

# Race, Gender, Family Structure, Socioeconomic Status, Dietary Patterns, and Cardiovascular Health in Adolescents

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## ABSTRACT

**Background:** Dietary patterns represent a broad picture of food and nutrient consumption and may be more predictive of health outcomes than individual foods and nutrients.

**Objective:** We investigated the relations among race, gender, family structure, parental socioeconomic status (SES), dietary patterns, and cardiovascular disease (CVD) profiles among adolescents in the southeastern region of the United States.

**Methods:** A total of 743 adolescents from a cross-sectional study were divided into 4 dietary pattern groups by K-means cluster analysis. Multinomial logistic regression was performed to determine the relations among the parental SES, family structures, and dietary patterns of the adolescents. Associations between dietary patterns and CVD profiles were analyzed by multiple linear regression.

**Results:** Four dietary patterns were derived: "healthy" (17%), "snacks and sweets" (26%), "processed meat" (20%), and "sugar-sweetened beverage (SSB) and fried food" (37%). Whites and females were more likely to have a "healthy" dietary pattern ( $P_s < 0.001$ ). There were significant race/ethnicity differences in family structures, SES, and dietary patterns ( $P_s < 0.05$ ). In whites, higher mother's education and father's education and occupation were associated with greater likelihood of a "healthy" dietary pattern ( $P_s < 0.05$ ). Stay-at-home mother was associated with less likelihood of an "SSB and fried food" pattern ( $P = 0.023$ ). In blacks, higher mother's occupation, father's education, and living with both parents were associated with more likelihood of a "healthy" dietary pattern ( $P_s < 0.05$ ). Stay-at-home father was associated with less likelihood of the "snacks and sweets" ( $P = 0.025$ ) and "SSB and fried food" dietary patterns ( $P = 0.044$ ). Overall, adolescents with poor dietary patterns exhibited higher percentage body fat, waist circumference, systolic blood pressure, fasting insulin, homeostasis model assessment of insulin resistance, C-reactive protein, and total triglyceride ( $P_s < 0.05$ ).

**Conclusions:** Our data suggest that family structure, parental working status, and SES are associated with the diet quality in adolescents. Moreover, "snacks and sweets," "processed meat," and "SSB and fried food" dietary patterns are all associated with worse CVD risk profiles. *Curr Dev Nutr* 2019;3:nzz117.

## Introduction

Cardiovascular disease (CVD) is the leading cause of death in the United States (1). Relations have been found between CVD risk factors and dietary intakes, such as fat (2, 3), protein (4), sugar (5, 6), and fiber (7). However, investigating a single food or nutrient is unable to account for potential synergistic effects among them (8, 9). Dietary patterns represent a broader picture of food and nutrient consumption and thus may be more predictive of health outcomes than individual foods and nutrients (8). Analyses of dietary patterns can be applied a priori to estimate adherence to a predefined, theory-based dietary guideline, such as the Healthy Eating Index (HEI) (10), or



**Keywords:** dietary pattern, socioeconomic status, education, fast food, adolescent, Stroke Belt

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Abbreviations used: ASB, artificially sweetened beverage; CRP, C-reactive protein; CVD, cardiovascular disease; HF, heart failure; RRR, relative-risk ratio; SBP, systolic blood pressure; SES, socioeconomic status; SSB, sugar-sweetened beverage.

a posteriori to identify empirical dietary patterns in populations (11). For example, a Western dietary pattern is associated with increased CVD risk (12, 13).

A higher risk of CVD is associated with a southeastern US diet, which is characterized by relatively high amounts of fats, fried food, eggs, animal organs, processed meat, and sugar-sweetened beverages (SSBs) (14, 15). We previously found in this population that the mean sodium consumption was more than twice the daily intake recommended by the American Heart Association (16), and that ~66% of the adolescents consumed much less fiber than adequate intake recommendations (17). We also found that increased intakes of sodium and decreased intakes of fiber were associated with elevated CVD biomarkers, including blood pressure, visceral fat, and inflammation (16–18). Therefore, nutritional epidemiology studies in this “Stroke Belt” region are of special interest (19). Moreover, most of the previous studies about dietary patterns and CVD risks were focused on adults, especially the elderly. Findings from adolescents are limited (20) and a recent review suggests that further studies are warranted (21).

Some studies have found that dietary patterns are influenced by factors such as socioeconomic status (SES), living area (22, 23), education (23, 24), occupation, and income (24, 25). However, other studies were unable to find similar associations (26). The family structure also affects the diet of the children. For example, the diet quality of motherless children is lower than the diet quality of those living with both parents (27). Moreover, there is a strong relation between single-parent status and obesity in children (28). Associations between dietary patterns, socioeconomic factors, and family structure are understudied in adolescents (29).

In this study, we identified dietary patterns of adolescents in the southeastern region of the United States and explored the relations among family structure, SES, dietary patterns, and CVD risk factors. Race disparities have been found in family structure, SES, and diet quality (30–32). Therefore, we further explored these relations in white and black adolescents separately.

## Methods

### Participants

A cross-sectional study was previously conducted in a cohort of apparently healthy black and white adolescents aged 14–18 y ( $n = 743$ , 50% males; 49% black), who were from 34 local public and private high schools as well as home schools in the Augusta, GA area, which is in the southeastern region of the United States (33). Demographic information obtained from the school systems was used to select schools that enrolled both black and white students. After receiving approval from the county superintendents and school principals, flyers were distributed to all students in the selected schools. We also contacted the home-schooling association for assistance in reaching those youths. Subjects were asked to self-identify their ethnicity. Subjects who identified themselves as being white/Caucasian or black/African American were eligible for the study. Interested students who responded to the flyers and called the institute to participate were screened over the telephone to determine preliminary eligibility. Participants who self-reported the following conditions were excluded: taking current medications or diagnosed with chronic medical conditions

that could affect growth, maturation, physical activity, nutritional status, or metabolism. Adolescents who passed the telephone screening were invited to the Georgia Prevention Institute, accompanied by their parents if they were minors. All participants and the parents of participants who were minors provided written informed assent and consent before study participation. The Institutional Review Board at the Medical College of Georgia, Augusta University approved this project (Augusta, GA, USA, protocol #622505).

