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## Dietary Patterns, Abdominal Visceral Adipose Tissue and Cardiometabolic Risk Factors in African Americans: the Jackson Heart Study

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### Abstract

Dietary behavior is an important lifestyle factor to impact an individual's risk of developing cardiovascular disease (CVD). However, the influence of specific dietary factors on CVD risk for African Americans remains unclear. We conducted a cross-sectional study of 1775 participants from Jackson Heart Study (JHS) Exam 2 (between 2006 and 2009) who were free of hypertension, diabetes and CVD at the baseline (between 2001 and 2004). Dietary intakes were documented using a validated food-frequency questionnaire (FFQ) and dietary patterns were generated by factor analysis. Three major dietary patterns were identified: a "southern", a "fast food" and a "prudent" pattern. After adjustment for age, sex, smoking and alcohol status, education level and physical activity, high "southern" pattern score was associated with an increased odds ratio (OR) for high abdominal visceral adipose tissue (VAT) (OR:1.80, 95% CI:1.1–3.0,  $p=0.02$ ), hypertension (OR:1.42, 95% CI:1.1–1.9,  $p=0.02$ ), diabetes (OR:2.03, 95% CI:1.1–3.9,  $p=0.03$ ) and metabolic syndrome (OR:2.16, 95% CI:1.3–3.6,  $p=0.004$ ). Similar associations were also observed in the "fast food" pattern ( $p$  ranges 0.03–0.0001). The "prudent" pattern was significantly

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#### Disclosure:

The authors declared no conflict of interest.

#### Author Contributions:

Dr. Liu had full access to all of the data in the study and takes responsibility for integrity of the data and accuracy of data analysis.

Study Concept and Design: Drs. Liu, Fox, Talegawkar, Tucker and Taylor.

Acquisition of data: Dr. Liu.

Analysis and Interpretation of data: Drs. Liu, Fox, Hickson, Talegawkar and Taylor.

Manuscript drafting: Drs. Liu, Fox and Taylor.

Critical revisions of the manuscript for important intellectual content: Drs. Fox, Taylor, Liu, Hickson, Musani, Talegawkar and Tucker.

Statistical analysis: Dr. Liu.

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associated, in a protective direction, with hypertension (OR 0.69, 95%CI 0.5–0.9,  $p=0.02$ ). In conclusion, dietary patterns, especially the “southern” pattern, identified from a regional specific FFQ in this Deep South African Americans, are correlated with abdominal VAT and cardiometabolic risk factors.

## Keywords

Jackson Heart Study; dietary patterns; cardiometabolic risk factors

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## Introduction

African Americans, compared to other ethnic groups, have been shown to have similar risk for cardiovascular disease (CVD) but greater cardiovascular mortality (1). Our recent studies demonstrated higher CVD risk in African Americans from the Jackson Heart Study (JHS), with higher prevalence of obesity, diabetes and hypertension than that in European Americans from the Framingham Heart Study (FHS) (2,3). Although the underlying explanations for ethnic disparities remains poorly understood, they may be associated with a greater clustering of risk factors in African Americans, including lower socioeconomic status (4,5), lower physical activity (6) and genetic factors (7). These variations may also implicate environmental factors and/or modifiable lifestyle habits as important determinants of CVD risk. Numerous studies have shown that dietary behavior is an important lifestyle factor impacting risk of developing CVD (8–10). However, the influence of specific dietary factors on CVD risk for African Americans remains unsolved, particularly because the dietary behaviors and patterns differ across geographical areas and ethnic groups (11). Furthermore, associations of diet with CVD risk have been rarely examined in population-based studies with an adequate sample size of African Americans. Thus, the objective of this report is to describe dietary patterns, derived from principal component analysis (PCA), and to determine whether these dietary patterns can impact cardiometabolic abnormalities in African Americans of the JHS cohort from the Deep South metropolitan area of Jackson, Mississippi.

## Methods

### Study Sample

The JHS recruited 5301 African Americans from the Jackson, MS metropolitan area between September 2000 and March 2004 and comprises 5301 participants between the ages of 21–94 years (12). The cohort composed of four components: 1) approximately 31% of the cohort members were participants from the Atherosclerosis Risk in Communities (ARIC) study recruited to the JHS; 2) 30% were representative community volunteers who met census-derived age, sex and socioeconomic status eligibility criteria from the Jackson, MS metropolitan area; 3) 17% were randomly ascertained from the Jackson, Mississippi; 4) 22% were in the JHS family study. The sampling frame for the family study was participants in any one of the ARIC, random or volunteer samples whose family size met eligibility requirements as detailed previously (12). For the present study, study sample consisted of JHS participants, who underwent extensive dietary assessment interviews and multi-detector computed tomography scan. The study excluded participants with the presence of CVD, hypertension or diabetes ( $n=3361$ ) and those without dietary assessments ( $n=165$ ). Thus, the final sample size for this analysis is 1775.

