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Ethnic and Gender Disparities in Adolescent Obesity and Elevated Systolic Blood Pressure in a Rural US Population

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Abstract

A cross-sectional study was conducted to assess the prevalence of overweight, obesity, and elevated systolic blood pressure (SBP) in ethnically diverse adolescents (1064 males; 974 females; 13-17 years) in a rural community. Prevalence of overweight was 20.4% in females and 17.5% in males. In contrast, the prevalence of obesity was 29.4% in males and 14.5% in females. African American males had the highest prevalence of obesity (33.3%) compared with non-Hispanic whites (26.3%). Prevalence of elevated SBP was higher than pre-elevated SBP in males regardless of race/ethnicity, but not in females. Obese females had 4-fold and 9-fold greater odds of developing pre-elevated SBP and elevated SBP, respectively, than their normal weight cohorts. Prevalence of obesity is almost twice that of overweight in males in our rural population suggesting that adolescent males from disadvantaged, rural populations are potentially at a greater risk for metabolic disorders than those in major metropolitan areas.

Keywords

abdominal obesity, adiposity, adolescents, body mass index, waist circumference

Introduction

The prevalence of overweight and obesity among US adolescents has been increasing for the past 2 decades,[1,2] although recent national data suggest that the prevalence of overweight and obesity in adolescents may have plateaued.[3] Nonetheless, most data on US children and adolescents have come from studies on large metropolitan areas or national surveys that do not distinguish between urban and rural communities.[1-7] Although African American and Hispanic adolescents have higher incidence and prevalence of overweight and obesity compared with non-Hispanic whites adolescents,[1,3-6] it is unknown whether these ethnic differences exist in rural communities. Urban and rural differences have been shown with respect to overweight and obesity in children, adolescents, and adults,[8-10] but these studies do not account for ethnic/racial differences. Furthermore, prevalence data from adolescents are scarce and not well characterized with respect to ethnic/racial categorization.

The association between overweight and hypertension in children has been reported in a variety of ethnic/racial groups, with most studies finding higher blood pressure and/or higher prevalence of hypertension in overweight children.[5,11-13] Body mass index (BMI) percentile was the strongest determinant of elevated blood pressure when examined in conjunction with gender, ethnicity, and adiposity.[5] However, a potential limitation of previous studies may be the lack of data on the relationship between waist circumference (WC) and elevated systolic blood pressure (SBP) because abdominal obesity, using WC, is an important predictor of metabolic complications. It has been linked to diabetes, dyslipidemia, insulin resistance, hypertension, and metabolic syndrome in the adult population.[14-17] Abdominal obesity has also been linked to an increase in cardiovascular (CV) and metabolic risks in children and adolescents.[15,18-22] This study complements previous studies by extending

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analysis to gain a better understanding of how BMI and WC relate to SBP in adolescents from a predominantly minority community.

Obesity and its associated comorbidities produce a tremendous burden on public health systems. Understanding the potential health concerns in rural disadvantaged communities is critical for developing solutions and improving public health in these areas. Therefore, this study describes the current prevalence of overweight and obesity in adolescents using direct (not self-reported) measurements in a rural, predominantly minority population and uses these data to compare with published values from urban populations. An additional objective is to assess the relationships between BMI, WC, and SBP in adolescents, accounting for differences between gender and ethnicity. We address the hypothesis that the prevalence of overweight and obesity in minority adolescents in our rural population is greater than that in similar groups from large metropolitan areas or the national average.

Table 1. Mean (±Standard Error) Values for Age, BMI, and WC in Adolescents by Gender and Ethnicity

