Comparison of dietary intakes associated with metabolic syndrome risk factors in young adults: the Bogalusa Heart Study^{1–4}

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ABSTRACT

Background: Previous studies suggested that dietary intakes affect individual risk factors associated with metabolic syndrome.

Objective: The objective of this study was to examine dietary intakes in 1181 young adults aged 19–38 y (38.1% men; 25% African Americans and 75% whites) in relation to metabolic syndrome risk factors in the Bogalusa Heart Study.

Design: Participants were stratified into 3 groups according to the number of risk factors (0, 1–2, ≥3) associated with the metabolic syndrome according to the diagnostic criteria of the National Cholesterol Education Program, and dietary intakes were compared between the groups with a cross-sectional analysis.

Results: After adjustment for age, total energy intake, body mass index, and physical activity, mean (±SE) intakes of fruit, fruit juice, and vegetables were significantly higher in subjects who had no risk factors than in subjects who had 1–2 risk factors (3.30 ± 0.09 compared with 2.99 ± 0.07 servings/d; P < 0.05). The mean intake of sweetened beverages was lower in subjects who had no risk factors than in subjects who had 1–2 risk factors or ≥3 risk factors among whites (1.45 ± 0.08 compared with 1.77 ± 0.07 and 2.22 ± 0.15 serving/d, respectively, in men; 1.26 ± 0.06 compared with 1.62 ± 0.05 and 1.78 ± 0.13 servings/d, respectively, in women; P < 0.001) but not among African Americans.

Conclusion: Our results suggest that low fruit and vegetable consumption and high sweetened beverage consumption are independently associated with the prevalence of metabolic syndrome in specific sex-ethnicity populations. Am J Clin Nutr 2004;80:841–8.

KEY WORDS Metabolic syndrome, Bogalusa Heart Study, diet, alcohol, fruit and vegetables, sweetened beverages

INTRODUCTION

Insulin resistance, central obesity, dyslipidemia, and hypertension are risk factors for coronary heart disease among adults, and the clustering of these risk factors is referred to as metabolic syndrome, insulin resistance syndrome, or “syndrome X” (1). As many as 1 in 4 healthy Americans are at risk of developing metabolic syndrome (2), which was also observed in youth (3). Metabolic syndrome is related to increased mortality from coronary heart disease (4) and diabetes (5). Because the prevalence of obesity and overweight is increasing (6, 7), metabolic syndrome will continue to increase. The Third Report of the National Cholesterol Education Program Expert Panel (NCEP) on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III, ATP III) provided a working definition and drew the attention to metabolic syndrome (8).

Most components of metabolic syndrome are related separately to lifestyle factors such as weight control (9), diet (9–14), and physical activity (15–17). Most studies that examined diet and metabolic syndrome risk factors focused on nutrient-based, not food-based, analyses (18); assessed the relations with individual risk factors, not with risk factor clusters; and were conducted with middle-aged and older adults, not with biracial young adult populations. The Bogalusa Heart Study, a long-term epidemiologic study of cardiovascular risk factors from childhood to young adulthood (19), provided an opportunity to examine the relations between food group intakes and the number of metabolic syndrome risk factors in a biracial young adult population.

SUBJECTS AND METHODS

Study population

During 1995–1996, 1420 subjects (65% whites, 35% African Americans; 38% men, 62% women) aged 19–38 y (x̄: 29.6 y) were examined as part of the post–high school cohort study in Bogalusa, LA. Dietary data were collected from 1335 participants. Data from participants with missing values for laboratory data (n = 44) or participants in the nonfasting state on examination (n = 70) were excluded. Dietary information was judged...
unreliable and excluded from further analysis if reported energy
intakes were <600 kcal/d (n = 1) or >4000 kcal/d for women
(n = 23) and >4200 kcal/d for men (n = 16), which reduced the
final sample to 1181.

Measurements

A validated (20) youth and adolescent questionnaire was used
to assess food group consumption patterns of young adults. The
youth and adolescent questionnaire is a self-administered, semi-
quantitative food-frequency questionnaire that contains 131
foods with response categories for frequency of consumption in
terms of food items. Daily portion sizes were calculated for each
of the food items. The selected frequency choice for each food
was then converted to a daily intake; eg, “one serving per week”
was converted to 0.14 serving/d.

