Nutrition Research and Practice (*Nutr Res Pract*) 2010;4(6):528-534
DOI: 10.4162/nrp.2010.4.6.528

Adolescents' health behaviors and obesity: Does race affect this epidemic?

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Abstract

This study explores the influence of health behaviors and individual attributes on adolescent overweight and obesity using data from Wave II (Add Health). Structural equation model/ path analysis using maximum likelihood estimation was utilized to analyze the relationships of health behaviors and attributes with obesity. Results of the model reveal that the causal paths (adolescents' attributes and health behaviors) for overweight and obesity were different for African American and Caucasian adolescents. Generally, African Americans were more susceptible to overweight and obesity than Caucasians. Although increasing levels of vigorous physical activities lowers the risk for obesity among African American and Caucasian adolescents alike, low family SES and being sedentary were associated with overweight and obesity among Caucasians. No significant associations were found among African Americans. Increased hours of sleep at night relate positively with obesity among African Americans. These findings suggest important elements in the consideration of race in developing effective intervention and prevention approaches for curbing the obesity epidemic among U.S. adolescents.

Key Words: Adolescents, obesity, health behaviors, racial disparities, SES

Introduction

Overweight and obesity has reached epidemic proportions worldwide, affecting both genders, and all ages, racial and ethnic groups, and levels of economic status of the population [1,2]. In the United States, the obesity crisis potentially affects every state, city, community, and school across the nation, and nearly 2 out of 3 Americans [3]. Current data from the National Health and Nutrition Examination Survey [NHANES] show an estimated 74% of U.S. adults aged 20 and older are overweight or obese, along with 17% of children and adolescents aged 2-19 years [1]. Among adolescents aged 12 to19 years, obesity increased from 30% in 1999-2000 to 34% in 2007-2008 [4], and this trend appears to be continuing into the next generation.

Overweight and obesity are associated with numerous and varied deleterious health problems, ranging from premature death to several chronic conditions that adversely impact the overall quality of life [5]. Overweight adolescents are 8.5 times more susceptible than their leaner peers to hypertension, diabetes, and heart disease as young adults [6]. In addition, overweight adolescents are 18 times more likely than their normal-weight peers to become obese in early adulthood [7], and nearly 3 out of every 4 overweight adolescents may become obese adults [3].

The consequential adverse relationships of overweight and obesity with quality of life have spurred special concern for educators and health professionals to understand obesity and seek its correlates. Previous studies indicate that disparities in the prevalence of overweight and obesity in the U.S. follow an SES gradient. Lower SES groups are more likely than higher SES groups to be obese [8]. At the same time, certain subgroups of the U.S. population are at increased risk, in particular, the prevalence of obesity is soaring among African Americans and Hispanics more than any other ethnic groups. According to the National Health and Nutrition Examination Survey, 2007-2008, African American adolescent girls were more than twice as likely to be overweight as were their White counterparts (29%, vs. 14%) [9]. These estimates suggest that increases in obesity are correlated with SES and race/ethnicity.

Although genetic compositions undoubtedly contribute to an individual's susceptibility to weight gain, they cannot explain the increased prevalence in the rate of weight gain by age in recent years [3,10]. Genetic characteristics have not changed over the past two decades, but the prevalence of overweight and obesity among children, adolescents, and adults has approximately doubled [11]. According to studies by Baur [12] and Carmona [3], the fundamental reason for increasing prevalence of adolescent obesity is significant changes in lifestyle.

Even though, a growing body of research identified proximal and distal factors as contributing to the prevalence of obesity, there is, however, a paucity of research regarding individual

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Received: July 21, 2010, Revised: December 5, 2010, Accepted: December 5, 2010

health behaviors and racial disparities in the prevalence of obesity among adolescents. In addition, there is no known study that incorporated adolescents' health behaviors into one comprehensive model to examine the influence of all these variables together and of each separately on adolescent obesity.