### Dietary assessment

Dietary intakes were assessed with nonconsecutive, 24-h recalls covering the period from midnight to midnight using the Nutrition Data System for Research (NDS-R 2006; Nutrition Coordinating Center, University of Minnesota), by trained dietitians. Seven dietary recalls were obtained within a period of 12 wk for each participant; the first 2 were performed in person and the following ones were conducted by telephone. An mean value was taken from the recalls for further analysis. Subjects were blinded to the telephone recall schedule to minimize the potential for underreporting during the time frame for the 24-h recall; the calls were made on all days of the week to obtain diet data representing both weekdays and weekend days. Adolescents who provided  $\geq 4$  recalls were included. Fifty-two percent of the adolescents had recalls for all 7 d. The mean number of recalls for all participants was 5.9.

### SES and family structure

Parental education and occupation were collected as parts of the Hollingshead Four-Factor Social Status Index by a self-administrated questionnaire. The educational attainment was rated on a 7-point scale that lists the highest grade completed; the occupational prestige was rated on a 9-point scale. We further coded occupation into 2 variables: 1) stay-at-home and 2) other occupations. Three family structures were derived based on the living status of the adolescents, who were living with mother alone, living with father alone, or living with both parents.

### Body size and composition measurements

Body size was measured by a trained laboratory technician. Height was measured twice to the nearest 0.1 cm using a wall-mounted stadiometer; weight was measured twice to the nearest 0.1 kg using a calibrated electronic scale with the participants not wearing shoes and in light clothing (model CN2OL; Cardinal Detecto). BMI was calculated as  $\text{kg}/\text{m}^2$ . BMI-for-age percentile was calculated based on the CDC growth charts for children and adolescents. The waist circumference was measured twice at the midpoint between the lowest rib and the iliac crest, and the values were averaged. Fat mass and percentage body fat were measured with DXA using the Hologic QDR-4500W or QDR-1000W. In the first 219 participants, we performed 2 scans on the QDR-4500W and found the intraclass correlation to be 0.99 (34).

### Clinical and biochemical examination

Resting blood pressure was measured in a supine position after 10 min quiet rest with a Dinamap monitor (Critikon); 5 readings were made at 1-min intervals and the last 3 were averaged. Blood samples were collected from fasting participants for the assessment of serum fasting glucose, fasting insulin, triglyceride, and C-reactive protein (CRP). Fasting glucose was measured using an EK tachem DT system (Johnson

and Johnson Clinical Diagnostics) and run in duplicate. Fasting insulin was assayed in duplicate 100- $\mu$ L aliquots of sera by specific RIA (Linco Research). HOMA-IR was calculated using the following formula: fasting insulin (in microunits per liter)  $\times$  fasting glucose (in milligrams per deciliter)/405. Plasma CRP concentrations were assayed by using high-sensitivity ELISA (ALPCO Diagnostics) and run in duplicate, with intra- and interassay CVs of 3.8% and 7.0%, respectively. Triglycerides were measured with the Ektachem DT II system.

### Statistical analysis

The general characteristics of the subjects are presented as mean  $\pm$  SD for continuous variables and  $n$  (%) for categorical variables. The normality of each continuous variable was tested based on a combination of skewness and kurtosis (35). Univariate analysis testing the difference of continuous measurements between different dietary pattern groups was conducted using ANOVA for normally distributed continuous variables or by the Kruskal–Wallis test, otherwise. Chi-squared tests were conducted for categorical variables. Log transformations of skew-distributed variables (fasting insulin, HOMA-IR, CRP, and total triglyceride) were made to approximate the normal distribution before modeling.

### Cluster analysis.

Cluster analysis was used to derive dietary patterns and has been proven to have reasonable reproducibility and validity (36). In the present study, a total of 19 food groups were constructed using individual food variables, based on nutrient similarities and previous studies. These dietary intakes were standardized by the energy intake of each individual, which accounted for different energy intake needs due to age, gender, and other measures (37). Because cluster analysis is sensitive to outliers,  $z$  scores of food consumptions were calculated for standardization before clustering, because differences in variances of the variables may otherwise affect the resulting clusters (38). Participants were grouped into mutually exclusive and homogeneous dietary pattern groups by cluster analysis based on consumptions of each food group. The K-means method was used to derive clusters with maximized distances between each other based on least-squares estimation with Euclidean distances (39). Clusters derived by the K-means procedure are more reproducible than Ward's minimum variance method and flexible- $\beta$  method (40). Cluster analysis was performed several times, varying the number of the clusters from 2 to 8 to identify the optimal number. Four clusters were selected to distinguish meaningful dietary patterns for our sample size.

### Modeling.

Multinomial logistic regression models were performed to explore the relations between parental SES—which included race, family structure, parental education, and occupation—and dietary patterns. These models were adjusted for age, gender, BMI percentile, and energy intake. Relative-risk ratio (RRR) was calculated based on the estimated coefficients of the regression. Multiple linear regressions were performed to determine the associations between dietary patterns and CVD risk factors. These models were adjusted for age, gender, race, BMI percentile, and energy intake. A 2-sided  $P < 0.05$  was considered statistically significant. No correction was made for multiple

comparisons. All statistical analysis was performed using Stata version 12.0 (Stata Corp LLC).