Food items were grouped into categories that included refined
grain foods; whole-grain foods; potatoes; fruit, fruit juice, and
vegetables (FJV); meat; seafood; high-fat dairy products; low-fat
dairy products; dishes with cheese; snack foods; sweetened bev-
erages; and diet beverages. Refined-grain foods included white
bread or toast, muffins, bagels, biscuits or rolls, rice, noodles,
pasta, pancakes, waffles, and tortillas. Whole-grain foods in-
cluded hot breakfast cereals (eg, oatmeal, grits), dark breads,
cornbread, and other grains (eg, bulgur, kasha, and couscous).
Potatoes included baked, boiled, and mashed potatoes, as well as
potato salad. FJV included raisins, grapes, bananas, cantaloupes,
melons, apples, pears, oranges, strawberries, peaches, plums,
and apricots; orange juice, apple juice, and other fruit juices;
tomatoes, broccoli, greens or kale, coleslaw, spinach, lettuce,
tossed salad, yams, carrots, beets other than greens, corn, green
or red peppers, eggplant, zucchini, summer squash, mixed veg-
etable, string beans, peas, lentils, and soybeans. Meat included
hamburgers, processed meats, liver, meat as a main dish, and
meat in a sandwich. Seafood included fresh fish as a main dish,
tuna, fish sticks, fish cakes, shrimp, lobster, and scallops. Low-
fat dairy products included skim or 1% milk, nonfat or low-fat
yogurt, and cheese. High-fat dairy products included whole or
2% milk, whipped cream, regular yogurt, cheese, cottage cheese,
cream cheese, pudding, frozen yogurt, ice cream, and milkshake
or frappe. Dishes with cheese included cheeseburgers, pizza,
tacos, lasagna, and macaroni and cheese. Snack foods included
potato chips, corn chips, nachos, popcorn, pretzels, and crackers.
Sweetened beverages included soda, punch, lemonade, noncar-
bonded fruit drink, and iced tea. Diet beverages included diet
soda, tea, and coffee.

Trained examiners collected all data by following standard-
dized protocols (19). The participants were asked about age, sex,
etnicity, smoking status (nonsmoker, current smoker, ex-
smoker), and education level. Physical activity was assessed by
self-report of physical activity outside of work on a scale from 1
(inactive) to 5 (very active) and average hours of watching tele-
vision (TV) per day. These measures of physical activity in the
Bogalusa Heart Study showed a significant inverse association
with multiple risk factors for metabolic syndrome (21).

Subjects were instructed to fast 12 h before venipuncture, and
compliance was assessed by interview on the morning of the
screening. The screening consisted of venipuncture followed by
replicate measurements of height, weight, and waist circumfer-
ence. Right arm systolic and diastolic (fifth Korotkoff phase)
blood pressures were measured with the participant relaxed and
sitting and were measured in triplicate by each of 2 randomly
assigned trained nurses. Means of replicate measures were used
in all analyses. Plasma glucose concentration was measured as
part of a multiple chemistry profile by a glucose oxidase method;
a commercial radioimmunoassay kit was used for measuring
plasma immunoreactive insulin concentration (Padebas Pharma-
cia, Piscataway, NJ). Triacylglycerol concentration was mea-
sured with the use of enzymatic procedures on the Abbott VP
instrument (Abbott Laboratories, North Chicago, IL). Serum
lipoprotein cholesterol concentration was analyzed by a combi-
nation of heparin-calcium precipitation and agar-agarose gel
electrophoresis procedures (22).

Statistical analysis

Diagnostic criteria for abnormal values for metabolic syn-
drome risk factors from the NCEP ATP III (8) included 1) ab-
dominal obesity (waist circumference ≥102 cm in men and ≥88
cm in women); 2) hypertriglyceridemia (≥150 mg/dL); 3) low
HDL cholesterol (<40 mg/dL in men and <50 mg/dL in wom-

en); 4) high blood pressure (≥130/85 mm Hg or taking medica-
tion); 5) high fasting glucose (≥110 mg/dL or taking medica-
tion). Participants were divided into 3 groups according to the
number of risk factors they had: no risk factors, 1–2 risk factors,
or ≥3 risk factors. For example, a male subject with waist cir-
cumference ≥102 cm but no other abnormal values was catego-
rized as having 1–2 risk factors. Metabolic syndrome was de-
finite as having ≥3 risk factors, and the prevalence of metabolic
syndrome was calculated with the use of this definition.