## Dietary Assessment and dietary Patterns

As part of the standard dietary data collection, usual dietary intake was assessed for all participants with a short food frequency questionnaire (FFQ) developed from a long questionnaire previously designed for the USDA Delta Nutrition Intervention Research Initiative (Delta-NIRI) (13). This Delta NIRI FFQ was specifically designed for a southern United States population to capture the regional eating patterns and the regional foods such as ham hocks, chitterling, grits, etc, with specified serving sizes that were described using natural portions or standard weight and volume measures of servings commonly consumed, based on 24 hour recall data in the Delta region. Due to limitations in time for the questionnaire, a shorter version of the Delta NIRI questionnaire was created for the JHS, reducing the number of food items from 283 to 158 by collapsing similar food items into categories (14). Average daily energy intakes of food items and total energy intake were calculated with software at Nutrition coordinating Center (University of Minnesota, Minneapolis, MN) and developed for the survey instrument (15). In order to minimize within-person variation in consumption of individual foods, the 158 food items were aggregated into 31 predefined food groups based on their energy contributions. Individual food items were preserved if they constituted distinct items on their own (i.e., chicken, corn products, butter, soup, coffee and tea) or if they were thought to represent particular dietary habits (Table 1).

For the reproducibility and validity of the short Delta NIRI JHS FFQ used for the entire cohort, a subset of participants (n=499) was selected from the whole JHS cohort (n=5301) for the Diet and Physical Activity sub-Study (DPASS) (15,16). Participants included for DPASS were matched on age, sex, socioeconomic status and physical activities (15). The original, long FFQ and 24-hour diet recalls were administered for participants during their initial clinic visit, followed by four 24-hour dietary recalls scheduled a month apart from a month after the initial clinic visit, and the quality control checks were performed on both the short and the long FFQ (16). For most nutrients analyzed, both short and the long FFQ are reasonably valid for assessment of dietary intake of adult African Americans in the South (16).

## Risk Factors and Covariate Assessment

Risk factors and covariates were measured at Exam 2 (2005 – 2008) (17). Body mass index (BMI) was defined as weight (in kilograms) divided by the square of height (in meters). Two measures of waist circumference (WC) (at the level of the umbilicus, in the upright position) were averaged to determine WC for each participant. Fasting blood samples were collected according to standardized procedures and the assessment of plasma glucose and lipids were processed at the Central Laboratory (University of Minnesota) as previously described. Sitting blood pressure was measured twice at 5-minutes intervals and the average of two measurements was used for analysis.

Participants were considered to have hypertension if they were taking antihypertensive medications and/or if their systolic pressure was  $\geq 140$  mm Hg or diastolic pressure  $\geq 90$  mm Hg. Impaired fasting glucose was defined as fasting plasma glucose of 100–125 mg/dl among those not treated for diabetes. Diabetes was defined as a fasting plasma glucose level  $\geq 126$  mg/dl or treatment with insulin or hypoglycemic agents. High triglycerides level were defined as fasting plasma triglyceride level  $\geq 150$  mg/dl and low HDL-C level was defined as fasting plasma HDL-C level  $< 40$  mg/dl in men and  $< 50$  in women. Participants were considered current smokers if they had smoked, used chewing tobacco or nicotine gum, or were wearing a nicotine patch at the time of interview. Daily alcohol consumption were assessed by the validated food frequency questionnaires and collected during the face-to-face encounters by trained interviewers (16). Physical activity was assessed using the JHS

Physical Activity Cohort survey (JPAC) (18). Obesity was defined by BMI of at least 30 kg/m<sup>2</sup> and modified National cholesterol Education Program Adult Treatment Panel III criteria were used to define the metabolic syndrome (19).

### **Multi-Detector CT Scan Protocol for Measuring Abdominal Adipose tissue (VAT) and Liver Fat**

Abdominal adipose tissues (VAT) was measured at Exam 2 (2005 – 2008) and the research CT protocol has been reported previously (17). Briefly, the CT images included scout images, one ECG gated series of the entire heart, and a series through the lower abdomen detected by computed tomography system equipped with cardiac gating (GE Healthcare Lightspeed 16 Pro, Milwaukee, Wisconsin). The abdominal muscular wall was first manually traced and 24 contiguous 2-mm thick imaging slices covering the lower abdomen from L3 to S1 were used to measure VAT by semiautomatic segmentation technique. The abdominal fat volumes were the sum of VAT voxels over 24 slices. Volume Analysis software (Advantage Windows, GE Healthcare, Waukesha, WI) was used to segment and characterize each individual voxel as a tissue attenuation of fat using a threshold range –190 to –30 Hounsfield units. Participants were excluded from the CT scan Exam if: 1) body weight was greater than 350 lbs (~160 kg); 2) pregnant or unknown pregnancy status; 3) female participant < 40 years of age; 4) Male participant < 35 years of age.

The CT diagnosis of fatty liver can be made by measuring CT attenuation in Hounsfield Units (HU), which have been shown to be inversely correlated with the fatty filtration of the liver seen on liver biopsy (20). A more recent study demonstrates that a simple measurement of liver attenuation on unenhanced CT scans is the best method of predicting pathologic fat content in the liver (21). Thus, measurement of liver attenuation in HU (LA) was performed in multi-detector CT scans of the abdomen at the level of the T<sub>12</sub> – L<sub>1</sub> intervertebral space and was used to estimate liver fat. The LA was determined by calculating the mean HU of three regions of interest (ROI) in the parenchyma of the right lobe of the liver (20). In this study, high VAT or high liver fat were defined by 90<sup>th</sup> percentile of VAT or 10<sup>th</sup> percentile of LA (low LA = high liver fat) generated from the healthy participants. These participants were free of abnormal conditions including CVD, diabetes, hypertension and dyslipidemia at the time when CT Exam were conducted.

