

# SOCIAL AND BEHAVIORAL FACTORS ASSOCIATED WITH BMI AND WAIST CIRCUMFERENCE AMONG ADOLESCENTS: THE JACKSON HEART KIDS PILOT STUDY

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**Background:** African American children and adolescents make up a disproportionately large segment of those classified as overweight and obese. The purpose of this study was to examine social and behavioral factors associated with accelerated accumulation of weight and adiposity among this group.

**Methods:** The data for this cross-sectional study were drawn from the Jackson Heart KIDS Pilot Study – an offspring cohort study comprising 12- to 19-year-old descendants of Jackson Heart Study participants (N=212). Body mass index (BMI) and waist circumference were the outcomes of interest. Daily hassles, fruit and vegetable consumption, physical activity, television watching, parent/grandparent weight status and participant birth weight, age and sex were the independent variables included in the analyses.

**Results:** Males and females were equally represented in the study and the mean BMI and waist circumference for adolescents in the study was  $25.81 \pm 7.78$  kg/m<sup>2</sup> and  $83.91 \pm 19.81$  cm, respectively. Fully adjusted linear regression models for the total sample produced results indicating that age, television viewing, weight control, and parental weight status were positively associated with BMI and waist circumference, respectively. Findings from sex-stratified models for BMI and waist circumference indicated that the significance of coefficients for age, television viewing, and parent/grandparent weight status varied by sex.

**Conclusions:** Knowledge is limited about how sex or gender interact with social and behavioral factors to influence African Americans' health and additional studies are needed to specify how these factors interact to accelerate weight gain and adipose tissue

## INTRODUCTION

Adolescents who are overweight or obese have elevated risks for poor health because excess body weight is a risk factor for the early onset and accelerated progression of cardiovascular diseases and even some cancers.<sup>1-6</sup> African American children and adolescents continue to make up a disproportionately large segment of youth classified as overweight or obese, raising concerns about a widening of racial disparities in cardiovascular health.<sup>7</sup> These patterns are persistent and there is an urgent need for research examining factors

associated with excess weight among African American adolescents.<sup>7</sup>

The preponderance of studies examining excess weight among adolescents use age- and sex-specific body mass index (BMI) percentiles based on Centers for Disease Control and Prevention (CDC) growth reference curves to identify weight categories in children and adolescents.<sup>2,7-10</sup> BMI is a widely accepted measure used to classify weight status and it is assumed that overweight or obese classifications are indicative of an overabundance of adipose tissue. The distribution of excess adiposity can vary across individuals and studies over

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the past two decades suggest that abdominal adiposity is a risk factor for poor health in adults and youth.<sup>11,12</sup> Abdominal obesity during adolescence has been linked to the alteration of biological processes through adipokines and other pathways in endocrine, neurological, pulmonary, and cardiovascular systems<sup>7</sup> that are associated with the premature development of disease conditions such as insulin resistance,<sup>4</sup> hypertension,<sup>7,8</sup>

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and coronary heart disease.<sup>12,13</sup> BMI, however, does not explicitly measure abdominal adiposity and may be a poor indicator of metabolic disease risk among pediatric populations.<sup>13,14</sup>

The utility of BMI for assessing cardiovascular disease risk among African American adolescents is debatable. Weber and colleagues<sup>15</sup> note that BMI is limited by its failure to

distinguish fat mass and lean body mass. Results from their analysis of National Health and Nutritional Exam Study data indicated that African American adolescents and children had greater lean body mass than their peers from other racial and ethnic groups.<sup>15</sup> The salience of BMI as a marker of health for African Americans has been further questioned because it does not accurately account for the increased fat-free body mass density among African Americans.<sup>3</sup> BMI also has limited utility for comparisons by sex. Adiposity varies by sex over the lifecourse and Daniels and colleagues<sup>16</sup> assert that BMI should not be used as an equivalent measure of fatness in males and females. The preponderance of pediatric weight-related research with African Americans has focused primarily on girls. Data about obesity among African American male children and adolescents have been largely absent from the literature<sup>7,17</sup> and there is an urgent need to understand sex, gender and related factors contributing to excess weight and adiposity.

Waist circumference has been introduced as an alternative to BMI because it is a more localized proxy for central adiposity; however, there are no studies to our knowledge that concurrently explore factors associated with BMI and those related to central adiposity measures such as waist circumference among African American adolescents.