## Results

### Demographics and univariate analysis

A total of 743 adolescents (mean  $\pm$  SD age: 16.1  $\pm$  1.2 y) were divided into 4 dietary pattern groups: “healthy” (16.6%); “snacks and sweets” (26.0%); “processed meat” (20.2%); and “SSB and fried food” (37.3%), named by their predominant diet components. Whites and females were more likely to have a “healthy” dietary pattern ( $P$ s  $<$  0.001). Adolescents with an “SSB and fried food” diet had the highest BMI, BMI percentile, waist circumference, systolic blood pressure (SBP), fasting insulin, HOMA-IR, and CRP ( $P$ s  $<$  0.05). Percentage body fat was highest among adolescents with a “healthy” pattern ( $P = 0.008$ ). When stratified by gender, percentage body fat of the “healthy” dietary pattern was lower than the other 3 groups combined both in males (16.8% in “healthy” compared with 18.6% other,  $P = 0.220$ ) and in females (29.6% in “healthy” compared with 29.7% other,  $P = 0.905$ ). The proportion of adolescents with a healthy dietary pattern was higher among those with more educated mothers or fathers ( $P$ s  $<$  0.001), and those whose mothers or fathers had higher-ranked jobs ( $P <$  0.001) (Table 1, Supplemental Table 1).

### Dietary patterns and characterized consumption of each food group

Adolescents who exhibited “healthy” dietary patterns consumed more fruits, all kinds of vegetables, artificially sweetened beverages, whole grain, fish and other seafood, egg, and nuts than did others ( $P$ s  $<$  0.05). Ones who exhibited a “snacks and sweets” dietary pattern consumed 1.2 more servings per day of snacks and sweets and only half as much fish and seafood compared with the “healthy” dietary pattern ( $P$ s  $<$  0.05). Adolescents who exhibited a “processed meat” dietary pattern consumed 0.4 more servings per day of processed meat than the “healthy” dietary pattern ( $P$ s  $<$  0.05). Ones who reported an “SSB and fried food” dietary pattern consumed an additional 2.04 servings of SSBs and 0.56 servings of fried food and added fat per day than the “healthy” dietary pattern, and consumed only 28% fruits, 51% vegetables, and 22% nuts relative to the mean amount consumed in the “healthy” dietary pattern ( $P$ s  $<$  0.05) (Figure 1, Supplemental Table 2).

Adolescents reporting a “healthy” dietary pattern had the highest fiber intake and percentage of energy from protein ( $P$ s  $<$  0.05). Those in the “SSB and fried food” group had the highest percentage of energy from fat. Those in the “processed meat” category had the highest intake of saturated fat ( $P$ s  $<$  0.05). The percentage of energy from carbohydrate was significantly higher in the “snacks and sweets” group than in the other groups ( $P <$  0.001) (Table 2).

### Race differences, family structure, SES, and dietary patterns

In the whole sample, adolescents with more educated parents were less likely to report “snacks and sweets” and “SSB and fried food” dietary patterns rather than a “healthy” dietary pattern. Children of stay-at-home mothers were less likely to report an “SSB and fried food” dietary pattern (RRR: 0.56; CI: 0.33, 0.96), whereas no significant association with dietary pattern was found for the category

**TABLE 1** Demographics of the participants by dietary patterns<sup>1</sup>

Demographics	Total	Dietary patterns				P
		Healthy	Snacks and sweets	Processed meat	SSB and fried food	
n (%)	743 (100)	123 (16.6)	193 (26.0)	150 (20.2)	277 (37.3)	
Age, y	16.1 ± 1.2	16.2 ± 1.3	16.2 ± 1.1	15.9 ± 1.2	16.2 ± 1.2	0.206
Sex						<0.001
Male, %	368 (49.5)	42 (34.2)	71 (36.8)	99 (66.0)	156 (56.3)	
Female, %	375 (50.5)	81 (65.9)	122 (63.2)	51 (34.0)	121 (43.7)	
Race						<0.001
White, %	377 (50.7)	93 (75.6)	112 (58.0)	71 (47.3)	101 (36.5)	
Black, %	366 (49.3)	30 (24.4)	81 (42.0)	79 (52.7)	176 (63.5)	
BMI, kg/m <sup>2</sup>	23.2 ± 5.1	22.5 ± 4.0	22.4 ± 4.9	22.7 ± 4.8	24.2 ± 5.7	<0.001
BMI percentile	0.61 ± 0.28	0.60 ± 0.26	0.55 ± 0.29	0.59 ± 0.28	0.66 ± 0.29	<0.001
Percentage body fat, %	24.1 ± 10.1	25.2 ± 9.3	24.4 ± 9.5	21.7 ± 10.5	24.6 ± 10.5	0.008
Waist circumference, cm	74.5 ± 11.1	72.6 ± 8.6	72.4 ± 10.4	74.8 ± 11.2	76.7 ± 12.1	<0.001
Systolic blood pressure, mm Hg	111.3 ± 10.4	107.0 ± 9.0	110.1 ± 10.3	113.0 ± 10.4	113.2 ± 10.5	<0.001
Diastolic blood pressure, mm Hg	59.9 ± 6.1	58.6 ± 5.4	60.0 ± 6.3	59.3 ± 6.0	60.8 ± 6.3	0.224
Fasting insulin, μU/mL	16.4 ± 8.9	13.6 ± 7.0	15.6 ± 8.2	16.6 ± 8.7	18.3 ± 9.7	<0.001
HOMA-IR	3.7 ± 2.0	3.0 ± 1.7	3.5 ± 2.0	3.7 ± 2.0	4.0 ± 2.2	<0.001
C-reactive protein, ng/mL	1080 ± 2196	788 ± 1722	1000 ± 2587	1150 ± 2109	1238 ± 2145	<0.001
Total triglyceride, mg/dL	66.4 ± 38.6	61.9 ± 26.1	65.3 ± 34.6	70.6 ± 45.6	66.8 ± 41.7	0.625
Family structure						0.005
Living with mother alone, %	222 (31.1)	20 (16.7)	55 (30.1)	50 (35.2)	97 (36.1)	
Living with father alone, %	26 (3.6)	3 (2.5)	6 (3.3)	7 (4.9)	10 (3.7)	
Living with both parents, %	466 (65.3)	97 (80.8)	122 (66.7)	85 (60.0)	162 (60.2)	
Mother's education	5.0 ± 0.9	5.4 ± 0.7	5.0 ± 0.9	5.1 ± 0.9	4.9 ± 0.9	<0.001
Father's education	5.1 ± 0.9	5.6 ± 0.7	5.0 ± 0.9	5.3 ± 0.8	4.8 ± 0.9	<0.001
Mother's occupation	5.6 ± 2.0	6.3 ± 1.9	5.6 ± 2.1	5.7 ± 2.1	5.2 ± 1.9	<0.001
Stay-at-home mother, %	154 (22.6)	33 (28.2)	38 (21.5)	35 (26.9)	48 (18.5)	0.108
Father's occupation	5.9 ± 2.2	7.0 ± 1.9	5.9 ± 2.2	6.1 ± 2.2	5.3 ± 2.1	<0.001
Stay-at-home father, %	35 (7.0)	9 (9.0)	11 (8.5)	4 (4.3)	11 (6.3)	0.516