The study protocol was approved by the institutional review board of the participating institutions: the University of Mississippi Medical Center, Jackson State University and Tugaloo College. All participants provided informed consent.

### **Statistical Analysis**

To identify major dietary patterns based on the 31 food groups, principal component analysis (PCA) was performed (22). Selected factors were rotated by an orthogonal transformation, which maintains uncorrelated factors and achieves a simple structure with greater interpretability. To determine the number of factors to be retained, the criteria of an eigenvalue > 1, the scree plot and interpretability of the factors were considered (22). The factor score for each pattern was constructed by summing observed energy intakes of the component food groups weighted by their factor loadings (23), and each participants received a factor score for each identified dietary pattern. The dietary patterns were interpreted and named based on high or low factor loadings of the food group relative to the population mean intake and to relative ranking of all food groups included in the PCA (Table 2).

LA and triglycerides were normalized by logarithmic transformation. Dietary factor scores were divided into tertiles. Descriptive statistics (means, SE and percentage) by tertiles of

each dietary pattern were calculated for demographic/lifestyle/nutrient intakes of study participants. The generalized linear or logistic regression models were constructed with cardiometabolic risk factors as the independent variable and measures of dietary pattern as the dependent variable. Odds ratios and 95% confidence intervals from logistic regression models were calculated to ascertain the associations of dietary patterns with cardiometabolic risk factors after adjustment for age, sex, smoking and alcohol status, education and physical activities. All computations were performed by SAS software version 9.2 (SAS Institute Inc., Cary, North Carolina).

## Results

### Study Sample Characteristics by Dietary Patterns

Three major dietary patterns were identified in this study: the “southern”, the “fast food” and the “prudent” dietary pattern (Table 1). The “Southern” dietary pattern was principally characterized by high consumption of traditional rural southern US foods, such as beans & legumes, corn products, fried fish & chicken, margarine & butter, rice & pasta, and low consumption of wine, liquor and salty snacks. The “Fast Food” pattern was characterized by high consumption of sugar & candy juice, fast food and salty snacks, and the “Prudent” pattern was characterized by high intakes of fruits & vegetables, cold & hot cereals, nuts & seeds and low intakes of white bread and sweets. Compared with participants with lower “southern” dietary pattern scores, those with higher scores had significantly higher intakes of total energy, fat, total cholesterol and protein, but lower intake of dietary fibers (*All p* < 0.0001 for trend) (Table 3). Participants with higher “southern” pattern scores had adverse risk factor profiles, including larger WC, more VAT, elevated diastolic blood pressure, lower HDL-C and greater likelihood of metabolic syndrome (*p range 0.007–0.0001 for trend*). Similar trends were observed for the “fast food” pattern, with the exception of VAT. However, no significance was found between “prudent” pattern scores and any cardiometabolic risk factor (Table 4).

### Multivariate-Adjusted Association of Dietary Patterns with Cardiometabolic Risk Factors

Odds ratio (OR) for associations of dietary patterns with cardiometabolic risk factors were computed in multivariable models (Table 5). After adjustment for age, sex, energy intake, smoking and alcohol status, education level and physical activity, higher “southern” pattern scores were significantly associated with increased OR for high VAT, hypertension, diabetes and metabolic syndrome (*p ranges 0.02–0.0005*). Similar significant associations were observed with higher “fast food” pattern scores for hypertension, diabetes, metabolic syndrome, and low HDL-C (*p ranges 0.03–0.0001*). However, no significant associations were found between the “prudent” pattern scores and most cardiometabolic risk factors; with the exception of hypertension and high liver fat, which was inversely associated with the “prudent” pattern (OR 0.75, 95% CI 0.6–0.9 in Tertile 2, *p=0.049* and OR 0.69, 95% CI 0.5–0.9 in Tertile 3, *p=0.02*).

## Discussion

### Principal Findings

Using the Delta NIRI JHS FFQ that was specifically designed for the southern United States population to capture the regional food behaviors and eating habits, three dietary patterns, the “southern”, the “fast food” and the “prudent”, were identified in this cohort of African American adults. Both the “southern” and “fast food” dietary patterns were correlated with abdominal VAT and most of cardiometabolic risk factors. In contrast, the “prudent” pattern was significantly associated, in a protective direction, with liver fat and hypertension.

## In the Context of the Current Literature

Identification of the “southern”, the “fast food” and the “prudent” patterns in this study sample is consistent with findings of our previous study (24) and others (8,10,11,15,25–27), and with anthropological and historical accounts of traditional African American eating habits in the southern United States (11). The “fast food” and the “prudent” patterns identified in our study are characterized by high-fat, high-cholesterol, high-refined carbohydrate foods or with high-fruits, high-vegetables and high-fibers foods, respectively. These two dietary patterns resemble the “western” and the “healthy” patterns observed in other studies (8,10,23,25,26,28). The “southern” pattern is less commonly reported but is highlighted as a major recognizable dietary pattern in our study sample. Using the Delta NRI JHS FFQ that was specifically designed for the southern United States populations to capture the regional eating habits and the regional foods, this pattern may reflect the southern roots and African American ancestral experiences of living in the South (11). Moreover, the observed associations between the “southern” dietary pattern, cardiometabolic risk factors and abdominal adiposity are especially intriguing because African Americans are more likely to consume this pattern (11), and this may contribute to higher risk for cardiovascular disease and obesity (1).