Thus, the purpose of this study was to assess the associations among adolescents' attributes (family SES, age, race), health behaviors (vigorous physical activity, sedentary activity, fruit and vegetable intake, hours of sleep), and obesity, using a path analysis/structural equation model (SEM). The proposed model tested whether race moderates the relationship of adolescents' attributes, including SES and health behaviors, on obesity. We hypothesized that: (a) low family SES would increase BMI; (b) high family SES would increase dietary intake of fruits and vegetables, leading to decreased BMI; (c) low vigorous physical activity and few hours of sleep at night would increase BMI; and (d) sedentary activities would raise BMI levels.

Subjects and Methods

Participants

This study used the second-wave data from the National Longitudinal Study of Adolescent Health (Add Health). Add Health is a longitudinal study collected in four waves on adolescents' lifestyles and health-related behaviors in the U.S. All high schools in the U.S. with an 11th grade enrolling a minimum of 30 students and a feeder school qualified for the study. High schools were stratified into 80 clusters by region, urbanicity, school size and type, ethnicity, and curriculum. The final sample for the study consisted of 134 schools, with school size ranging from 125 to more than 2,000 students. Minority adolescents were oversampled. The first wave consisted of 20,745 adolescent in-home interviews and 17,700 parent questionnaires.

The second-wave data used in this study were collected with the same Wave I in-home interview sample. During Wave II, 14,738 adolescents completed in-home interviews. Telephone interviews were also conducted with 128 school administrators to update school information. This study utilized in-home interview data of only Caucasian and African American adolescents at Wave II. The second-wave data were selected because adolescence (ages 14-18 years) has been identified as a critical period for the development of overweight and obesity. In addition, Wave II provides detailed information on adolescent nutrition, one of the main independent variables (not available in Wave I or Wave III) for the assessment of adolescents' dietary intake of fruits and vegetables.

Measures

Adolescent obesity

Body mass index (BMI), defined as weight in kilograms divided by height in meters squared (kg/m^2) with age- and gender-specific percentile values [13] were used to categorize adolescents as overweight and obese. Adolescents with BMI between the 85th and 95th percentiles for their age and gender were considered overweight, and those with BMI higher than the 95th percentile for age and gender were categorized as being obese. Self-reported weight and height were used to compute the BMI.

Demographic variables

Demographics of gender, race, and age were assessed. Race was measured using self-reports from adolescents. A set of dichotomous variables (coded 0 and 1) was used to contrast race/ethnicity of Caucasians and African Americans. Age was self-reported in the questionnaire, but only Caucasians and African Americans aged 14 to 18 years were selected for the study because of the increasing health disparities between them [14].

Socioeconomic status

Adolescents' SES was assessed by three hardship items reported by the parent at Wave I and linked directly to each adolescent in the Wave II data set by identification numbers. These SES variables were selected based on exploratory factor analysis. The items loaded on one common factor. Also, previous research used similar items to measure family economic hardship [15,16]. The three items used to measure SES include: (1) "Are you receiving public assistance, such as welfare?" (2) "Are you receiving Aid to Families with Dependent Children?" and (3) "Are you receiving food stamps?" A single score was computed by summing these three items, with the highest scores signifying low SES (greatest economic adversity). The Cronbach's alpha standardized reliability coefficient for this measure was 0.85.

Vigorous physical activity

Adolescent vigorous physical activity was measured using three items selected based on previous studies that used similar items to assess vigorous physical activity among adolescents [17,18]. (1) "During the past week, how many times did you go roller-blading, roller-skating, skate-boarding, or bicycling?" (2) "During the past week, how many times did you play an active sport, such as baseball, softball, basketball, soccer, swimming, or football?" and (3) "During the past week, how many times did you exercise, such as jogging, walking, doing karate, jumping rope, doing gymnastics, or dancing?" Responses to the above items ranged from 0 (not at all) to 3 (5 or more times). To generate a total average vigorous activity score for each adolescent, the 3 items were summed and then divided by 3, with scores ranging from 0 (low) to 3 (high). The mean score of vigorous activity was 1.2.