	White, Non-Hispanic	Hispanic	African American
n	613	1281	144
Males	312	671	81
Females	301	610	63
Age (years)	15 (0.1)	15 (0.1)	15 (0.1)
BMI (kg/m^2)			
Males	23.9 (0.32)	24.5 (0.21)	25.2 (0.72)
Normal	20.1 (0.14)	20.3 (0.10)	20.1 (0.29)
Overweight	25.0 (0.13)	24.8 (0.09)	24.8 (0.23)
Obese	31.5 (0.54)	31.5 (0.27)	32.6 (0.99)
Females	22.9 (0.32)	23.4 (0.22)	24.1 (0.68)
Normal	19.9 (0.15)	20.5 (0.09)[a]	20.3 (0.33)
Overweight	25.2 (0.15)	25.5 (0.10)	25.5 (0.36)
Obese	33.4 (0.86)	33.9 (0.61)	32.8 (0.86)
WC (cm)			
Males	82.6 (0.84)	85.0 (0.64)[a]	84.9 (1.90)
Normal	77.8 (0.53)	78.5 (0.39)	77.4 (1.15)
WC ≥90th	108.5 (1.48)	107.7 (0.87)	108.5 (3.00)
Females	75.5 (0.85)	77.5 (0.58)	77.6 (1.86)
Normal	70.9 (0.52)	72.6 (0.32)[a]	72.2 (1.22)
WC ≥90th	101.5 (2.02)	101.1 (1.10)	102.5 (2.59)

Abbreviations: BMI, body mass index; WC, waist circumference.
[a]$P < .05$ versus White, non-Hispanics.

Methods

Subjects

The study population consisted of 2038 (1064 males and 974 females) ethnically diverse adolescents aged between 13 and 17 years. The demographics of students participating in the study are presented in Table 1. The majority (79%) of the data were collected from Merced Union High School District (MUHSD) annual health assessments, with 21% from MUHSD annual sports physicals for 2007. Students in MUHSD are predominately Hispanic/Latino (54%), followed by non-Hispanic white (24%), Asian/Hmong (15%), African American (5%), and other (2%). This study population is representative of Merced County, which has a population of predominately Hispanic/Latino residents (53%), followed by non-Hispanic white (35%), Asian/Hmong (7%), African American (4%), and other (1%).

Measurements

Age, gender, and ethnicity of participants were attained from the annual health assessment and sports physicals. Students self-reported race/ethnicity, which was categorized as non-Hispanic white, Hispanic/Latino, African American, Asian/Hmong or other. For this article, analyses focus only on comparisons between African Americans, Hispanics, and non-Hispanic whites. Trained technicians and nurses measured each participant's height, weight, WC, and SBP by using standardized protocols. Weight was measured to the nearest 0.1 kg using a digital scale (Tanita HD-351, Tanita Corporation, Arlington Heights, IL) and height was measured to the nearest 0.1 cm using a measuring tape against a wall. Waist circumference was measured to the nearest 0.1 cm using a measuring tape, with the subject standing at minimal respiration and the measurement taken in a horizontal plane at the level of the high point of the iliac crest as previously detailed.[23] BMI was calculated using the standard metric formula (kg/m^2). SBP was measured using an automated oscillometric device (Omron HEM-780, Omron Healthcare, Bannockburn, IL). A mercury sphygmomanometer and extra large cuff were used when the cuff of the automated device was not large enough to fit some of the subjects.

Anthropometric Definitions

Overweight and obesity were defined according to BMI index cutoff points for age and gender published by the Centers for Disease Control and Prevention.[24] For the purposes of this discussion, subjects were classified using the following metrics: BMI <5th percentile = "underweight," BMI ≥5th and <85th percentile = "normal weight," BMI ≥ 85th and ≤94.9th percentile = "overweight," and BMI ≥95th percentile = "obese."[25] Only 53 (33 males, 20 females, 2.3%) of the 2038 adolescents were determined to be underweight and were removed from the analyses and not considered here. There is no agreed on definition of excess adiposity in children and adolescents based on WC. For the purpose of this discussion, we used the 90th percentile values of WC for gender and age generated in NHANES (National Health and Nutrition Examination Survey) III as cutoff values to identify abdominal obesity.[23] Blood pressure was classified using guidelines detailed in the "Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents."[26] Because the guidelines recommend multiple SBP measurements at different times be used to diagnosis prehypertension and hypertension, we used the terminology of Ostchega et al,[27] which is similar to that of Din-Dzietham et al.[28] Thus, a SBP measurement in the prehypertensive range as defined by SBP ≥90th percentile was termed "pre-elevated SBP" and measurements in the hypertensive range, SBP ≥95th, was termed "elevated SBP."[26]

Statistical Analysis

Means (±standard error) were compared by analysis of variance (ANOVA) for ethnic/racial groups, gender, and ethnic/racial group × gender differences. Prevalence rates according to gender and ethnicity/race were compared using χ^2 distribution statistics as previously described.[29] Prevalence values are presented as percentage with lower and upper 95% confidence intervals. Age had no significant effect on any of the variables in the analyses so data for each age category were combined. Relationships between dependent and independent variables were evaluated by simple regression, and correlations were evaluated using Pearson correlation coefficients. Means, regressions, and correlations were considered significant at $P < .05$. Statistical analyses were performed using Statview software (SAS, Cary, NC).