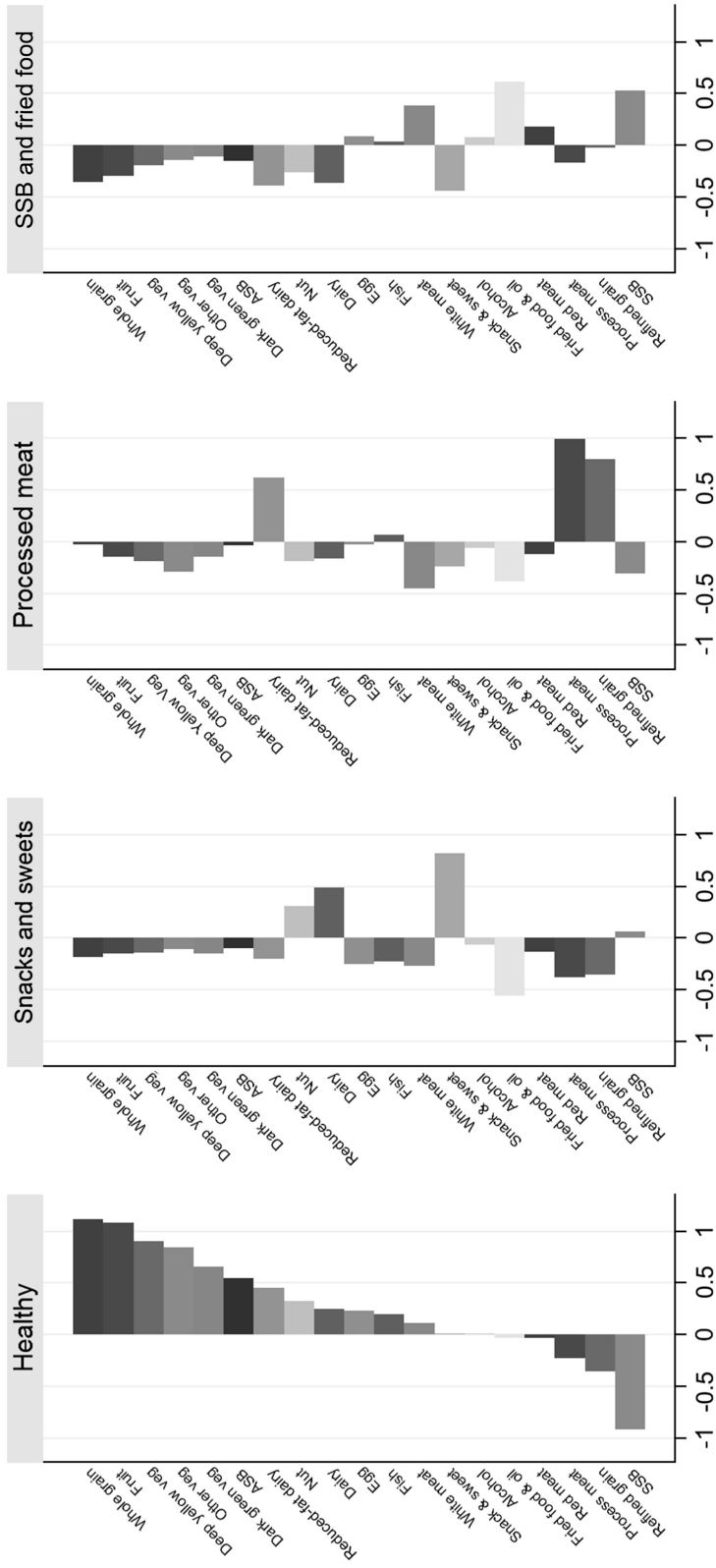
<sup>1</sup>Summary statistics are calculated in the total population as well as in each dietary group; values are mean ± SD for continuous variables and n (%) for categorical variables. Row percentages were calculated for sample size (n), column percentages were calculated for other categorical variables. Parental education and occupation are treated as continuous variables; bigger values represent higher education levels or higher-ranked occupations. Education: 1, less than seventh grade; 2, junior high school; 3, partial high school; 4, high school graduate; 5, partial college or specialized training; 6, standard college or university graduation; 7, graduate professional training. Occupation: 0, stay-at-home; 1, farm laborers, menial service workers; 2, unskilled workers; 3, machine operators and semiskilled workers; 4, owners of small businesses and farms valued at less than \$25,000, skilled manual workers, craftsmen, and tenant farmers; 5, clerical and sales workers, small farm owners; 6, technicians, semiprofessionals; 7, smaller business owners, farm owners, managers, and minor professionals; 8, administrators, lesser professionals, and proprietors of medium-sized businesses; 9, higher executives, proprietors of large businesses, and major professionals. SSB, sugar-sweetened beverage.