Linear regression models were used to investigate the effects
of sex, ethnicity, and their interactions on the continuous vari-
ables: age, watching TV, all metabolic syndrome risk variables,
and dietary intake variables. The effects of sex, ethnicity, and
their interactions were investigated with logistic regression mod-
el on the categorical variables (current smoking, self-perception
of activity outside of work, and overweight) and with propor-
tional odds model on the prevalence of metabolic syndrome.

Sex and ethnicity showed significant interactions for some risk
factor variables (waist circumference, HDL cholesterol, and glu-
cose) and dietary intakes (alcohol and sweetened beverages) in
the preliminary analysis. Thus, demographic characteristics and
metabolic syndrome risk factor variables were presented for each
sex and ethnicity subgroup. Arithmetic means and SDs of demo-
graphic characteristics and risk factor variables were presented.
The main effects of sex and ethnicity and the sex × ethnicity
interaction were presented.

Analysis of variance was used to test for differences in dietary
intakes across the 3 risk factor groups. Dietary intake variables
included total energy intake (in kcal), alcohol intake (in g), and
food group consumption (in servings/d). Analysis of covariance
was used to adjust for important covariates. Covariates included
as potential confounders were age, total energy intake, and body
mass index (BMI; in kg/m²). Because the level of physical ac-
"ivity was related to multiple metabolic syndrome risk factors,
the model was also adjusted for the effect of physical activity
outside of work. A hierarchical approach to model testing was
taken. The first model compared only dietary intakes with no
covariates across the 3 risk factor groups. The next model in-
cluded age, sex, and ethnicity group. Succeeding models added
one variable at a time: total energy intake, BMI, and physical
activity. Because no differences were detected between the
model that included all of the covariates and the model without
physical activity, these were reported as one model with all variables included.

Because the sex × ethnicity interaction was significant for consumption of alcohol and sweetened beverages, mean intakes of these food groups were compared across the 3 risk factor groups in the subgroup analysis. The first model compared only dietary intakes without the covariates, and the next model included age. Because no differences were detected between the model adjusted with age and the model that included age and total energy intake, these were reported as one model adjusted with only age. Because no differences were detected between the model that included all of the covariates and the model without physical activity, these were reported as one model with all variables included.

Significant differences found by analysis of variance and analysis of covariance were further assessed by post hoc multiple comparison tests with the use of Bonferroni’s correction. SPSS software (release 11.0.1; SPSS Inc, Chicago) was used for all statistical analyses.

RESULTS

Demographic characteristics of participants by sex and ethnicity are shown in Table 1. The main effect of sex was significant for age, self-perception as being active outside of work, watching TV, and overweight (men > women). The main effect of ethnicity was significant for age (whites > African Americans), watching TV, and overweight (whites < African Americans). The sex × ethnicity interaction was significant for current smoking, watching TV, and overweight status.

The means and SDs of the metabolic syndrome risk factors according to the NCEP ATP III criteria by sex and ethnicity are shown in Table 2. The main effect of sex was significant for waist circumference, triacylglycerols, fasting blood glucose,
cholesterol (men > women), and HDL cholesterol (men < women). The main effect of ethnicity was significant for waist circumference, HDL cholesterol, systolic blood pressure (whites < African Americans), and triacylglycerols (whites > African Americans). Sex × ethnicity interaction was significant for waist circumference, HDL cholesterol, and fasting blood glucose.

Metabolic syndrome, defined as a combination of any 3 or more risk factors according to the NCEP ATP III criteria, was evident in 12.0% of the young adult population. The prevalence of metabolic syndrome was higher among white men (15.5%) than among African American men (11.2%), white women (10.7%), or African American women (10.0%). The main effect of ethnicity and the sex × ethnicity interaction were significant for the proportion of participants who had 0, 1–2, or ≥3 metabolic syndrome risk factors (Table 2).