Sedentary activity

Sedentary activity patterns of adolescents were measured based on extant literature. Previous studies used similar items, including watching television and playing video or computer games to measure sedentary lifestyles in adolescents [19,20]. Three items were selected to measure sedentary activities among adolescents: (1) "How many hours a week do you watch television?" (2) "How many hours a week do you watch videos?" and (3) "How many hours a week do you play video or computer games?" The sum of these three items was computed to generate a total score of sedentary activity for each adolescent, with a higher score representing a high level of adolescent sedentary lifestyle. On average, adolescents spend approximately 21 hours per week on sedentary activities.

Adolescents' intake of fruits and vegetables

Given the previous research that shows consuming diets rich in vegetables, legumes, fruits, and whole grains daily will sustain a total fat intake without the risk of unhealthy weight gain [5], adolescent dietary intake focused on consumption of fruits and powerhouse vegetables. The classification of foods into the fruits and powerhouse vegetables group was based on their nutrient content and examples of foods in the food pyramid [21]. A total score was generated based on whether adolescents ate a particular fruit and powerhouse vegetable the day before, as a regular meal or a snack, coded 0 (does not eat the fruit or vegetable) or 1 (consumes the food item) [22]. In previous research, test-retest reliability of fruits and vegetable measures for adolescents was found to have good reliability of 0.68. For validity, the measure correlated significantly with serving of fruits and vegetables assessed by the food records (Spearman's $r = 0.23$, $P = 0.008$) [23]. Examples of the items considered include: (1) "Yesterday, did you eat apples, apple sauce, pears, or pineapple?" (2) "Yesterday, did you eat oranges, grapefruit, tangerines, or kiwi?" (3) "Yesterday, did you eat bananas, plantains, grapes, berries, or cherries?" (4) "Yesterday, did you eat broccoli?" (5) "Yesterday, did you eat cabbage or bok choy?" (6) "Yesterday, did you eat spinach?" and (7) "Yesterday, did you eat string beans, green beans, peas, or snow peas?" Previous studies have used similar items to assess children's and adolescents' consumption of healthy foods [24]. Higher scores signify dietary intake rich in fruits and powerhouse vegetables. The Cronbach's alpha standardized coefficient of reliability for these items in the present study was 0.67.

Hours of sleep

Although different age groups need different amounts of sleep, and sleep needs are individual, inadequate sleep can lead to serious health consequences, such as increased BMI, increased risk of diabetes, and heart problems [25,26]. The hours of sleep adolescents normally get was assessed by a single item: "How many hours of sleep do you usually get?" Responses ranged from 2 to 16 hours. The average hours of sleep adolescents reported they usually get was 7.6.

Statistical analysis

The proposed moderation model examined whether race moderates the influence of adolescents' attributes including SES and health behaviors on obesity. A fully saturated structural equation model (estimated with LISREL 8.7 using the maximum likelihood procedure) with observed variables (that is, a path model) was estimated [27]. Five indices were used to assess goodness of fit of the model: (a) chi-square with *P*-value > 0.05; (b) root mean square error of approximation (RMSEA) less than 0.05; (c) comparative fit index (CFI) greater than 0.95; (d) standardized root mean square residual (SRMR) less than 0.09; and adjusted goodness of fit index (AGFI) greater than 0.95 [28-30].

Results

The BMI categories defined by the Centers for Disease Control and Prevention, with age- and gender-specific percentile values for children and adolescents aged 2 to 20 years, are presented in Table 1. Bivariate correlations among the study variables also appear in Table 2. The structural model was estimated, and some of the structural parameter estimates were nonsignificant. To ensure model parsimony [31], those structural paths were trimmed from the model. An estimation of the trimmed model (see Fig. 1.) provided a very good fit to the data, χ^2 (10, n =

Table 1. Adolescents' BMI levels defined by CDC growth chart by race and gender

Race	Underweight (%)	Normal (%)	Overweight (%)	Obese (%)
Caucasian (n = 2,696)	2.2	72.1	14.5	11.2
African American (n = 899)	2.0	63.8	20.6	13.6
Total	2.1	70.1	16.0	11.8

N = 3, 596. Data are from wave ii of national longitudinal study of adolescent health.