Characterized by high intakes of energy, fat, saturated fat and *trans* fatty acids from typical southern food items including grits, corn products, processed meats and poultry, margarine and butter, and miscellaneous fat (24), our results support the hypothesis that the “southern” dietary pattern, similar to the “fast food” pattern, is associated with increased risk for cardiometabolic abnormalities and abdominal fat accumulation. The detrimental association between the “southern” dietary pattern and cardiometabolic risk factors could be attributed to high-energy or high-fat but low-fiber constituents, which have been reported to be associated with visceral fat accumulation (29) or with lower insulin sensitivity (28) but higher plasma lipids (26), inflammatory cytokines (25) and metabolic syndrome (9,26). Therefore, it is possible that the “southern” dietary pattern clustering with other risk factors, such as socioeconomic status (4,5), physical activity (6) and genetic factors (7), represents one of the possible mechanisms leading to the high prevalence of hypertension, diabetes and obesity in this cohort (2,17).

## Implications

Identifying and recognizing existing dietary patterns and their relationships with unhealthy outcomes in African American cohort from Jackson, MS are critically important to understand the pathological mechanisms linking obesity and CVD, two of most pressing diseases in the African American community. Our findings highlight an important role of the “southern” dietary pattern in the development of cardiometabolic abnormalities for the African American populations living in the south United States.

## Limitations

The dietary pattern approach is complementary to analyses using individual food or nutrients, which are limited by biological explanations because of numerous dietary factors that can act individually, in combination and/or in interaction with each other. Thus, the logic behind the dietary pattern approach is that foods and nutrients are not eaten separately but are eaten in the form of specified dietary patterns. Although the statistical methods that have been used for data reduction have their own limitations, similar dietary patterns derived by factor analysis have been observed in different populations (8–10,23–28). In addition, limitations of the FFQ also apply to dietary pattern analyses that are based on dietary information collected by this method. The other limitation of this study is its cross-sectional nature, thus, the associations between these dietary patterns and cardiometabolic risk factors remain to be confirmed in prospective analyses. We cannot generalize our findings to other

ethnic groups because of geographical locations and cultural differences in eating behaviors and eating habits.

## Conclusions

Dietary patterns, especially the “southern” pattern, identified from a regionally specific FFQ in this population of Deep South African Americans, are correlated with abdominal VAT and cardiometabolic risk factors.

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**Table 1****Food Grouping Used in Dietary Pattern Analysis in the Jackson Heart Study**

| <b>Foods Groups</b>      | <b>Food Items</b>  |
|--------------------------|--|
| Alcohol                  | Beer, Wine, liquor, other alcoholic beverages.   |
| Beans & Legumes          | Beans (dried and mixed bean preparations), soy products  |
| Baked Desserts           | Cakes, pies, doughnuts, sweet rolls, cereal bars, pop tarts, cookies, muffins  |
| Bread                    | Bread (all types), crackers (all types), stuffing, other grain products  |
| Sugar & Candy            | Jams, jellies, syrup, chocolate, non chocolate candy, sugar, gelatin, sherbet  |
| Cold Cereal              | Ready to eat cold cereal, oats, bran, granola  |
| Poultry                  | Chicken and turkey preparations (regular and dark meat)  |
| Corn & Corn Products     | Grits, cornbread, corn muffins, prepared corn meal, hush puppies, corn tortillas   |
| Dairy Desserts           | Puddings, cheesecakes, ice-creams, frozen yogurt, ice-milk   |
| Eggs                     | Egg and egg preparations (regular and egg beaters)   |
| Fast Food                | Food from fast food restaurants (hamburgers, chicken, fish, french fries, onion rings, fast food desserts etc.)  |
| Fruit Drinks             | Fruit drinks (fortified and unfortified)   |
| Fruit Juice              | Fruit Juices (citrus and non citrus, sweetened and unsweetened, fortified and unfortified)   |
| Fruit                    | Fruit (citrus and non citrus)  |
| Hot Cereal               | Oatmeal, cream of wheat, other hot breakfast cereal  |
| Margarine & Butter       | Butter (regular, unsalted, light, fat free and spreads), margarine (regular, light, stick or spread)   |
| Meat                     | Beef, Pork and Lamb preparations (all cuts)  |
| Miscellaneous Fats       | Non dairy creamer, gravy, spray oils, lard, cream cheese, sour cream   |
| Milk & Dairy             | Milk and chocolate milk (whole, 1 or 2% fat and skim), cheese or cottage cheese (regular, low fat and fat free), yogurt (regular, low fat and fat free), cream (heavy, light and half & half)                    |
| Nuts & Seeds             | Almonds, walnuts, sunflower seeds, pecans, pistachios, cashews, coconuts, Peanut, peanut butter (including peanut butter sandwich)   |
| Oils & Salad Dressing    | Vegetable oils, salad dressings (regular, light and fat free), mayonnaise  |
| Organ Meats              | Liver, venison, ham hocks, neck bones, other organ meats   |
| Vegetables               | Orange vegetables, tomato and tomato products, green leafy vegetables, cruciferous vegetables, other vegetables including onions, lettuce, radish, mixed greens, peppers, string beans, plantains, turnips, etc. |
| Potato                   | Potato and potato preparations   |
| Processed Meat & Poultry | Processed meats and poultry, including breakfast type (regular, lean and extra lean)   |
| Rice & Pasta             | Rice and mixed rice preparations, pasta and pasta preparations, tortillas, burritos, tacos   |
| Sea Food                 | Fish and shell fish preparations   |
| Soda                     | Carbonated soft drinks (regular and diet), powdered drink mixes  |
| Soups                    | Soups (water and cream based)  |
| Salty Snacks             | Salted chips, crackling, popcorn, peanuts or other nut   |
| Tea & Coffee             | Coffee (regular and decaf), Tea (regular, decaf and green)   |