The means and SEs of various dietary intakes across the 3 metabolic syndrome risk factor groups are presented in model 1 (Table 3). Model 2 is adjusted for age, sex, and ethnicity; model 3 is further adjusted for total energy; BMI and level of physical activity were further adjusted in model 4.

No significant differences were seen in mean total daily energy intake across the 3 risk factor groups, even after adjustment for age, sex, ethnicity, BMI, and physical activity. Models 1, 2, and 3 also showed no difference in mean intake of low-fat dairy products. However, mean intake of low-fat dairy products was higher in subjects who had no risk factors than in subjects who had 1–2 risk factors (0.73 compared with 0.56 servings/d) after adjustment for age, sex, ethnicity, total energy, BMI, and physical activity.

No differences in mean intake of FJV across the 3 risk factor groups were found in model 1 or model 2. However, mean intakes of FJV were higher in subjects who had no risk factors than in subjects who had 1–2 risk factors in models 3 and 4 (3.29 compared with 3.01 servings/d in model 3; 3.30 compared with 2.99 servings/d in model 4). Mean intakes of diet beverages were significantly higher in subjects who had no risk factors than in subjects who had 1–2 risk factors after adjustment for all covariates (0.76 compared with 0.62 servings/d).

Because the sex × ethnicity interaction was significant for consumption of alcohol and sweetened beverages, mean intakes of these food groups were compared across the 3 risk factor groups in the subgroup analysis (Tables 4 and 5). Mean intake of alcohol was significantly higher in white men who had no risk factors (3.05 g/d) than in white men who had 1–2 risk factors (2.22 g/d) or ≥3 risk factors (1.80 g/d). These differences remained after adjustment for age and total energy intake but disappeared after further adjustment for BMI and physical activity. Mean intake of alcohol across the 3 risk factor groups for white women (2.10 compared with 1.61 and 1.17 g/d in analysis of variance) showed a similar pattern with that for white men. No significant difference in mean intake of alcohol between African American men and African American women was noted even after adjustment for covariates.

Only whites showed significant differences in the mean intakes of sweetened beverages across the 3 risk factor groups. Mean intake of sweetened beverages was significantly lower in white men who had no risk factors (1.60 servings/d) than in white men who had ≥3 risk factors (2.07 servings/d), even after adjustment for covariates (1.56 compared with 2.14 servings/d in model 2; 1.45 compared with 2.22 servings/d in model 3). Mean intake of sweetened beverages was significantly higher in white women who had no risk factors (1.30 servings/d) than in white women who had 1–2 risk factors or ≥3 risk factors (1.63 and 1.67 servings/d, respectively) even after adjustment for covariates (1.30 compared with 1.62 and 1.71 servings/d, respectively, in model 2; 1.26 compared with 1.62 and 1.78 servings/d, respectively, in model 3).

**DISCUSSION**

The present study examined the relations between various dietary intakes and multiple metabolic syndrome risk factors. Young adults who had no risk factors consumed more alcohol, low-fat dairy products, FJV, and diet beverages and less sweetened beverages than did subjects who had ≥1 risk factor associated with metabolic syndrome. Differences in dietary intakes across the risk factor groups were more evident in whites than in African Americans. Specifically, whites who had no risk factors consumed more alcohol and less sweetened beverages than did subjects who had ≥1 risk factor associated with metabolic syndrome.

A body of evidence shows that dietary intakes are different among ethnic groups (23–26). Ethnic differences in the expression of components in metabolic syndrome were also proposed (27). Less clear is whether the relation between various food groups and metabolic syndrome among African Americans might reflect that obesity is less strongly related to cardiovascular diseases among African Americans than among whites (28–30). Overweight adults have more insulin resistance, and they can be particularly susceptible to lifestyle effects (13). When the study population was divided into 2 groups by overweight status (overweight (BMI ≥ 25; n = 672) compared with normal weight (BMI < 25; n = 509)) and main models were rerun within overweight status groups, differences in consumption of alcohol, FJV, and sweetened beverages across the 3 risk factor groups were noted only in the overweight group in the present study (data not shown).