The purpose of this study was to examine factors known to be linked with the accumulation of excess weight in adolescents and their association with two measurements of adiposity (BMI and waist

circumference) among adolescents participating the Jackson Heart KIDS Pilot Study (JHS-KIDS).

## METHODS

Data for the present cross-sectional study were drawn from JHS-KIDS, a prospective offspring cohort feasibility study designed to examine sensitive developmental and transition periods and their associations in the development of CVD-related risk factors, including obesity. Eligible participants for this study were children or grandchildren of Jackson Heart Study (JHS) participants and were aged between 12-19 years. After receiving approval from the University of Mississippi Medical Center Institutional Review Board, multiple methods were used to recruit participants through contact with JHS participants. Detailed information about the recruitment methods is provided elsewhere.<sup>7</sup> Interested parents or grandparents called the study office and received additional information about the study, had the opportunity to ask questions, and responded to screening questions to ensure eligibility. All participants aged >18 years in the study associated with this research freely provided informed consent. All participants younger than aged 18 years freely provided assent and their parent or legal guardian freely provided informed consent.

Eligible youth and an accompanying parent or grandparent attended a study visit in which they received further information about the study and completed consent and assent forms prior to data collection. Adolescents had their blood pressure,

height, weight, and waist circumference measured by trained data collectors, and were asked to complete a self-administered survey containing a number of psychosocial (ie, daily hassles, bullying experiences, religiosity/spirituality) and health behavior (ie, nutrition, physical activity) measures. The accompanying parent or grandparent, regardless of their participation in the JHS, had their blood pressure, height, and weight measured and were asked to complete the Childhood Feeding Questionnaire. The total number of adolescents participating in the pilot study was 212, equally divided between females (n=107) and males (n=105).

### Study Variables: Outcome Variables

#### *Body mass index (BMI)*

BMI was calculated by dividing weight in kilograms by height in meters squared. Height was measured using a Shorr Height Measuring Board and weight was measured using a Seca 770 Model scale.<sup>7</sup>

#### *Waist circumference (WC)*

WC was measured in triplicate to the nearest tenth of a centimeter using a Tech-Med Model #4414 fiberglass measuring tape (Hauppauge, NY). Participants were instructed to loosen or adjust their own clothing, point to their navel, and breathe normally while trained research personnel took measurements.

### Study Variables: Independent Variables

A daily hassles score was derived from a self-reported inventory of

18 items measuring the adolescent's experience with hassles related to school, social relationships, family relationships, and health.<sup>10</sup> Respondents were asked to rate the extent to which each item had been a hassle during the past week using responses on a 4-point Likert scale, ranging from "not at all a hassle" to "a very big hassle." The responses were summed to create an overall score of the number of hassles, ranging between 0 and 54, with higher scores representing greater experience of hassles.

Adolescent health behavior variables were derived from responses to items about diet, physical activity, and television viewing. The recommended fruit and vegetable consumption variable was a binary (yes/no) variable derived from the composite of responses to items asking respondents to report their consumption of fruits and vegetables during the previous week. The physical activity variable was derived from the response to an item asking participants to provide the number of days they participated in at least 60 minutes of physical activity during the past week. The television watching variable was derived from an item asking participants to provide the number of hours spent watching television on an average school day. The weight control variable was a composite measure of responses to items asking respondents if they ever attempted to lose weight by exercising, eating less, fasting, using dietary supplements, or purging. All response choices were "yes" or "no" and were summed to create a weight control score ranging between 0 and 5, with higher scores representing more attempts at controlling weight.

Adolescent birth weight, age, and sex were included in the analytic models. Adolescent birth weight (in pounds) and current age (in years) were reported at the time of study enrollment. Adolescent sex was based on the response asking participants to identify themselves as male or female.

Anthropometric data from accompanying parents/grandparents were also included in this analysis. Approximately 30% of the accompanying adults were grandparents and their inclusion did not significantly impact analysis in previous studies.<sup>7,18</sup> Parent/grandparent weight status was a three-category variable (normal weight, overweight, and obese) based on BMI calculated using the same formula ( $BMI = \text{weight in kilograms} / \text{height in meters}^2$ ) and procedures for adolescent participants.<sup>7</sup> Cut points for each BMI category are those specified by the Centers for Disease Control and Prevention.<sup>19</sup>

### Analytic Strategy

Sample characteristics were generated for the total sample and by sex using means and standard deviations for continuous variables and proportions for categorical variables. T-test and Chi-square tests were used to assess how female and male adolescents varied across the study variables included in the analysis. Fully adjusted ordinary least squares regression models were estimated to examine relations between health behaviors and adolescent BMI and waist circumference, respectively. Regression models including all variables were estimated for the total sample, a female subsample, and male subsample independently. P-values <.05 were considered

significant. All statistical analyses were conducted with Stata/SE Version 16.