**Table 2**

Factor Loadings\* for Food Groups to the Dietary Patterns (Southern, Fast Food and Prudent)

| <b>Foods Group</b>       | <b>Southern</b> | <b>Fast Food</b> | <b>Prudent</b> |
|--------------------------|-----------------|------------------|----------------|
| Alcohol                  | -               | -                | -              |
| Beans & Legumes          | 0.593           | -                | -              |
| Baked Desserts           | -               | 0.483            | -              |
| Bread                    | 0.423           | -                | -              |
| Sugar & Candy            | -               | 0.600            | -              |
| Cold Cereal              | -               | -                | 0.477          |
| Chicken & Turkey         | 0.340           | -                | -              |
| Corn & Corn Products     | 0.529           | -                | -              |
| Dairy Desserts           | -               | -                | 0.369          |
| Eggs                     | 0.468           | -                | -              |
| Fast Food                | 0.320           | 0.620            | -              |
| Fruit Drinks             | -               | 0.420            | -              |
| Fruit Juice              | -               | -                | 0.311          |
| Fruit                    | -               | -                | 0.632          |
| Hot Cereal               | -               | -                | 0.492          |
| Margarine & Butter       | 0.581           | -                | -              |
| Meat                     | 0.446           | 0.475            | -              |
| Miscellaneous Fats       | 0.525           | -                | -              |
| Milk & Dairy             | -               | 0.355            | 0.307          |
| Nuts & Seeds             | -               | -                | 0.339          |
| Oils & Salad Dressing    | -               | 0.395            | -              |
| Organ Meats              | 0.458           | -                | -              |
| Vegetables               | 0.453           | -                | -              |
| Processed Meat & Poultry | 0.473           | 0.394            | -              |
| Rice & Pasta             | 0.674           | -                | -              |
| Sea Food                 | 0.311           | -                | -              |
| Soda                     | -               | 0.427            | -              |
| Soups                    | 0.361           | -                | -              |
| Salty Snacks             | -               | 0.612            | -              |
| Potato                   | 0.638           | -                | -              |
| Tea & Coffee             | -               | -                | -              |

\* Values &lt; 0.30 were excluded for simplicity.