Table 2. Bivariate correlations among study variables

Variables	1	2	3	4	5	6	7
1. Family SES	--						
2. Vigorous activity	-0.03	--					
3. Sedentary activity	0.13**	0.02	--				
4. Sleeping pattern	0.01	0.08**	0.10**	-			
5. Fruit intake	-0.03	0.24**	-0.05**	0.08**	-		
6. Vegetable intake	-0.05**	0.13**	-0.02	0.03*	0.37**	-	
7. Adolescent BMI	0.05**	-0.08**	0.05**	-0.05**	-0.007	-0.02	-
Mean	0.28	1.20	21.33	7.62	1.23	1.45	22.87
Standard Deviation	0.76	0.68	2.87	1.39	1.28	1.40	4.58

* $P < 0.05$; ** $P < 0.01$

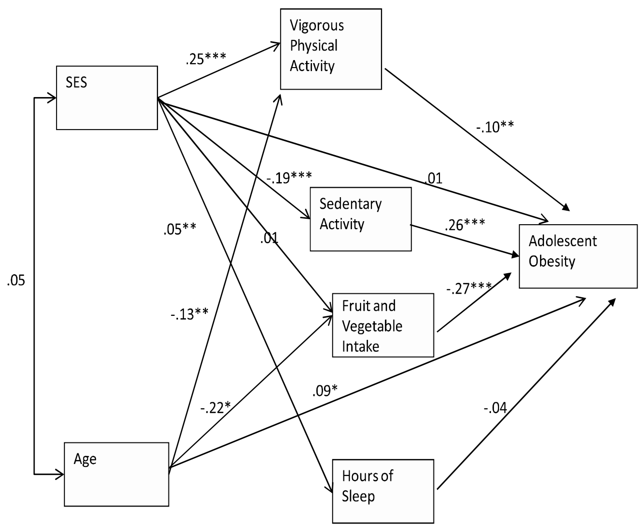

Fig. 1. Adolescents' health behaviors and obesity. *** $P<0.001$, ** $P<0.01$, * $P<0.05$

3,596) = 74.34, $P<0.01$, CFI > 0.999, RMSEA < 0.001, AGFI = 0.98, SRMR = 0.022.

The standardized path coefficients from the trimmed model are presented in Fig. 1. All health behavior paths were significant, as hypothesized, except the path from hours of sleep to adolescent obesity (β = -0.04; $P > 0.05$). Therefore, all of the endogenous manifest variables appeared to have been measured satisfactorily by their respective indicators. Among the exogenous variables, there is a statistically significant direct effect from age to adolescent obesity (β = 0.09; $P<0.05$).

There are statistically significant ($P<0.001$) standardized direct effects from SES to vigorous physical activity (β = 0.25) and sedentary activity (β = -0.19). Also, there are significant ($P<0.01$) standardized effects from SES to sleep (β = 0.05) and age to vigorous physical activity (β = -0.13). In addition, the direct standardized effect from age to fruit and vegetable intake is marginally significant ($P<0.05$). These results suggest that adolescents' family SES and age have significant (positive and inverse) influence on their vigorous physical activity, and may influence their BMI.

There are statistically significant standardized direct effects from sedentary activity and fruit and vegetable intake ($P<0.001$) and vigorous physical activity ($P<0.01$) to adolescents' obesity. However, the standardized direct effect from hours of sleep to adolescents' obesity was insignificant. Thus, being vigorously active and eating sufficient fruits and vegetables are inversely associated with adolescents' obesity, while sedentary lifestyle is positively associated with adolescents' obesity.