of stay-at-home fathers. Mothers' and fathers' education levels and fathers' occupation were positively related to the likelihood of a "healthy" dietary pattern ( $P < 0.05$ ) (**Supplemental Table 3**). There were significant race/ethnicity differences in family structure, SES, and dietary patterns ( $P_s < 0.05$ ). Therefore, we conducted further analyses stratified by race. As shown in **Table 3**, 76% of the white adolescents had a "healthy" dietary pattern, but only 24% of the black adolescents had a "healthy" dietary pattern. A total of 78% of white adolescents lived with both parents, and only 47% of black adolescents lived with both parents. Higher percentages of adolescents had a "healthy" dietary pattern if living with both parents than if living with one parent in both races. **Tables 4** and **5** present the RRRs of dietary patterns by parental economic status stratified by race. Among the white adolescents, higher levels of mother's education and father's education and occupation were associated with more likelihood of a "healthy" dietary pattern ( $P_s < 0.05$ ). Moreover, stay-at-home mother was associated with less likelihood of an "SSB and fried food" dietary pattern ( $P = 0.023$ ). Among the black adolescents, higher levels of mother's occupation and father's education were associated with more likelihood of a "healthy" dietary pattern ( $P_s < 0.05$ ). Unlike the whites,

stay-at-home father, instead of stay-at-home mother, was associated with less likelihood of the "snacks and sweets" ( $P = 0.025$ ) and "SSB and fried food" dietary patterns ( $P = 0.044$ ).

#### Adjusted associations between dietary patterns and CVD risk factors

Compared with the "healthy" dietary pattern, adolescents reporting the "snacks and sweets" dietary pattern exhibited a 3.16-mm Hg increase in SBP, 17% increase in fasting insulin, and 20% increase in HOMA-IR ( $P_s < 0.05$ ). The adolescents with the "processed meat" dietary pattern had a 2.96-mm Hg increase in SBP, 18% increase in fasting insulin, 18% increase in HOMA-IR, 59% increase in CRP, and 13% increase in total triglyceride ( $P_s < 0.05$ ). The adolescents with the "SSB and fried food" dietary pattern had a 2.67-mm Hg increase in SBP, 23% increase in fasting insulin, 22% increase in HOMA-IR, 56% increase in CRP, 2.03% higher percentage body fat, and 2.71-cm increase in waist circumference ( $P_s < 0.05$ ) (**Table 6**). Further adjustment of physical activity did not change the results significantly. There was no interaction between dietary pattern and race on the CVD markers.



**FIGURE 1** Energy intake-adjusted standardized food group consumption by dietary patterns. Food categories were sorted by the consumption amount in the healthy dietary pattern. The consumption amount of each food category was first divided by total energy intake, then standardized by rescaling the variable to have a mean of 0 and an SD of 1. ASB, artificially sweetened beverage; SSB, sugar-sweetened beverage.

**TABLE 2** Dietary factors by dietary patterns<sup>1</sup>

Nutrient component	Total	Dietary patterns				P
		Healthy	Snacks and sweets	Processed meat	SSB and fried food	
Energy intake, kcal	1967 ± 592	1933 ± 639	2029 ± 585	1916 ± 523	1939 ± 609	0.192
Kcal from carbohydrate, %	53.6 ± 6.3	53.1 ± 6.3	55.9 ± 5.7	52.9 ± 6.2	52.8 ± 6.3	<0.001
Kcal from protein, %	13.9 ± 2.7	15.5 ± 2.6	12.5 ± 2.3	14.3 ± 2.4	13.8 ± 2.7	<0.001
Kcal from fat, %	33.5 ± 4.9	32.9 ± 5.1	32.9 ± 4.6	33.6 ± 5.2	34.1 ± 4.9	0.031
Kcal from saturated fat, %	11.6 ± 2.1	11.3 ± 2.3	11.8 ± 2.0	12.1 ± 2.2	11.2 ± 2.0	<0.001
Fiber, g	10.8 ± 4.3	14.3 ± 4.9	11.1 ± 4.0	10.0 ± 3.5	9.4 ± 3.7	<0.001
Sodium, g	3.2 ± 1.1	3.2 ± 1.1	3.1 ± 1.0	3.4 ± 1.0	3.2 ± 1.1	0.009

<sup>1</sup>Statistics are calculated in the total population as well as in each dietary group; values are mean ± SD. SSB, sugar-sweetened beverage.