**Table 3**  
Baseline Characteristics of Jackson Heart Study Participants without Medical Conditions by Dietary Pattern

|                                    | Southern   |                       |                        | Fast Food  |                       |                        | Prudent    |                       |                       |        |
|------------------------------------|------------|-----------------------|------------------------|------------|-----------------------|------------------------|------------|-----------------------|-----------------------|--------|
|                                    | T1 (n=588) | T2 (n=588)            | T3 (n=589)             | T1 (n=588) | T2 (n=588)            | T3 (n=589)             | T1 (n=588) | T2 (n=588)            | T3 (n=589)            | P      |
| <b>Demographic Characteristics</b> |            |                       |                        |            |                       |                        |            |                       |                       |        |
| Age (years)                        | 51±12      | 48±12                 | 43±11                  | 53±12      | 47±11                 | 42±11                  | 44±11      | 48±12                 | 49±1                  | 0.0001 |
| Sex (% female)                     | 76.6       | 58.7                  | 48.1                   | 72.1       | 59.4                  | 52.0                   | 56.6       | 62.4                  | 64.4                  | 0.02   |
| <b>Socioeconomic Status</b>        |            |                       |                        |            |                       |                        |            |                       |                       |        |
| College Education                  | 52.8       | 48.9                  | 37.9                   | 52.1       | 46.7                  | 40.2                   | 42.7       | 47.1                  | 49.2                  | 0.14   |
| Income (affluent)                  | 38.6       | 36.8                  | 27.0                   | 37.9       | 38.1                  | 26.4                   | 31.7       | 35.5                  | 35.0                  | 0.39   |
| <b>Health Behaviors</b>            |            |                       |                        |            |                       |                        |            |                       |                       |        |
| Smoking %                          | 6.9        | 12.6                  | 20.1                   | 8.3        | 11.3                  | 20.1                   | 18.2       | 8.8                   | 12.6                  | 0.0001 |
| Alcohol Drinker%                   | 48.1       | 54.7                  | 64.7                   | 46.0       | 57.1                  | 64.3                   | 65.9       | 53.9                  | 47.6                  | 0.0001 |
| PA Score *                         | 9.1±0.1    | 9.2±0.1               | 9.2±0.1                | 9.3±0.1    | 9.2±0.1               | 9.0±0.1                | 8.9±0.1    | 9.2±0.1 <sup>†</sup>  | 9.3±0.1 <sup>†</sup>  | 0.005  |
| Energy (Kcal)                      | 1580±25    | 1970±25 <sup>†</sup>  | 2983±25 <sup>†</sup>   | 1568±25    | 1880±24 <sup>†</sup>  | 3084±26 <sup>†</sup>   | 1961±28    | 1985±26 <sup>†</sup>  | 2588±27 <sup>†</sup>  | 0.0001 |
| <b>Nutrient Intake *</b>           |            |                       |                        |            |                       |                        |            |                       |                       |        |
| Total Fat (g)                      | 89.5±1.0   | 94.4±0.8 <sup>†</sup> | 104.7±1.1 <sup>†</sup> | 90.0±1.0   | 95.8±0.8 <sup>†</sup> | 102.7±1.1 <sup>†</sup> | 91.9±0.8   | 97.8±0.8 <sup>†</sup> | 98.8±0.8 <sup>†</sup> | 0.0001 |
| Saturated Fat (g)                  | 28.6±0.4   | 30.1±0.3 <sup>†</sup> | 33.5±0.4 <sup>†</sup>  | 28.5±0.4   | 30.4±0.3 <sup>†</sup> | 33.2±0.4 <sup>†</sup>  | 28.7±0.3   | 30.9±0.3              | 32.5±0.3 <sup>†</sup> | 0.0001 |
| TRANS Fat (g)                      | 5.2±0.1    | 5.3±0.1 <sup>†</sup>  | 6.2±0.1 <sup>†</sup>   | 5.3±0.1    | 5.5±0.1               | 5.9±0.1 <sup>†</sup>   | 5.6±0.1    | 5.8±0.1 <sup>†</sup>  | 5.3±0.1 <sup>†</sup>  | 0.0001 |
| Cholesterol (mg)                   | 343±8.4    | 374±6.9 <sup>†</sup>  | 448±9.1 <sup>†</sup>   | 388±8.7    | 393±7.0               | 383±9.0                | 397±7.1    | 392±7.0               | 374±7.2 <sup>†</sup>  | 0.0001 |
| Carbohydrate (g)                   | 319±3.1    | 308±2.6 <sup>†</sup>  | 275±3.4 <sup>†</sup>   | 307±3.2    | 299±2.5               | 297±3.5                | 296±2.6    | 299±2.6               | 306±2.7 <sup>†</sup>  | 0.03   |
| Total Sugars (g)                   | 182±3.7    | 168±3.0 <sup>†</sup>  | 116±4.0 <sup>†</sup>   | 154±3.9    | 153±3.2               | 158±4.2                | 159±3.1    | 150±3.0               | 157±3.2               | 0.16   |
| Total Protein (g)                  | 78.8±1.1   | 82.6±0.8 <sup>†</sup> | 93.7±1.1 <sup>†</sup>  | 84.9±1.1   | 85.3±0.9              | 84.9±1.2               | 85.1±0.9   | 84.8±0.8              | 85.1±0.9              | 0.96   |
| Dietary Fiber(g)                   | 17.4±0.2   | 16.9±0.2              | 17.0±0.3               | 18.4±0.2   | 17.3±0.2 <sup>†</sup> | 15.6±0.3 <sup>†</sup>  | 15.6±0.2   | 17.0±0.2 <sup>†</sup> | 18.8±0.2 <sup>†</sup> | 0.0001 |

\* age-, sex- and energy intake-adjusted (mean ± SE);

<sup>†</sup> difference with tertile 1 ( $P < 0.05$ );  $P$  for trends.

PA: physical activity.

**Table 4**  
Cardiometabolic Risk Factor Profiles (Mean  $\pm$  SE or Prevalence %) in Jackson Heart Study Participants without Medical Conditions by Dietary Pattern