To explore whether race moderates adolescent overweight and obesity, two models were analyzed simultaneously to determine if the estimated causal paths for overweight and obesity varied between African America and Caucasian adolescents. The originally hypothesized model yielded a perfect fit, as is true by definition for a saturated model. Paths statistically irrelevant to the multigroup model were trimmed, to obtain a new parsimonious structural model that still fits the data well. A trimmed multigroup model was estimated to determine whether the confirmatory factor structures were different between African Americans and Caucasians. In the first estimation, the factor items were allowed to load freely on the model for African Americans and Caucasians. The multigroup model yielded the χ^2 value of 53.35 with 14 degrees of freedom (CFI > 0.99, GFI = 0.98). Both CFI and GFI values suggest that the multigroup model provided adequate fit to the data [31].

The models showed distinctive loadings on a number of variables for the African American and Caucasian models. The model for Caucasians yielded a worse fit (χ^2 (7) = 41.00, $P<0.01$) than the model for African Americans (χ^2 (7) = 12.36, $P<0.08$), suggesting that the structural paths are different between African Americans and Caucasians. The estimated structural paths with their respective significant pathways are presented in Fig. 2 and 3.

In the model for Caucasians (Fig. 2), significant pathways existed from family SES to adolescents' obesity, β = 0.17, $P<0.01$, from vigorous physical activity to obesity, β = -0.21, $P<0.001$, and from sedentary activity to obesity, β = 0.11, $P<0.01$. For the African American model, there were also significant pathways from vigorous physical activity to

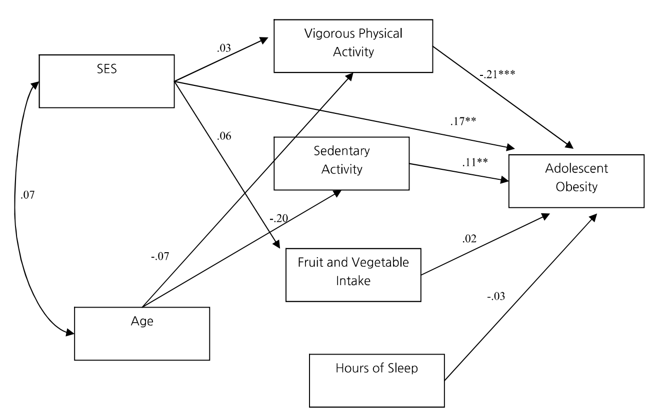

Fig. 2. Structural paths for Caucasions *** $P<0.001$, ** $P<0.01$, * $P<0.05$

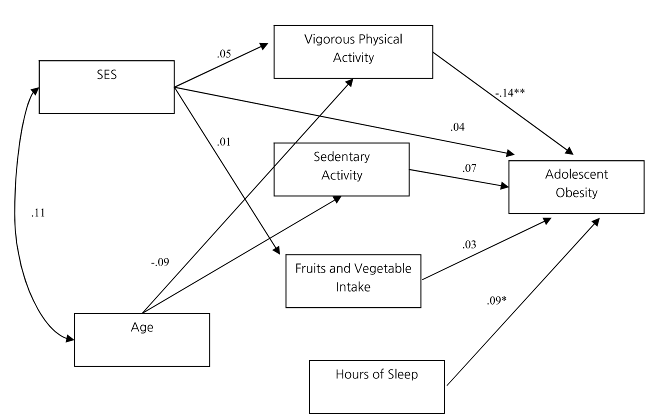

Fig. 3. Structural paths for African Americans *** $P<0.001$, ** $P<0.01$, * $P<0.05$

adolescents' obesity, $\beta = -0.14$, $P < 0.01$ and from hours of sleep to obesity, $\beta = 0.09$, $P < 0.05$. The difference between the structural models lays in the significant pathways between exogenous and endogenous variables. In the model for Caucasian adolescents, two additional significant pathways were noted from family SES and sedentary activity to adolescents' obesity, as compared to the model for African Americans. In addition, a significant pathway from hours of sleep to adolescents' obesity was noted in the African American model, compared to the Caucasian model. Overall, the Caucasian model has more significant pathways as compared with the African American model, and therefore appears to explain better the influences of the exogenous and endogenous manifest variables on adolescents' obesity. Nonetheless, it should be noted that hours of sleep seems to influence obesity in the African American model but not in the Caucasian model.