Findings from our study are in agreement with previous investigations on metabolic syndrome and its relation to intakes of alcohol (31–34), dairy products (13), and FJV (35, 36). Moderate alcohol consumption increased circulating concentrations of HDL cholesterol and appeared to reduce platelet aggregation, thereby providing an antithrombotic benefit similar to that of aspirin (37, 38). Alcohol was recognized as a major risk factor for the development of hypertension; however, a recent study showed that the incidence of hypertension increased with the elevation of baseline insulin concentrations and that alcohol modified and reduced this relation (39). The antiobesity effect of dairy product consumption through intracellular \( \text{Ca}^{2+} \) (40) and additional bioactive compounds (41) was suggested. Fruit and vegetables rich in dietary fiber can reduce the risk of developing diabetes by improving glucose control and peripheral insulin sensitivity (42). Moreover, minerals, antioxidants, and vitamins were shown to have favorable effects on impaired glucose tolerance (35) and cardiovascular diseases (36, 43). However, red meat or processed meat consumption, both associated with a higher risk of diabetes (44) and coronary heart disease (45) in previous studies, was not related to metabolic syndrome in this study (data not shown).

It is notable that differences in mean intakes of low-fat dairy products, FJV, and diet beverages became significant only after...
TABLE 3
Daily intakes of energy and of foods from various food groups according to number of metabolic syndrome risk factors among participants in the Bogalusa Heart Study.

<table>
<thead>
<tr>
<th></th>
<th>No risk factors (n = 468)</th>
<th>1–2 risk factors (n = 571)</th>
<th>≥3 risk factors (n = 142)</th>
<th>P</th>
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</thead>
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<tr>
<td><strong>Total energy (kcal)</strong></td>
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<tr>
<td>Model 1</td>
<td>2115.02 ± 31.25</td>
<td>2114.23 ± 28.25</td>
<td>2132.01 ± 59.41</td>
<td>0.96</td>
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<tr>
<td>Model 2</td>
<td>2101.28 ± 30.73</td>
<td>2125.41 ± 27.82</td>
<td>2132.36 ± 56.01</td>
<td>0.81</td>
</tr>
<tr>
<td>Model 3</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Model 4</td>
<td>2087.40 ± 34.37</td>
<td>2129.00 ± 28.87</td>
<td>2143.12 ± 67.57</td>
<td>0.64</td>
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<tr>
<td><strong>Low-fat dairy products (servings)</strong></td>
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<tr>
<td>Model 1</td>
<td>0.73 ± 0.05</td>
<td>0.76 ± 0.04</td>
<td>0.60 ± 0.08</td>
<td>0.24</td>
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<tr>
<td>Model 2</td>
<td>0.67 ± 0.05</td>
<td>0.68 ± 0.04</td>
<td>0.60 ± 0.08</td>
<td>0.19</td>
</tr>
<tr>
<td>Model 3</td>
<td>0.68 ± 0.04</td>
<td>0.68 ± 0.04</td>
<td>0.59 ± 0.08</td>
<td>0.14</td>
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<td>Model 4</td>
<td>0.73 ± 0.05</td>
<td>0.76 ± 0.04</td>
<td>0.52 ± 0.10</td>
<td>0.03</td>
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<td><strong>Refined grains (servings)</strong></td>
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<tr>
<td>Model 1</td>
<td>0.56 ± 0.04</td>
<td>0.83 ± 0.04</td>
<td>0.87 ± 0.08</td>
<td>0.55</td>
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<td>Model 2</td>
<td>0.79 ± 0.04</td>
<td>0.84 ± 0.04</td>
<td>0.88 ± 0.08</td>
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<td>Model 3</td>
<td>0.77 ± 0.04</td>
<td>0.84 ± 0.03</td>
<td>0.87 ± 0.07</td>
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<td>Model 4</td>
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<td>0.95 ± 0.08</td>
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<tr>
<td><strong>Whole grains (servings)</strong></td>
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<td>0.48 ± 0.03</td>
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<td>0.45 ± 0.05</td>
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<td>0.43 ± 0.06</td>
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<td>1.68 ± 0.05</td>
<td>1.59 ± 0.09</td>
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<td><strong>Fruit, fruit juice, and vegetables (servings)</strong></td>
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<td>3.26 ± 0.09</td>
<td>3.00 ± 0.16</td>
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<td>Model 2</td>
<td>3.27 ± 0.09</td>
<td>2.96 ± 0.16</td>
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<tr>
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<td>3.29 ± 0.08</td>
<td>3.01 ± 0.07</td>
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<td>Model 4</td>
<td>3.30 ± 0.09</td>
<td>2.89 ± 0.17</td>
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<tr>
<td><strong>Potatoes (servings)</strong></td>
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<td>0.32 ± 0.01</td>
<td>0.34 ± 0.02</td>
<td>0.41</td>
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<td><strong>Meat (servings)</strong></td>
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<td>0.76 ± 0.03</td>
<td>0.71</td>
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<td><strong>Seafood (servings)</strong></td>
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<td>0.30 ± 0.01</td>
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<td><strong>Dishes with cheese (servings)</strong></td>
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<tr>
<td>Model 1</td>
<td>0.48 ± 0.01</td>
<td>0.48 ± 0.02</td>
<td>0.99</td>
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<td>0.88</td>
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<tr>
<td><strong>Diet beverages (servings)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>0.68 ± 0.04</td>
<td>0.61 ± 0.03</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Model 2</td>
<td>0.70 ± 0.03</td>
<td>0.62 ± 0.03</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Model 3</td>
<td>0.70 ± 0.03</td>
<td>0.68 ± 0.06</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Model 4</td>
<td>0.76 ± 0.04</td>
<td>0.59 ± 0.07</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td><strong>Sweet snacks (servings)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>1.29 ± 0.05</td>
<td>1.32 ± 0.11</td>
<td>0.49</td>
<td></td>
</tr>
<tr>
<td>Model 2</td>
<td>1.28 ± 0.06</td>
<td>1.30 ± 0.11</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>Model 3</td>
<td>1.29 ± 0.05</td>
<td>1.28 ± 0.09</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>Model 4</td>
<td>1.27 ± 0.06</td>
<td>1.30 ± 0.11</td>
<td>0.14</td>
<td></td>
</tr>
</tbody>
</table>