## RESULTS

Descriptive statistics characterizing the sample of African American adolescents (N=212) in the JHS-KIDS study are presented in Table 1. Males and females were equally represented in the study sample and the average age of study participants was slightly greater than 15 years (15.16 ± 2.19). The mean BMI and waist circumference for adolescents in the study was 25.81±7.78 kg/m<sup>2</sup> and 83.91 ± 19.81 cm, respectively. The average birth weight for adolescents in the sample was 6.88±1.5 lbs and the mean daily hassles score for study participants was 24.41±10.30. Nearly one-third of the study group (32.08%) reported eating five or more fruits and vegetables each day. The total sample reported exercising 60 minutes a day on an average of 3.41±2.25 days per week. The adoles-

cents in the sample reported an average of 3.61±1.85 hours of daily television viewing time on school days and had a mean weight control score of 1.5±1.1. Two-thirds of parent/grandparent participants (66.04%) could be classified as obese. Sex-stratified descriptive statistics presented in Table 1 also indicated that the male and female adolescents were similar across most of the variables in the analysis. The only exceptions were physical activity and weight control score. Males had higher levels of physical activity (3.91±2.33 vs 2.92±2.07) and females had higher weight control scores (1.8±1.0 vs 1.2±1.0).

### Adolescent Body Mass Index

Results from the fully adjusted models examining the association between BMI and health behaviors for the total sample and by sex are presented in Table 2. Estimates from the regression model for the total sample indicate that the hassles score was inversely related to BMI while age, television viewing, weight control,

and parent/grandparent weight status were positively associated with BMI (shown as kg/m<sup>2</sup>). A one-point increase in the adolescent hassles score was associated with a .10 decrease in BMI. Each additional year (age), hour of television viewing, and weight control point was associated with a .72, .80, and 3.92 increase in BMI, respectively. Adolescents in the study with overweight parents had BMIs that were on average 4.27 and 5.59, respectively, higher than their peers with normal weight parents. The sex-stratified models in Table 2 also indicate television viewing (1.07, P<.01), weight control (4.53, P<.001), and obese parents/grandparents (4.35, P<.05) were significant factors related to BMI among female adolescents while age (.96, P<.01), weight control (3.57, P<.001), and parent/grandparent weight status were associated with BMI among their male peers. The BMIs of males with overweight and obese parents/grandparents were on average 6.99, P<.01 and 7.63, P<.01, respectively,

**Table 1. Characteristics of adolescents in the Jackson Heart KIDS Pilot Study**

Variable	All, N = 212	Females, n = 107	Males, n = 105	P
Male, %	49.53			
Age, years	15.16 ± 2.19	15.17 ± 2.14	15.14 ± 2.24	.933
Birth weight, lbs	6.88 ± 1.35	6.70 ± 1.25	7.06 ± 1.42	.052
Adolescent hassles score	24.41 ± 10.30	25.36 ± 10.03	23.46 ± 10.53	.181
5+ fruits and vegetables per day, %	32.08	28.04	36.19	.204
60+ mins physical activity, days	3.41 ± 2.25	2.92 ± 2.07	3.91 ± 2.33	.001
Television time, hours × day-1	3.61 ± 1.85	3.42 ± 1.98	3.80 ± 1.69	.135
Weight control score	1.5 ± 1.1	1.8 ± 1.0	1.2 ± 1.0	<.001
Parent weight status				.754
Normal weight	10.85	10.28	11.43	
Overweight	23.11	25.23	20.95	
Obese	66.04	64.49	67.62	
Waist circumference, cm	83.91 ± 19.81	85.34 ± 21.45	82.45 ± 17.98	0.289
Body mass index, kg × m-2	25.81 ± 7.78	26.28 ± 8.02	25.33 ± 7.53	0.375

Data are presented as mean ± standard deviation for continuous variables and proportions for discrete variables.