## Discussion

This study reports the dietary patterns characterized by cluster analysis among adolescents who reside in the southeastern region of the United States. In the present study, we have shown that there were race and gender differences in dietary patterns. Whites and females were more likely to have a “healthy” dietary pattern. In addition, there were race differences in family structure, parental education, and occupation, which were associated with dietary patterns. Adolescents with poor dietary patterns exhibited higher percentage body fat, waist circumference, SBP, fasting insulin, HOMA-IR, CRP, and total triglyceride.

The “Western” dietary pattern, which is characterized by high amounts of refined grains, snacks, red meats, processed meat, pizza, soft drinks, and poultry, is the most commonly identified dietary pattern in adolescents around the world (41–44). In this study, “snacks and sweets,” “processed meat,” and “SSB and fried food” are different aspects of the “Western” diet, and exhibit different associations with cardiovascular health. Therefore, our findings are significant in understanding the etiology of CVD predictors by further distinguishing the “Western” dietary pattern.

As has been shown in previous studies (32, 45), our white and female adolescents were more likely to have a “healthy” dietary pattern than blacks and males, suggesting that race and gender play a role in food choice. A previous study found that SES explained a small proportion of race/ethnic differences in diet (46). Another study focused on the gender differences in healthy eating behavior (47). Male adolescents were mostly influenced by perceived barriers, such as taste of healthy foods, convenience of including healthy foods in their daily diet, and access to affordable and healthy food options. Female adolescents were mostly affected by situations, including the availability and accessibility of healthy or unhealthy foods at home, and consequences of their eating behavior (47).

A systematic review found that the positive association between SES and a healthy dietary pattern among children and adolescents was only significant in developed countries (48). In our case, adolescents’ consumptions of food were also associated with their parental SES. Besides knowledge of nutrient facts, affordability and availability of healthy food could be important determinants of dietary patterns as well. Accessibility of healthy food and perceived parental rules limiting unhealthy food intake were suggested to mediate the association between parental education and dietary pattern (49). A total of 49% of our adolescents were 16 y and older;

thus, they may make their own dietary choices for most of the day.

Family structure is an important factor for adolescents associated with the unhealthy dietary pattern. Among the overall cohort, adolescents living with both parents and the ones with stay-at-home mothers were more likely to adopt a healthy dietary pattern. Previous studies also have discovered the importance of parental companions. An 8-h workday was associated with a significant reduction in food preparation time among employed mothers (50), who have a greater influence on the weight of the children than fathers have (51). A study found that having a mother stay at home in early to middle childhood was associated with better diet quality in adolescence, which might help to establish healthy eating habits and have a long-term effect on health outcomes (52).

In our study, 75.6% of the adolescents who had a “healthy” dietary pattern were white and only 24.4% were black. Moreover, a “healthy” dietary pattern was associated with stay-at-home mother in the whites, and living with both parents and stay-at-home father in the blacks. The different findings may be due to the distinct family structures between races. Most (78%) white adolescents lived with both parents, whereas only half (47%) of black adolescents lived with both parents. The underlying explanations were unknown due to the limitations of our data set.

It is noteworthy that, in our study, the “SSB and fried food” dietary pattern was most prevalent of the 4 patterns, and was associated with more CVD risk factors than the other patterns. It was associated with higher percentage body fat, waist circumference, SBP, fasting insulin, HOMA-IR, and CRP. Other studies have also shown that SSB consumption is related to several CVD risk factors, including blood pressure (53–55), fasting insulin (56), insulin resistance (56–58), CRP (59, 60), and waist circumference (59, 61). In prospective studies, SSB consumption was further associated with a greater incidence of type 2 diabetes (62), heart failure (HF) (63), and coronary artery disease (64). SSB consumption is also a driver of purchasing other poor-quality food (65), such as fried food, which also has a deleterious impact on cardiovascular health (66), hypertension (67), and HF (68). We found that in the southeastern region of the United States, the consumption of SSBs and fried food were correlated, and in combination they defined the most prevalent dietary pattern.

Adolescents reporting the “processed meat” dietary pattern exhibited higher SBP, fasting insulin, HOMA-IR, CRP, and total triglyceride. Processed meat consumption has been related to obesity (69, 70), elevated risk of hypertension (71, 72), diabetes, HF (73, 74), CVD mortality (75), and even all-cause mortality (76). Processed meat

**TABLE 3** Distribution of dietary patterns by race, family status, and parental working status<sup>1</sup>

Groups	Healthy	Snacks and sweets	Processed meat	SSB and fried food	P
Whites (n = 384)	93 (25)	112 (30)	71 (19)	101 (27)	
Living with mother alone (n = 66)	13 (20)	17 (25)	13 (20)	23 (35)	0.871
Stay-at-home mother (n = 6)	1 (17)	1 (17)	1 (17)	3 (49)	
Working mother (n = 60)	12 (20)	16 (27)	12 (20)	20 (33)	
Living with father alone (n = 14)	3 (21)	4 (29)	3 (21)	4 (29)	0.120
Stay-at-home father (n = 2)	0 (0)	2 (100)	0 (0)	0 (0)	
Working father (n = 12)	3 (25)	2 (17)	3 (25)	4 (33)	
Living with both parents (n = 300)	75 (26)	89 (30)	55 (19)	74 (25)	0.107
Both unemployed (n = 3)	0 (0)	2 (67)	0 (0)	1 (33)	
Stay-at-home mother/working father (n = 74)	25 (35)	18 (25)	17 (24)	12 (17)	
Working mother/stay-at-home father (n = 11)	3 (27)	6 (55)	1 (9)	1 (9)	
Both working (n = 212)	47 (23)	63 (30)	37 (18)	60 (29)	
Blacks (n = 372)	30 (8)	81 (22)	79 (22)	176 (48)	
Living with mother alone (n = 158)	7 (5)	38 (24)	37 (24)	74 (47)	0.909
Stay-at-home mother (n = 32)	1 (3)	9 (28)	8 (25)	14 (44)	
Working mother (n = 126)	6 (5)	29 (23)	29 (23)	60 (49)	
Living with father alone (n = 12)	0 (0)	2 (17)	4 (33)	6 (50)	N/A
Stay-at-home father (n = 0)	N/A	N/A	N/A	N/A	
Working father (n = 12)	0 (0)	2 (17)	4 (33)	6 (50)	
Living with both parents (n = 173)	22 (13)	33 (19)	30 (17)	88 (51)	0.107
Both unemployed (n = 8)	4 (50)	0 (0)	1 (13)	3 (37)	
Stay-at-home mother/working father (n = 32)	2 (6)	7 (22)	8 (25)	15 (47)	
Working mother/stay-at-home father (n = 11)	2 (18)	1 (9)	2 (18)	6 (55)	
Both working (n = 122)	14 (12)	25 (20)	19 (16)	64 (52)	