For a meaningful comparison to be possible, the factor structures between groups need to be invariant [30]. Thus, another model with the structural paths allowed to be invariant was estimated for African Americans and Caucasians. The fit of this model yielded χ^2 (18) = 62.60, $P < 0.01$, and was a significant improvement from the freely estimated structural model, χ^2 (14) = 53.35. Comparing the fit of these two models yielded a significant difference, $\Delta\chi^2$ (4) = 9.25, $P < 0.05$, indicating that the causal paths were different for African Americans and Caucasians.

A final comparison between the models was undertaken with two indices-Akaike's Information Criterion (AIC) and the consistent version of Akaike's Information Criterion (CAIC)-that share the same conceptual framework [28]. The AIC and CAIC are helpful indices to use when comparing two or more models [28]. Upon examination of the AIC and CAIC indices of both models, the model for African Americans had a better fit (AIC = 70.31, CAIC = 238.54) than the model for Caucasians (AIC = 98.71, CAIC = 298.81). Therefore not only are the two models differed in terms of their respective significant pathways, but also in goodness of fit statistics.

Discussion

The present study has three purposes. First, this research explored the role individual attributes (i.e., race, age) and family SES play in the prevalence of African American and Caucasian adolescents' obesity. The relationships of these attributes with health behaviors were also examined. Second, the study examined the influence of health behaviors (i.e., vigorous physical activities, sedentary activities, fruits and vegetables intake, and hours of sleep) on African American and Caucasian adolescents' overweight and obesity. Third, the study investigated the unique influence of race/ethnicity in explaining obesity. SEM (path analysis) was utilized to explain the relationships of these attributes and health behaviors with adolescents' obesity.

The findings in this study support the hypothesis of family SES contributing to the increased propensity of overweight and obesity among African American and Caucasian adolescents, and are consistent with previous research [8]. Of note is the racial disparity in the relationship of family SES with adolescents' obesity. In the multigroup comparison, family SES had a statistically significant positive influence on Caucasian adolescents' obesity, but not for African Americans. Consistent with [32], the relationship between SES and overweight is greater for Caucasian adolescents from lower-income families than are the relationships for minority groups (in this case, African Americans). This may be explained by the higher "buoyancy" that minority adolescents need to survive under adverse conditions, and therefore that they may be less sensitive to the impact of family poverty compared to Caucasians who may not be as contented under such conditions [20]. Thus, we need to focus our intervention measures at the family level, as this lifestyle may persist into several generations because many families are incapable of breaking the (family) poverty cycle.

Regarding the health behavior variables, several significant pathways existed. It was hypothesized that adolescents' low levels of vigorous physical activity and few hours sleep at night would increase obesity. It was also predicted that sedentary lifestyle would raise overweight and obesity levels. Moreover, it was envisaged that dietary intakes of fruits and vegetables would decrease overweight and obesity. These predictions were supported by the findings. Higher levels of vigorous physical activity and daily consumption of sufficient fruits and vegetables statistically significantly decrease the risk for overweight and obesity. Also, being sedentary contributes to overweight status. Literature supports these findings of the relationship of vigorous physical activity and dietary intake of fruits and vegetables with reduced obesity, and sedentary lifestyle as a likely contributor to obesity status [19,33-35]. However, no significant association was found between nightly hours of sleep and overweight. This finding would seem rather peculiar, considering the evidence that exists for the relationships between insufficient night sleep and obesity across all age groups [24,36].