|                          | Southern        |                 |                 |        | Fast Food       |                 |                             |        | Prudent         |                 |                 |      |
|--------------------------|-----------------|-----------------|-----------------|--------|-----------------|-----------------|-----------------------------|--------|-----------------|-----------------|-----------------|------|
|                          | T1 (n=588)      | T2 (n=588)      | T3 (n=589)      | p      | T1 (n=588)      | T2 (n=588)      | T3 (n=589)                  | p      | T1 (n=588)      | T2 (n=588)      | T3 (n=589)      | p    |
| <b>Fat-related</b>       |                 |                 |                 |        |                 |                 |                             |        |                 |                 |                 |      |
| BMI (kg/m <sup>2</sup> ) | 30.4 $\pm$ 0.3  | 31.2 $\pm$ 0.3  | 31.1 $\pm$ 0.3  | 0.16   | 30.5 $\pm$ 0.3  | 30.8 $\pm$ 0.3  | 31.4 $\pm$ 0.3 <sup>†</sup> | 0.09   | 31.2 $\pm$ 0.3  | 31.0 $\pm$ 0.3  | 30.4 $\pm$ 0.3  | 0.23 |
| WC (cm)                  | 95.9 $\pm$ 0.7  | 99.2 $\pm$ 0.7  | 99.8 $\pm$ 0.7  | 0.0001 | 96.4 $\pm$ 0.7  | 98.8 $\pm$ 0.7  | 99.7 $\pm$ 0.7              | 0.003  | 98.9 $\pm$ 0.7  | 98.4 $\pm$ 0.7  | 97.5 $\pm$ 0.7  | 0.37 |
| Log LA                   | 4.08 $\pm$ 0.01 | 4.07 $\pm$ 0.01 | 4.08 $\pm$ 0.01 | 0.79   | 4.09 $\pm$ 0.01 | 4.07 $\pm$ 0.01 | 4.08 $\pm$ 0.01             | 0.58   | 4.08 $\pm$ 0.01 | 4.08 $\pm$ 0.01 | 4.08 $\pm$ 0.01 | 0.99 |
| VAT (cm <sup>2</sup> )   | 681 $\pm$ 18    | 722 $\pm$ 18    | 764 $\pm$ 18    | 0.007  | 691 $\pm$ 17    | 740 $\pm$ 18    | 731 $\pm$ 19                | 0.12   | 714 $\pm$ 20    | 722 $\pm$ 18    | 721 $\pm$ 18    | 0.93 |
| Obesity %                | 38.1            | 40.6            | 38.4            | 0.63   | 38.1            | 39.6            | 39.4                        | 0.85   | 41.0            | 39.4            | 36.7            | 0.38 |
| High VAT %               | 35.1            | 39.1            | 41.6            | 0.22   | 35.8            | 39.7            | 40.1                        | 0.44   | 36.8            | 39.3            | 38.3            | 0.79 |
| High liver fat %         | 50.7            | 52.8            | 60.3            | 0.002  | 48.8            | 53.3            | 61.3                        | 0.0001 | 59.0            | 51.3            | 53.5            | 0.02 |
| <b>BP-related</b>        |                 |                 |                 |        |                 |                 |                             |        |                 |                 |                 |      |
| SBP (mm Hg)              | 120 $\pm$ 0.7   | 120 $\pm$ 0.7   | 119 $\pm$ 0.7   | 0.31   | 121 $\pm$ 0.7   | 120 $\pm$ 0.7   | 119 $\pm$ 0.7               | 0.17   | 120 $\pm$ 0.7   | 120 $\pm$ 0.7   | 120 $\pm$ 0.7   | 0.82 |
| DBP (mm Hg)              | 76 $\pm$ 0.4    | 77 $\pm$ 0.4    | 78 $\pm$ 0.4    | 0.002  | 76 $\pm$ 0.4    | 77 $\pm$ 0.4    | 78 $\pm$ 0.4                | 0.002  | 78 $\pm$ 0.4    | 77 $\pm$ 0.4    | 77 $\pm$ 0.4    | 0.12 |
| HTN (%)                  | 35.0            | 40.6            | 33.8            | 0.15   | 36.4            | 36.0            | 37.2                        | 0.95   | 40.6            | 35.5            | 34.0            | 0.19 |
| <b>Lipid-related</b>     |                 |                 |                 |        |                 |                 |                             |        |                 |                 |                 |      |
| Log TRG                  | 4.4 $\pm$ 0.0   | 4.4 $\pm$ 0.0   | 4.4 $\pm$ 0.0   | 0.48   | 4.3 $\pm$ 0.0   | 4.4 $\pm$ 0.0   | 4.4 $\pm$ 0.0               | 0.01   | 4.4 $\pm$ 0.0   | 4.4 $\pm$ 0.0   | 4.4 $\pm$ 0.0   | 0.69 |
| High TRG                 | 11.4            | 11.4            | 12.7            | 0.71   | 9.9             | 12.9            | 12.7                        | 0.19   | 11.4            | 13.2            | 10.9            | 0.41 |
| HDL-C (mg/dl)            | 56.3 $\pm$ 0.6  | 52.9 $\pm$ 0.6  | 51.8 $\pm$ 0.6  | 0.0001 | 57.1 $\pm$ 0.6  | 52.1 $\pm$ 0.6  | 51.8 $\pm$ 0.6              | 0.0001 | 53.0 $\pm$ 0.6  | 53.6 $\pm$ 0.6  | 54.5 $\pm$ 0.6  | 0.21 |
| Low HDL-C                | 29.1            | 30.4            | 31.2            | 0.72   | 25.5            | 32.9            | 32.3                        | 0.009  | 30.8            | 31.2            | 28.7            | 0.59 |
| <b>Glucose-related</b>   |                 |                 |                 |        |                 |                 |                             |        |                 |                 |                 |      |
| Glucose (mg/dl)          | 96.6 $\pm$ 0.9  | 97.4 $\pm$ 0.9  | 96.8 $\pm$ 0.9  | 0.80   | 97 $\pm$ 0.9    | 98.4 $\pm$ 0.9  | 96 $\pm$ 0.9                | 0.16   | 96.9 $\pm$ 0.9  | 96.6 $\pm$ 0.9  | 97.4 $\pm$ 0.9  | 0.83 |
| Impaired Glu %           | 12.4            | 13.4            | 11.9            | 0.72   | 13.3            | 14.4            | 10.0                        | 0.06   | 11.9            | 13.6            | 12.2            | 0.65 |
| T2D %                    | 5.8             | 8.6             | 6.9             | 0.19   | 5.1             | 8.1             | 7.5                         | 0.21   | 6.9             | 6.4             | 7.4             | 0.85 |
| <b>Syndrome-related</b>  |                 |                 |                 |        |                 |                 |                             |        |                 |                 |                 |      |
| MetS (%)                 | 29.4            | 36.9            | 38.3            | 0.056  | 26.1            | 41.5            | 36.4                        | 0.0006 | 36.4            | 33.7            | 33.0            | 0.62 |

BMI: body mass index; WC: waist circumference; LA: liver attenuation in Hounsfield unit; VAT: abdominal visceral adipose tissue; BP: blood pressure; SBP/DBP: systolic/diastolic blood pressure; Glu: glucose; HTN: hypertension; TRG: triglyceride; T2D: type 2 diabetes; MetS: metabolic syndrome.