<sup>1</sup>Values are n (%) unless otherwise indicated. There were missing values of family structure and working status. Row percentages are presented. N/A, not available; SSB, sugar-sweetened beverage.

usually contains SFA, cholesterol, sodium, and nitrates, which have been demonstrated to be risk factors for a variety of chronic diseases (69).

Although the mechanisms whereby dietary intake is associated with CVD risk factors are not fully elucidated, several hypotheses have been proposed. First, the associations of dietary intake and CVD risk factors could be mediated by body weight (37, 77). Second, the

increased glycemic load resulting from sugar intake might result in insulin resistance,  $\beta$ -cell dysfunction, and inflammation, leading to elevated blood pressure and risk of CVD (78). Third, chronic low-grade systemic inflammation caused by poor-quality food may also contribute to insulin resistance (37). The elevated CRP in all 3 less healthy groups found in this study supports these hypotheses. We found that

**TABLE 4** RRR of dietary patterns by parental SES in white adolescents<sup>1</sup>

SES	Snacks and sweets, RRR (95% CI)	Processed meat, RRR (95% CI)	SSB and fried food, RRR (95% CI)
Age <sup>2</sup>	0.88 (0.70, 1.12)	0.69 (0.52, 0.92)	0.88 (0.69, 1.12)
Sex <sup>2</sup>			
Male	Reference		
Female	0.69 (0.38, 1.23)	0.22 (0.11, 0.43)	0.29 (0.16, 0.54)
Family structure <sup>2</sup>			
Living with mother alone	Reference		
Living with father alone	1.05 (0.20, 5.60)	1.08 (0.17, 6.73)	0.73 (0.14, 3.91)
Living with both parents	0.95 (0.43, 2.09)	0.83 (0.35, 1.97)	0.63 (0.29, 1.35)
Mother's education <sup>3</sup> (n = 358)	0.73 (0.48, 1.09)	0.66 (0.42, 1.05)	0.48 (0.32, 0.72)
Mother's occupation <sup>3,4</sup> (n = 278)	0.95 (0.77, 1.16)	1.10 (0.86, 1.41)	0.88 (0.72, 1.09)
Stay-at-home mother <sup>3</sup> (n = 359)	0.55 (0.28, 1.08)	0.71 (0.34, 1.52)	0.42 (0.20, 0.89)
Father's education <sup>5</sup> (n = 307)	0.42 (0.27, 0.68)	0.71 (0.41, 1.24)	0.37 (0.23, 0.61)
Father's occupation <sup>4,5</sup> (n = 291)	0.70 (0.58, 0.84)	0.82 (0.66, 1.01)	0.66 (0.54, 0.79)
Stay-at-home father <sup>5</sup> (n = 307)	2.96 (0.77, 11.28)	0.41 (0.04, 4.21)	0.59 (0.09, 3.77)

<sup>1</sup>RRR is the ratio of relative risks of an adolescent adopting a certain dietary pattern other than the "healthy" dietary pattern when he/she is in a certain SES category compared with the reference group. RRR, relative-risk ratio; SES, socioeconomic status; SSB, sugar-sweetened beverage.

<sup>2</sup>Including all participants, adjusted for age, sex, and family structure (n = 373).

<sup>3</sup>Including participants living with both parents or just mother, adjusted for age, sex, and family structure.

<sup>4</sup>Occupation in this table excludes housewife/househusband/unemployed.

<sup>5</sup>Including participants living with both parents or just father, adjusted for age, sex, and family structure.

**TABLE 5** RRR of dietary patterns by parental socioeconomic status in black adolescents<sup>1</sup>

SES	Snacks and sweets, RRR (95% CI)	Processed meat, RRR (95% CI)	SSB and fried food, RRR (95% CI)
Age <sup>2</sup>	1.33 (0.92, 1.93)	1.08 (0.73, 1.58)	1.24 (0.88, 1.75)
Sex <sup>2</sup>			
Male	Reference		
Female	1.18 (0.47, 2.93)	0.35 (0.14, 0.86)	0.53 (0.23, 1.21)
Family structure <sup>2</sup>			
Living with mother alone	Reference		
Living with father alone	N/A	N/A	N/A
Living with both parents	0.28 (0.11, 0.75)	0.26 (0.10, 0.69)	0.39 (0.16, 0.96)
Mother's education <sup>3</sup> (n = 321)	0.59 (0.34, 1.00)	0.81 (0.47, 1.40)	0.65 (0.40, 1.06)
Mother's occupation <sup>3,4</sup> (n = 246)	0.74 (0.56, 0.97)	0.73 (0.55, 0.97)	0.76 (0.59, 0.97)
Stay-at-home mother <sup>3</sup> (n = 329)	0.87 (0.31, 2.46)	1.13 (0.40, 3.20)	0.75 (0.29, 1.95)
Father's education <sup>5</sup> (n = 183)	0.50 (0.25, 1.01)	0.75 (0.37, 1.52)	0.45 (0.24, 0.82)
Father's occupation <sup>4,5</sup> (n = 164)	0.99 (0.74, 1.33)	1.00 (0.73, 1.37)	0.92 (0.71, 1.20)
Stay-at-home father <sup>5</sup> (n = 185)	0.08 (0.01, 0.73)	0.31 (0.07, 1.52)	0.29 (0.09, 0.97)