**Table 2. Relation between body mass index and behavioral factors among adolescents in the Jackson Heart KIDS Pilot Study**

Variable	All, N = 212	Females, n = 107	Males, n = 105
	β (SE)	β (SE)	β (SE)
Male	1.20 (.91)	---	---
Age, years	.72 (.20) <sup>c</sup>	.31 (.33)	.96 (.27) <sup>b</sup>
Birth weight, lbs	-.19 (.33)	.34 (.50)	-.80 (.45)
Adolescent hassles score	-.10 (.04) <sup>a</sup>	-.10 (.06)	-.08 (.06)
5+ fruits and vegetables per day, %	-.22 (.95)	.91 (1.41)	-1.19 (1.31)
60+ mins physical activity, days	-.12 (.21)	-.33 (.34)	-.13 (.28)
Television time, hours × day-1	.80 (.23) <sup>b</sup>	1.07 (.31) <sup>b</sup>	.44 (.37)
Weight control	3.92 (0.43) <sup>c</sup>	4.53 (.64) <sup>c</sup>	3.57 (.61) <sup>c</sup>
Parent weight status (reference group: normal weight)			
Overweight	4.27 (1.60) <sup>b</sup>	2.70 (2.29)	6.99 (2.29) <sup>b</sup>
Obese	5.59 (1.45) <sup>c</sup>	4.35 (2.05) <sup>a</sup>	7.63 (2.10) <sup>c</sup>

a. P<.05.  
b. P<.01.  
c. P<.001.

higher than their male peers with normal weight parents/grandparents.

**Adolescent Waist Circumference**

Table 3 presents results from models examining the association between waist circumference and health behaviors for the total sample and by sex. Estimates from the fully adjusted regression model for the total sample

indicated that age, television viewing, weight control, and parent/grandparent weight status were positively associated with waist circumference (shown in cm). Each additional year (age), hour watching television and weight control point, was associated with 1.56 (P<.01), 2.57 (P<.001), 9.57 (P<.001) increases in waist circumference, respectively. The parent/grandparent weight status coefficients

indicate that adolescents with overweight parents or grandparents had a 9.03 (P<.05) greater waist circumference, on average, than their peers with normal weight parents or grandparents. Study participants with obese parents or grandparents had a 12.97 (P<.01) greater waist circumference, on average, than participants with normal weight parents or grandparents. The male regression models in

**Table 3. Relation between waist circumference and behavioral factors among adolescents in the Jackson Heart KIDS Pilot Study**

Variable	All, N =212	Females, n = 107	Males, n = 105
	β (SE)	β (SE)	β (SE)
Male	2.16 (2.40)	---	---
Age, years	1.56 (.54) <sup>b</sup>	.80 (.93)	2.05 (.65) <sup>b</sup>
Birth weight, lbs	-.71 (.86)	.71 (1.40)	-1.86 (1.08)
Adolescent hassles score	-.10 (.11)	.05 (.18)	-.17 (.15)
5+ fruits and vegetables per day, %	-2.29 (2.49)	.27 (3.97)	-3.47 (3.14)
60+ mins physical activity, days	.11 (.54)	.23 (.96)	-.47 (.67)
Television time, hours × day-1	2.57 (.62) <sup>c</sup>	3.65 (.86) <sup>c</sup>	1.16 (.88)
Weight control	9.57 (1.12) <sup>c</sup>	10.85 (1.80) <sup>c</sup>	8.68 (1.47) <sup>c</sup>
Parent weight status, (reference group: Normal Weight)			
Overweight	9.03 (4.20) <sup>a</sup>	3.38 (6.43)	16.65 (5.47) <sup>b</sup>
Obese	12.97 (3.81) <sup>b</sup>	10.81 (5.77)	18.01 (18.01) <sup>b</sup>

a. P<.05  
b. P<.01  
c. P<.001



Table 3 were more robust than those for their female peers. Television viewing (3.65,  $P < .001$ ) and weight control (10.85,  $P < .001$ ) were associated with adolescent female waist circumference. Age (2.05,  $P < .001$ ), weight control (8.68 cm ( $P < .001$ )) and parent/grandparent weight status were associated with BMI among their adolescent males in the study. The waist circumferences (cm) of males with overweight and obese parents/grandparents were 16.65 ( $P < .01$ ) and 18.01 ( $P < .01$ ), respectively, higher than their male peers with normal weight parents/grandparents.