**Table 5**  
Association\* between Dietary Patterns and Cardiometabolic Risk Factors across Score Tertiles

|                | Southern |               |               | Fast Food |               |               | Prudent |               |               |
|----------------|----------|---------------|---------------|-----------|---------------|---------------|---------|---------------|---------------|
|                | T1       | T2            | T3            | T1        | T2            | T3            | T1      | T2            | T3            |
| High VAT       | 1        | 1.39(0.9-1.9) | 1.80(1.1-3.0) | 1         | 1.38(0.9-1.9) | 1.52(0.8-2.3) | 1       | 1.13(0.8-1.6) | 0.91(0.6-1.3) |
| <i>P</i>       |          | 0.056         | 0.02          |           | 0.06          | 0.14          |         | 0.47          | 0.61          |
| <i>n</i>       | 130      | 130           | 121           | 134       | 137           | 113           | 112     | 140           | 132           |
| High liver fat | 1        | 0.71(0.5-1.1) | 0.78(0.4-1.4) | 1         | 0.92(0.7-1.2) | 0.92(0.6-1.4) | 1       | 0.94(0.6-1.4) | 1.07(0.7-1.6) |
| <i>P</i>       |          | 0.24          | 0.29          |           | 0.48          | 0.68          |         | 0.24          | 0.82          |
| <i>n</i>       | 298      | 311           | 355           | 287       | 314           | 363           | 347     | 302           | 315           |
| HTN            | 1        | 1.42(1.1-1.9) | 1.14(0.7-1.8) | 1         | 1.35(0.9-1.8) | 1.67(1.1-2.7) | 1       | 0.75(0.6-0.9) | 0.69(0.5-0.9) |
| <i>P</i>       |          | 0.02          | 0.6           |           | 0.057         | 0.03          |         | 0.049         | 0.02          |
| <i>n</i>       | 172      | 189           | 137           | 177       | 173           | 148           | 167     | 167           | 164           |
| Impair Glu     | 1        | 1.20(0.8-1.8) | 1.23(0.7-2.2) | 1         | 1.13(0.8-1.6) | 0.80(0.5-1.4) | 1       | 1.12(0.8-1.6) | 0.98(0.7-1.5) |
| <i>P</i>       |          | 0.36          | 0.46          |           | 0.52          | 0.48          |         | 0.53          | 0.93          |
| <i>n</i>       | 73       | 79            | 70            | 78        | 85            | 59            | 70      | 80            | 72            |
| Diabetes       | 1        | 2.03(1.1-3.9) | 1.55(0.6-4.0) | 1         | 2.46(1.2-4.9) | 2.86(1.0-7.9) | 1       | 0.88(0.5-1.6) | 0.88(0.5-1.7) |
| <i>P</i>       |          | 0.03          | 0.36          |           | 0.01          | 0.04          |         | 0.66          | 0.71          |
| <i>n</i>       | 21       | 33            | 25            | 20        | 32            | 27            | 25      | 25            | 29            |
| High TRG       | 1        | 0.78(0.5-1.2) | 0.76(0.4-1.3) | 1         | 1.26(0.8-1.9) | 1.14(0.6-1.9) | 1       | 1.25(0.9-1.8) | 0.92(0.6-1.4) |
| <i>P</i>       |          | 0.23          | 0.31          |           | 0.25          | 0.65          |         | 0.22          | 0.70          |
| <i>n</i>       | 67       | 67            | 75            | 58        | 76            | 75            | 67      | 78            | 64            |
| Low HDL        | 1        | 1.01(0.8-1.3) | 1.02(0.7-1.5) | 1         | 1.34(1.0-1.7) | 1.24(0.8-1.9) | 1       | 1.15(0.8-1.5) | 0.98(0.7-1.3) |
| <i>P</i>       |          | 0.96          | 0.93          |           | 0.04          | 0.29          |         | 0.29          | 0.92          |
| <i>n</i>       | 171      | 179           | 184           | 150       | 194           | 190           | 181     | 184           | 169           |
| MeIS           | 1        | 1.88(1.3-2.7) | 2.16(1.3-3.6) | 1         | 2.48(1.7-3.6) | 2.40(1.4-4.2) | 1       | 0.94(0.7-1.3) | 0.75(0.5-1.1) |
| <i>P</i>       |          | 0.0005        | 0.004         |           | 0.0001        | 0.002         |         | 0.71          | 0.12          |

|   | Southern |     |     | Fast Food |     |     | Prudent |     |     |
|---|----------|-----|-----|-----------|-----|-----|---------|-----|-----|
|   | T1       | T2  | T3  | T1        | T2  | T3  | T1      | T2  | T3  |
| n | 110      | 130 | 111 | 100       | 150 | 101 | 111     | 124 | 116 |

\* Adjusted for age, sex, smoking and alcohol status, energy intake, education levels and physical activity.

n: numbers of participants with conditions.

VAT: abdominal visceral adipose tissue; Glu: glucose; HTN: hypertension; TRG: triglyceride; MetS: metabolic syndrome.