Categorical definitions of BMI, WC, and SBP were also used in our analyses as they offer an alternative approach to interpreting the data. In this study, we are primarily interested in the differences across discrete categories (ie, "normal weight" vs "overweight" vs "obese"). Because of our use of categorical variables, logistic regression was used to calculate adjusted odds ratios. When analyzing abdominal obesity using WC, a WC ≤90th percentile was used as the baseline outcome. For the evaluation of SBP a SBP ≤90th percentile was used as the baseline outcome and non-Hispanic white was the comparison group for analyses using race and ethnicity.

After running a pooled model of both male and female respondents, it was clear that there were both gender and race/ethnicity effects. We then estimated models using gender and race/ethnicity interaction terms, however, what became clear was that gender was the most important characteristic in the multivariate models, so a strategy of running logistic regression with only males and only females was employed. Adjusted odds ratio (95% confidence intervals) and predicted probabilities were estimated using logistic regression using STATA software (version 10, StataCorp LP, College Station, TX).

Results

Body Mass Index

The population characteristics, along with mean BMI and WC are shown in Table 1. The mean age for all groups and genders was 15 ± 0.1 years (Table 1). The overall prevalence of normal weight was 58.8% (57.9% to 62.1%) with females (65.1%; 63.2% to 68.8%) higher ($P < .001$) than males (53.1%; 51.2% to 58.6%). The prevalence of normal weight in non-Hispanic white ($P < .05$), Hispanic ($P < .01$), and African American ($P < .05$) females was higher than in their male cohorts (Figures 1A and 1B). Among males, Hispanics ($P < .001$) and African Americans ($P < .001$) had lower prevalence rates of normal weight than non-Hispanic whites (Figure 1A). Effects of ethnicity/race on the prevalence of normal weight in females were not detected (Figure 1B).

The overall prevalence of overweight was 18.9% (17.4% to 20.6%) with females (20.4%; 17.7% to 22.4%) higher ($P < .05$) than males (17.5%; 14.9% to 19.1%). The prevalence of overweight in Hispanic ($P < .01$) and African American ($P < .05$) females was higher than in their male cohorts (Figure 1B). Effects of ethnicity/race on the prevalence of overweight in males were not detected. Among females, the prevalence of overweight was higher ($P < .01$) in Hispanics than non-Hispanic whites (Figure 1B).

The overall prevalence of obesity was 22.3% (19.3% to 22.7%) with males (29.4%; 25.5% to 30.5%) twice ($P < .001$) that of females (14.5%; 12.0% to 16.0%). The prevalence of obesity was higher in all male ethnic/racial groups than in their female cohorts (Figure 1B). Among males, the prevalence of obesity was higher in Hispanics ($P < .001$) and African Americans ($P < .0001$) than in non-Hispanic whites (Figure 1A). The prevalence of obesity in males was nearly twice ($P < .001$) that of overweight (Figure 1A). Among females, the prevalence of obesity was lower in Hispanics ($P < .001$) than in non-Hispanic whites.