In the group comparison, it was intriguing to find that structural pathways for African Americans and Caucasians were statistically significantly different from each other. Apart from vigorous physical activity significantly predicting obesity for African Americans and Caucasians alike, other endogenous and exogenous variables influencing adolescent obesity were different for each group. Regarding exogenous variables in the model (family SES and age), a significant relationship was found between family SES and obesity for Caucasians. Caucasian adolescents with low family SES were at risk for overweight and obesity. This result is consistent with previous studies in that family SES has a considerable relationship with Caucasians' obesity in comparison with minority groups, in particular African Americans [32,37] Moreover, a significant direct path existed between sedentary activity and obesity for Caucasian adolescents. Literature supports the conclusion that increased participation in sedentary activity augmented the risk for obesity [19,38]. Conversely, the finding in the present study challenges the conclusion [14] that racial differences in obesity, particularly for African Americans, depended on them spending more time than their White counterparts watching television. This finding is surprising, and any conclusions would need to be drawn with caution. Perhaps sedentary activity is not statistically significant in predicting obesity in African American adolescents in this study because of the relatively small sample size.

The notion that sleeping fewer hours at night would increase overweight and obesity was not supported by the results of the stacked model. African Americans demonstrated a positive association between more hours of sleep and obesity. Future research needs to validate the possible variations in the impact of hours of sleep at night on African American and Caucasian adolescents' obesity.

The current study provides invaluable information in the quest to understand the correlates of overweight and obesity, and implications for targeting prevention and intervention endeavors. In general, the current findings are consistent with previous studies of nationally representative samples [35], that found significant associations between high levels of vigorous physical activity and less adiposity in adolescence. In addition, the current study's findings that race is a moderating factor in adolescents' health behaviors (such as sedentary lifestyle and lack of sleep at night) and its associations with overweight and obesity, propose the presence of cultural beliefs and practices that must be considered in developing intervention and prevention programs for youth. The results also underscore racial differences in the link between family SES and obesity for youth and the need for joint effort at the national, state, and community levels in addressing lower levels of family SES, particularly among Caucasians, who demonstrated significant associations between family SES, eating insufficient fruits and vegetables, and being obese.

The data utilized for this study were drawn from a nationally representative sample of adolescents. While the findings support the predictions and lend empirical support to previous research findings, a number of limitations of the present study must be acknowledged. First, the estimation of adolescents' BMI was based on self-reports of weight and height. Personal measurement of weight is subject to error. However, adolescents' self-report of height and weight has been found to be sufficiently accurate in comparison with measured height and weight ($r = 0.92$) [39]. Second, estimates of family SES were computed based on parents' reports, which might be biased. Third, measurement of exogenous and endogenous variables in the study may not be accurate and could obscure associations between variables. Finally, the data are cross-sectional; therefore, proposed causality cannot be determined definitively.

Despite these limitations, this study improves upon previous work by estimating several causal paths simultaneously and unveils important new information about the associations of adolescents' attributes and health behaviors on obesity among African American and Caucasian youth. The study also provides convincing evidence to support the impact of vigorous physical activity on obesity. Understanding distinctive impacts of race/ethnicity on adolescents' obesity is crucial for creating maximum effective intervention and prevention strategies and policies that must be culturally appropriate to curb the obesity pandemic among adolescents in this country. Parents should encourage adolescents to play active sports and exercise 3 to 4 times a week (the moderate level of physical activity). Schools, because they can reach nearly all youth from different racial and social backgrounds, must offer educational curricula (such as family and consumer sciences programs) that provide ample opportunities for students to practice skills that prepare them for living a healthy life throughout their life span. Additionally, communities need to promote vigorous physical activities by creating recreation centers with sports facilities and walking and bicycle trails safe enough for youth.

Acknowledgement

This research uses data from Add Health, a program project directed by Kathleen Mullan Harris and designed by J. Richard Udry, Peter S. Bearman, and Kathleen Mullan Harris at the University of North Carolina at Chapel Hill, and funded by grant P01-HD31921 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development, with cooperative funding from 23 other federal agencies and foundations. Special acknowledgment is due Ronald R. Rindfuss and Barbara Entwisle for assistance in the original design. Information on how to obtain the Add Health data files is available on the Add Health website (http://www.cpc.unc.edu/addhealth). No direct support was received from grant P01-HD31921 for this analysis.

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