1 All values are x ± SE. For total energy intake, the models were as follows: model 1, ANOVA; model 2, adjustment for age, sex, and ethnicity; model 3, not applicable (NA) for total energy intake; model 4, adjustment for age, sex, ethnicity, BMI, and physical activity. For intakes of foods from various food groups, the models were as follows: model 1, ANOVA; model 2, adjustment for age, sex, and ethnicity; model 3, adjustment for age, sex, ethnicity, and total energy intake; model 4, adjustment for age, sex, ethnicity, total energy intake, BMI, and physical activity. Values in the same row with different superscript letters are significantly different, P < 0.05 (Bonferroni correction for post hoc multiple comparisons).
TABLE 4
Daily intakes of alcohol and sweetened beverages according to number of metabolic syndrome risk factors in white and African American men who participated in the Bogalusa Heart Study

<table>
<thead>
<tr>
<th></th>
<th>Whites</th>
<th>African Americans</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>No risk factors</td>
<td>1–2 risk factors</td>
<td>≥3 risk factors</td>
<td>No risk factors</td>
</tr>
<tr>
<td>Alcohol (g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>3.05 ± 0.23a</td>
<td>2.22 ± 0.19b</td>
<td>1.80 ± 0.28b</td>
<td>&lt;0.01</td>
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<tr>
<td>Model 2</td>
<td>3.05 ± 0.21a</td>
<td>2.22 ± 0.20b</td>
<td>1.80 ± 0.34b</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Model 3</td>
<td>2.95 ± 0.24</td>
<td>2.24 ± 0.20</td>
<td>2.10 ± 0.42</td>
<td>0.07</td>
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<tr>
<td>Sweetened beverages (servings)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>1.60 ± 0.08a</td>
<td>1.74 ± 0.08b</td>
<td>2.07 ± 0.17b</td>
<td>0.02</td>
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<tr>
<td>Model 2</td>
<td>1.56 ± 0.09a</td>
<td>1.75 ± 0.08b</td>
<td>2.14 ± 0.14b</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Model 3</td>
<td>1.45 ± 0.08a</td>
<td>1.77 ± 0.07b</td>
<td>2.22 ± 0.15b</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

All values are x ± SE. Because the sex × ethnicity interaction was significant for alcohol and sweetened beverage consumption, mean intakes of these food groups were compared across the 3 risk factor groups in the subgroup analysis. The models were as follows: model 1, ANOVA; model 2, adjustment for age; model 3, adjustment for age, total energy intake, BMI, and physical activity. Values in the same row with different superscript letters are significantly different, P < 0.05 (Bonferroni correction for post hoc multiple comparisons).