<sup>1</sup>RRR is the ratio of relative risks of an adolescent adopting a certain dietary pattern other than the "healthy" dietary pattern when he/she is in a certain SES category compared with the reference group. N/A, not available; RRR, relative-risk ratio; SSB, sugar-sweetened beverage.

<sup>2</sup>Including all participants, adjusted for age, sex, and family structure (n = 341).

<sup>3</sup>Including participants living with both parents or just mother, adjusted for age, sex, and family structure.

<sup>4</sup>Occupation in this table excludes housewife/househusband/unemployed.

<sup>5</sup>Including participants living with both parents or just father, adjusted for age, sex, and family structure.

percentage body fat was highest among adolescents with a "healthy" pattern, which seemed due to the imbalanced distribution of sex groups. Compared with the other dietary patterns, the "healthy" dietary pattern group had a higher percentage of females and the females had much higher percentage body fat than the males. When stratified by gender, the mean percentage body fat of the "healthy" dietary pattern was actually lower than the other 3 groups in either gender group (male: 16.8% in "healthy" compared with 18.6% others; female: 29.6% in "healthy" compared with 29.7% others).

The present study has a number of strengths. First, to our knowledge for the first time we addressed the issue of dietary patterns and cardiovascular health in the southeastern region of the United States, which is part of the "Stroke Belt." Second, this study focused on adolescents, an understudied population. Third, we further analyzed the race, gender, socioeconomic, and family structure determinants of the adoption of dietary patterns. Fourth, the dietary intake measurements were based

on seven 24-h recalls, the validity and the reliability of which were better than the two 24-h recalls used by most similar studies (79, 80). Limitations of our study should also be recognized. First, no causal relation can be concluded from our cross-sectional study. Second, only data on race, family structure, parental education, and occupation were collected; other SES indicators such as household income were missing. Third, there may be a mixture of involuntary parental unemployment or voluntary staying at home while caring for younger children. However, we were not able to distinguish these 2 groups due to the lack of information collected. Moreover, other characteristics of adolescents such as mood, body image, media usage, vegetarian beliefs, etc., which may affect their own food choices, may exert a significant influence (81). However, we were unable to include those factors in our analysis due to the lack of data collected on these variables. Furthermore, no correction was made for multiple comparisons because a few planned hypothesis-driven comparisons may not need a formal correction (82).

**TABLE 6** Adjusted associations between dietary patterns and CVD risk factors compared with the healthy dietary pattern<sup>1</sup>

CVD risk factors	Snacks and sweets, $\beta$ (95% CI)	Processed meat, $\beta$ (95% CI)	SSB and fried food, $\beta$ (95% CI)
BMI percentile <sup>2</sup> (n = 651)	-0.05 (-0.12, 0.01)	-0.04 (-0.11, 0.03)	0.03 (-0.04, 0.09)
Percentage body fat <sup>2</sup> (n = 743)	-0.09 (-1.98, 1.80)	0.01 (-2.05, 2.06)	2.03 (0.18, 3.88)
Waist circumference <sup>2</sup> (n = 743)	-0.48 (-2.90, 1.93)	0.26 (-2.38, 2.89)	2.71 (0.34, 5.08)
Systolic blood pressure (n = 649)	3.16 (1.09, 5.22)	2.96 (0.70, 5.21)	2.67 (0.65, 4.69)
Diastolic blood pressure (n = 649)	1.14 (-0.28, 2.55)	0.16 (-1.39, 1.70)	0.97 (-0.42, 2.35)
Fasting insulin <sup>3</sup> (n = 615)	0.17 (0.06, 0.28)	0.18 (0.06, 0.30)	0.23 (0.12, 0.34)
HOMA-IR <sup>3</sup> (n = 606)	0.20 (0.09, 0.31)	0.18 (0.06, 0.31)	0.22 (0.11, 0.33)
C-reactive protein <sup>3</sup> (n = 589)	0.17 (-0.23, 0.57)	0.59 (0.16, 1.03)	0.56 (0.17, 0.95)
Total triglyceride <sup>3</sup> (n = 607)	0.07 (-0.04, 0.18)	0.13 (0.00, 0.25)	0.08 (-0.03, 0.19)

<sup>1</sup> $\beta$  value stands for the changes in CVD risk factors associated with changing diet from a "healthy" pattern to corresponding patterns. All models were adjusted for age, gender, race, BMI percentile, and energy intake. CVD, cardiovascular disease; SSB, sugar-sweetened beverage.

<sup>2</sup>This model was adjusted for age, gender, race, and energy intake. Waist circumference was further adjusted for height.

<sup>3</sup>Dependent variables were ln transformed.



In conclusion, race, gender, family structure, parental working status, and SES are associated with diet quality in adolescents. Moreover, “snacks and sweets,” “processed meat,” and “SSB and fried food” dietary patterns are all associated with worse CVD risk profiles.

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