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*Age, television viewing, weight control, and parental weight status were all positively associated with both BMI and waist circumference.*

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## DISCUSSION

Obesity, which is remarkably preventable, is a major factor contributing to the development of cardiometabolic conditions. BMI is the most common measure used to assess weight status; however, waist circumference is considered to be a direct indicator of abdominal adiposity that has greater utility for assessing cardiometabolic disease risks among

children and adolescents.<sup>13</sup> We examined factors known to be linked with accelerated weight and adipose tissue accumulation by estimating models for BMI and waist circumference using data from a sample of adolescents who were descendants of Jackson Heart Study participants. Age, television viewing, weight control, and parental weight status were all positively associated with both BMI and waist circumference. The results for BMI and waist circumference were also similar because the associations between age, television viewing, and parent weight status varied by sex. Parent/grandparent weight status was significant for BMI and television viewing was associated with both BMI and waist circumference among female adolescents in the study. Age and parent/grandparent weight status were significant for both outcomes of interest among adolescent male sample members.

Our study is one of few reporting adolescent data from an exclusively African American sample. Our results are consistent with other studies showing excess weight to be a function of health behaviors<sup>20-23</sup> and family environment<sup>7,18,24,25</sup>; however, they introduce a more refined understanding of how behavioral and familial factors may be related to excessive weight gain or adipose tissue accumulation among a population with elevated risks for early onset of cardiometabolic diseases and complications. Findings from this study indicate that the mean BMI and mean waist circumference among males in the sample were equivalent with their female peers. These findings are aligned with national-level

data<sup>26</sup> indicating no significant difference in the prevalence of obesity between male and female adolescents. The bulk of the studies focusing on weight-related outcomes among African American adolescents have focused on females, despite data indicating that the proportions of young African American males with obesity has risen steadily and significantly over the past two decades.<sup>27</sup> Results in our study contribute to an emerging body of literature highlighting the urgent need for future pediatric obesity studies of African Americans to include both males and females.<sup>7</sup>

Our findings highlight sex-related nuances that may have implications for weight-related outcomes among African American adolescents. Females in the study reported a slightly higher average number of attempts to lose weight than male sample members; yet the weight control coefficient was significant in the total sample and subgroup analyses. The positive association between weight control and weight outcomes can seem counterintuitive; however, adolescence is a period when individuals gain weight. Further, detailed data about quality and duration of weight loss attempts are not available and additional studies are needed for a closer examination of weight management and weight outcomes among African American adolescents.

The salience of sex for obesity-related outcomes among African American adolescents is also provided by results indicating that factors related to BMI and waist circumference for females are clearly distinct from their male counterparts. Health behaviors were the primary factors associated

with both outcomes of interest for females while the variables related to BMI and waist circumference for male sample members were more diverse. These sex-specific patterns may be indicative of the influence of gender. Gender refers to characteristics of males and females that are shaped by the surrounding cultural and social environment that influence health beliefs, perceptions and behaviors.<sup>28</sup> Gender identities, roles and relations are diverse and mediate health behaviors and practices<sup>29,30</sup>; thus, it is critical for future studies to examine how gender intersects with other identities (ie, race, age) and experiences to advance our understanding how social and behavioral factors affect weight and weight gain in sex-specific ways.

### Study Limitations

This research represents a step toward a deeper understanding of factors with implications for weight outcomes among African American adolescents; however, there are some noteworthy limitations. The analytic models are estimated using data from a pilot study of African American adolescents who reside in the South and are descendants of individuals enrolled in a longitudinal study. Results from this study may not be generalizable to the larger population of adolescents. Further, the small sample size limits the number of variables considered. Data presented in this study were generated from cross-sectional statistical models. As such, temporal order cannot be determined, nor can causality be inferred. Finally, most of the variables in the analyses are self-report and limitations such as recall bias and social desirability apply to this study.

## CONCLUSION

Obesity continues to be a health concern for African Americans adolescents; there is an urgent need to understand factors associated with body weight and distribution of adipose tissue among this population. Knowledge about the manner in which social and behavioral factors interact during youth to influence health is limited and additional studies are needed to specify how these factors interact to accelerate weight gain and adipose tissue accumulation over the life course. Findings from this work can lay the foundation for the development of tailored programs to reduce or prevent obesity among populations with disproportionate risks for early chronic disease development and premature mortality.

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### CONFLICT OF INTEREST

No conflicts of interest to report.

### AUTHOR CONTRIBUTIONS

Research concept and design: Bruce, Heitman, Reneker, Norris, Beech; Acquisition of data: Bruce, Beech; Data analysis and interpretation: Bruce, Thorpe, Teng, Reneker; Manuscript draft: Bruce, Thorpe, Heitman, Reneker, Norris, Beech; Statistical expertise: Bruce, Thorpe, Acquisition of funding: Bruce, Beech; Administrative: Bruce, Teng, Reneker, Norris; Supervision: Bruce, Heitman

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