Overall, the prevalence of overweight and obesity combined was 41.2% (38.0% to 42.0%) with males (46.9%; 43.2% to 48.8%) being higher ($P < .001$) than females (34.9%; 31.2% to 36.8%). Among males, the prevalence of overweight and obesity combined was

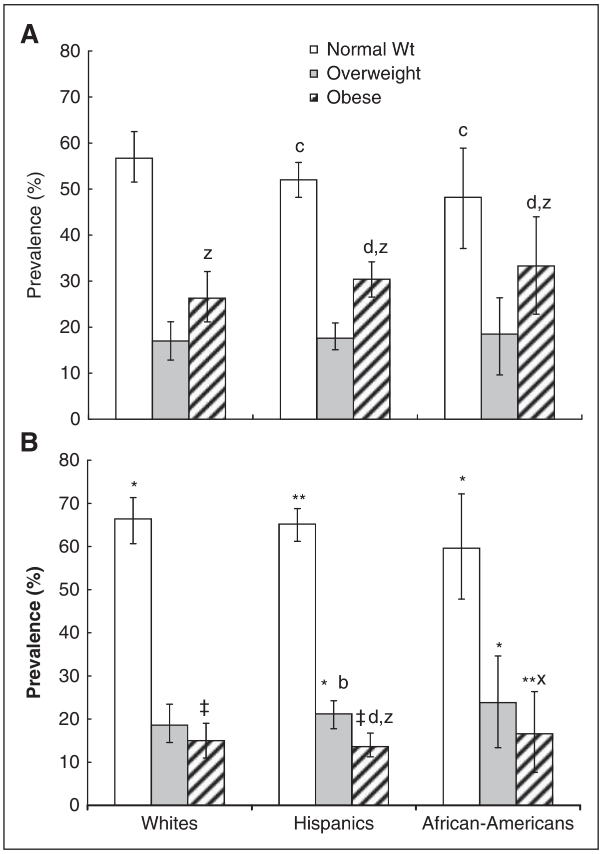

Figure 1. Prevalence (lower-upper 95% confidence intervals) of normal (open bars), overweight (shaded bars), and obese (striped bars) adolescents by ethnicity/race for (A) males and (B) females

*Different (*P* < .05) from male cohorts; **different (*P* < .01) from male cohorts; ‡different (*P* < .0001) from male cohorts; a = different (*P* < .05) from non-Hispanic Whites; b = different (*P* < .01) from non-Hispanic Whites; c = different (*P* < .001) from non-Hispanic Whites; d = different (*P* < .0001) from non-Hispanic Whites; x = different (*P* < 0.05) from overweight; z = different (*P* < .0001) from overweight.

greater ($P < .001$) in African Americans (51.8%; 41.1% to 62.9%) and Hispanics (48.0%; 44.2% to 51.8%) than non-Hispanic white males (43.3%; 37.5% to 48.5%). Among females, the prevalence of overweight and obesity combined was not different between non-Hispanic whites (33.6%; 22.9% to 33.1%) and any of the other groups (African Americans: 40.4%; 27.8% to 52.2% and Hispanics: 34.8%; 33.2% to 40.8%).

The adjusted odds ratio data from logistic regressions for BMI comparing normal weight and overweight by gender and ethnicity/race were not significant; however, both Hispanic and African American males and females exhibited a trend (28% to 45%) toward the likelihood of being overweight (Table 2). The differences between the obese category and all other categories were large and significant, especially for males. Normal-weight Hispanic and African American male's odds of being obese are increased by a factor of 2.11 and 2.50 ($P < .001$), respectively (Table 2). This finding can also be interpreted using predicted probabilities where Hispanic males are 37.6% more likely to be obese than other males, and African Americans are 44.5% more likely to be obese than other males (Table 3). Overweight Hispanic and African American male's odds of being obese increased by a factor of 1.88 ($P < .001$) and 1.96 ($P < .05$; Table 2), which when converted to predicted probabilities, result in Hispanics being 63.7% more likely to be obese, and African Americans being 65.9% more likely to be obese (Table 3) than overweight non-Hispanic white males. Although the trends toward obesity where more pronounced for normal weight and overweight African Americans they were not significant at $P < .05$ (Table 2).

Waist Circumference

Independent of ethnicity/race, mean WC was 8.6% greater ($P < .001$) in males than in females (Table 1). The overall prevalence of normal weight as measured by WC (<90th percentile) was 81.6% (81.4% to 84.7%) with females (84.5%; 81.7% to 86.3%) greater ($P < .001$) than males (80.5%; 78.6% to 83.4%). Among males, the prevalence of normal weight measured by WC was greater ($P < .05$) in non-Hispanic whites (84.3%; 79.7% to 88.3%) than African Americans (76.0%; 66.3% to 85.7%) and Hispanics (77.6%; 73.5% to 80.5%). Among females, no effect of ethnicity/race on normal weight was detected among the different groups.