TABLE 5
Daily intakes of alcohol and sweetened beverages according to number of metabolic syndrome risk factors in white and African American women who participated in the Bogalusa Heart Study

<table>
<thead>
<tr>
<th></th>
<th>Whites</th>
<th>African Americans</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No risk factors</td>
<td>1–2 risk factors</td>
<td>≥3 risk factors</td>
<td>No risk factors</td>
</tr>
<tr>
<td>Alcohol (g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>2.10 ± 0.17a</td>
<td>1.61 ± 0.11b</td>
<td>1.17 ± 0.25b</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Model 2</td>
<td>2.10 ± 0.15a</td>
<td>1.61 ± 0.13b</td>
<td>1.20 ± 0.28b</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Model 3</td>
<td>2.06 ± 0.16</td>
<td>1.62 ± 0.13</td>
<td>1.45 ± 0.33</td>
<td>0.08</td>
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<tr>
<td>Sweetened beverages (servings)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>1.30 ± 0.06a</td>
<td>1.63 ± 0.06b</td>
<td>1.67 ± 0.12b</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Model 2</td>
<td>1.30 ± 0.06a</td>
<td>1.62 ± 0.06b</td>
<td>1.71 ± 0.12b</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Model 3</td>
<td>1.26 ± 0.06a</td>
<td>1.62 ± 0.05b</td>
<td>1.78 ± 0.13b</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

All values are x ± SE. Because the sex × ethnicity interaction was significant for alcohol and sweetened beverage consumption, mean intakes of these food groups were compared across the 3 risk factor groups in the subgroup analysis. The models were as follows: model 1, ANOVA; model 2, adjustment for age; model 3, adjustment for age, total energy intake, BMI, and physical activity. Values in the same row with different superscript letters are significantly different, P < 0.05 (Bonferroni correction for post hoc multiple comparisons).
This study used a cross-sectional design, from which we could not conclude that dietary intakes of certain foods causally contributed to the incidence of metabolic syndrome. Dietary information from a self-reported food-frequency questionnaire has substantial error, including error in the estimation of portion sizes among individuals and the total number of foods actually consumed (52). Another limitation of this food-frequency questionnaire was the inability to separate 100% fruit juice from fruit juice flavored with sugar. In addition, the possibility of underreporting in food consumption by participants who had more risk factors cannot be precluded. Underreporting of energy intake among overweight individuals has been systematically shown (53, 54). Although a biracial population is a strength of this study, food consumption in this population, different from nutrient consumption, could differ from that of other populations. For example, when comparing the dietary intakes of the Bogalusa sample with the 1995 Continuing Survey of Food Intakes by Individuals (CSFII) measured by 2-d dietary recall (55), this young adult population showed similar total energy intake and percentage energy from fat but consumed less alcohol, whole-grain foods, and vegetables and more sweetened beverages (56).

Despite these limitations, the present study suggests that low consumption of fruit and vegetables and high consumption of sweetened beverages are independently associated with the prevalence of metabolic syndrome in specific sex-ethnicity populations. Additional studies are needed to confirm these findings in different sex-ethnicity populations and to explore the association between food groups in the development of metabolic syndrome before any dietary recommendations for metabolic syndrome can be made.

The Bogalusa Heart Study is a joint effort of many investigators and staff members whose contributions are gratefully acknowledged. We especially thank children, young adults, parents, teachers, research staff members, nurses, and doctors of Bogalusa, without whom this work could not be accomplished. We especially thank Jeanette Gustat for her assistance in locating data files and interpreting the food-frequency questionnaire. GSB and SRS designed the study and are particularly responsible for the conduct of study. SY, TN, and TB developed the hypothesis for this analysis and prepared the manuscript. S-JY managed the database and undertook locating data files and interpreting the food-frequency questionnaire. Additional studies are needed to confirm these findings in different sex-ethnicity populations and to explore the association between food groups in the development of metabolic syndrome before any dietary recommendations for metabolic syndrome can be made.

REFERENCES