energy intake and modeling repeated dietary measurements. Am J Epidemiol 1999; 149:531–40.
30. Jacobs DR Jr, Hahn LP, Haskell WL, et al. Reliability and validity of a short physical activity history: CARDIA and the Minnesota Heart Health Program. J Cardiopulm Rehabil 1989;9:448–59.
31. SAS Institute Inc. SAS/STAT user's guide, version 6. 4th ed. Vols 1 and 2. Cary, NC: SAS Institute Inc, 1989:1789.
32. Campbell DR, Gross MD, Martini MC, Grandits GA, Slavin JL, Potter JD. Plasma carotenoids as biomarkers of vegetable and fruit intake. Cancer Epidemiol 1994;3:493–500.
33. Pereira MA, Jacobs DR, Slattery ML, et al. The association of whole grain intake and fasting insulin in a biracial cohort of young adults: the CARDIA Study. CVD Prev 1998;1:231–42.
34. Ludwig DS, Pereira MA, Kroenke CH, et al. Dietary fiber, weight gain, and cardiovascular disease risk factors in young adults. JAMA 1999; 282:1539–46.
35. Fukagawa NK, Anderson JW, Hageman G, et al. High-carbohydrate, high-fiber diets increase peripheral insulin sensitivity in healthy young and old adults. Am J Clin Nutr 1990;52:524–8.
36. Holt SHA, Delargy HJ, Lawton CL, Blundell JE. The effects of high-carbohydrate vs high-fat breakfasts on feelings of fullness and alertness, and subsequent food intake. Int J Food Sci Nutr 1999;50:13–28.
37. Elliott P, Dennis B, Dyer AR, et al, for the INTERMAP Research Group. Relation of dietary protein (total, vegetable, animal) to blood pressure: INTERMAP epidemiologic study. J Hypertens 2000;18(suppl):S152.
38. Alexander H, Lockwood LP, Harris MA, Melby CL. Risk factors for cardiovascular disease and diabetes in two groups of Hispanic Americans with differing dietary habits. J Am Coll Nutr 1999;18:127–36.
39. Famodu AA, Osilesi O, Makinde YO, Osonuga OA. Blood pressure and blood lipid levels among vegetarian, semi-vegetarian, and non-vegetarian native Africans. Clin Biochem 1998;31:545–9.
40. McKeown NM, Meigs JB, Liu S, Wilson PW, Jacques P. Whole-grain intake is favorably associated with metabolic risk factors for type 2 diabetes and cardiovascular disease in the Framingham Offspring Study. Am J Clin Nutr 2002;76:390–8.
41. Steffen LM, Jacobs DR, Murtaugh MA, et al. Whole grain intake is associated with lower body mass and greater insulin sensitivity among adolescents. Am J Epidemiol 2003;158:243–50.
42. Cardillo C, Nambi SS, Kilcoyne CM, et al. Insulin stimulates both endothelin and nitric oxide activity in the human forearm. Circulation 1999;100:820–5.
43. Pietinen P, Rimm EB, Korhonen P, et al. Intake of dietary fiber and risk of coronary heart disease in a cohort of Finnish men. Circulation 1996; 94:2720–7.
44. Jacobs DR Jr, Meyer KA, Kushi LH, et al. Whole grain intake may reduce risk of coronary heart disease death in postmenopausal women: the Iowa Women's Health Study. Am J Clin Nutr 1998;68:248–57.
45. Jacobs DR Jr, Meyer KA, Kushi LH, Folsom AR. Is whole grain intake associated with reduced total and cause-specific death rates in older women? The Iowa Women's Health Study. Am J Public Health 1999; 89:322–9.
46. Liu S, Stamfer MJ, Hu FB, et al. Whole-grain consumption and risk of coronary heart disease: results from the Nurses' Health Study. Am J Clin Nutr 1999;50:421–9.
47. Wolk A, Manson JE, Stampfer MJ, et al. Long-term intake of dietary fiber and decreased risk of coronary heart disease among women. JAMA 1999;281:1998–2004.
48. Steffen LM, Jacobs DR, Stevens J, Shahar E, Carithers T, Folsom AR. Associations of whole grain, refined grain, and fruit and vegetable consumption with all-cause mortality, incident coronary heart disease and ischemic stroke: the ARIC Study. Am J Clin Nutr 2003;78:383–90.
49. Bietz R, Mensink GB, Fischer B. Blood pressure and vitamin C and fruit and vegetable intake. Ann Nutr Metab 2000;47:214–20.
50. John JH, Ziebland S, Yudkin P, Roe LS, Neil HA, Oxford Fruit and Vegetable Study Group. Effects of fruit and vegetable consumption on plasma antioxidant concentrations and blood pressure: a randomised controlled trial. Lancet 2002;359:1969–74.
51. Gillman MW, Cupples LA, Gagnon D, et al. Protective effect of fruits and vegetables on development of stroke in men. JAMA 1995;18:274: 1197–8.

52. Bazzano LA, He J, Ogden LG, Loria C, Vupputuri S, Myers L, Whelton PK. Dietary intake of folate and risk of stroke in US men and women: NHANES I Epidemiologic Follow-up Study. National Health and Nutrition Examination Survey. Stroke 2002;33:1183–8.
53. Fraser GE, Sabate J, Beeson WL, Strahan TM. A possible protective effect of nut consumption on risk of coronary heart disease. The Adventists Health Study. Arch Intern Med 1992;152:1416–24.
54. Hu FB, Stampfer MJ, Manson JE, et al. Frequent nut consumption and risk of coronary heart disease in women: prospective cohort study. BMJ 1998;317:1341–5.
55. Sabate J, Fraser GE, Burke K, Knutsen SF, Bennett H, Lindsted KD. Effects of walnuts on serum lipid levels and blood pressure in normal men. N Engl J Med 1993;328:603–7.
56. Jorde R, Bonaa KH. Calcium from dairy products, vitamin D intake, and blood pressure: the Tromso Study. Am J Clin Nutr 2000;71:1530–5.
57. Brown JM, McIntosh MK. Conjugated linoleic acid in humans: regulation of adiposity and insulin sensitivity. J Nutr 2003;133:3041–6.
58. Riserus U, Basu S, Jovinge S, Fredrikson GN, Arnlov J, Vessby B. Supplementation with conjugated linoleic acid causes isomer-dependent oxidative stress and elevated C-reactive protein: a potential link to fatty acid-induced insulin resistance. Circulation 2002;106:1925–9.
59. Zemel MB. Calcium modulation of hypertension and obesity: mechanisms and implications. J Am Coll Nutr 2001;20(suppl):428S–35S.
60. Gillum RF, Mussolino ME, Madans JH. The relationship between fish consumption and stroke incidence. The NHANES I Epidemiologic Follow-up Study (National Health and Nutrition Examination Survey). Arch Intern Med 1996;156:537–42.
61. Willett W. Nutritional epidemiology. 2nd ed. New York, NY: Oxford University Press, 1998.

The American Journal of Clinical Nutrition