Conversely, the overall prevalence of abdominal obesity as measured by WC (≥90th percentile) was 18.4% (15.4% to 18.7%) with males (19.5%; 16.6% to 21.4%) greater ($P < .001$) than females (15.5%; 13.7% to 18.3%). Among males, abdominal obesity was higher ($P < .001$) in African Americans (24.0%; 14.3% to 33.7%) and Hispanics (22.4%; 19.5% to 26.5%) than non-Hispanic whites (15.7%; 11.7% to 20.3%). Among females, abdominal obesity was higher ($P < .0001$) in African Americans (18.0%; 8.4% to 27.6%) and Hispanics (16.9%; 13.8% to 20.3%) than in non-Hispanic whites (14.7%; 10.7% to 19.3%).

Normal-weight Hispanic and African American males' odds of obesity are increased by a factor of 1.59 ($P < .001$) and 1.74 ($P < .05$), respectively, than normal-weight non-Hispanic white males (Table 2). Converting that finding to predicted probabilities, Hispanics males were 23.1% more likely, and African American males were 29.2% more likely of being obese (Table 2). Independent of gender, Hispanics and African Americans

Table 2. Adjusted Odds Ratios (95% Confidence Interval) by Race/Ethnicity and Gender Using Logistic Regression[a]

	Total Population	Male	Female
BMI: normal vs overweight			
White	1	1	1
Hispanic	1.16 (0.94-1.43)	1.12 (0.88-1.43)	1.18 (0.88-1.58)
African American	1.37 (0.87-2.17)	1.28 (0.69-2.34)	1.45 (0.76-2.81)
Male	1.05 (0.86-1.29)	—	—
BMI: normal vs obese			
White	1	1	1
Hispanic	1.23 (1.00-1.51)	2.11[b] (1.71-2.63)	1.01 (0.72-1.41)
African American	1.69[c] (1.11-2.57)	2.50[b] (1.51-4.16)	1.79 (0.91-3.54)
Male	2.38[b] (1.94-2.92)	—	—
BMI: overweight vs obese			
White	1	1	1
Hispanic	1.04 (0.81-1.35)	1.88[b] (1.43-2.47)	0.86 (0.57-1.27)
African American	1.24 (0.74-210)	1.96[d] (1.03-3.74)	1.23 (0.55-2.76)
Male	2.26[b] (1.76-2.92)	—	—
WC: normal vs obese			
White	1	1	1
Hispanic	1.46[c] (1.16-1.84)	1.59[b] (1.25-2.02)	1.35 (0.96-1.91)
African American	1.61[d] (1.03-2.51)	1.74[d] (1.00-3.00)	1.49 (0.74-3.01)
Male	1.34[c] (1.07-1.67)	—	—

[a]Body mass categories are based on body mass index (BMI) or waist circumference (WC). WC £ 90th percentile is the baseline outcome.
[b]$P < .001$.
[c]$P < .01$.
[d]$P < .05$.

Table 3. Predicted Probabilities (%) for Obesity by Race/Ethnicity Using Logistic Regressions[a]

	Male	Female
BMI: normal vs overweight		
White	23.2	22.1
Hispanic	25.6	24.9
African American	29.3	30.5
BMI: normal vs obese		
White	31.9	18.9
Hispanic	37.6	17.7
African American	44.5	26.2
BMI: overweight vs obese		
White	60.8	45.3
Hispanic	63.7	39.4
African American	65.9	44.7
WC: normal vs obese		
White	15.8	14.8
Hispanic	23.1	17.2
African American	29.2	20.0

[a]Body mass categories are based on body mass index (BMI) or waist circumference (WC).

odds of developing abdominal obesity increased ($P < .01$) by a factor of 1.46 and 1.61, respectively (Table 2). Although not significant (at $P < .05$), Hispanic and African American females exhibited increasing trends (35% and 49%, respectively) of developing abdominal obesity compared to non-Hispanic white females (Table 2).

Systolic Blood Pressure

Independent of ethnicity/race, mean SBP was 9% greater ($P < .001$) in males (124 ± 1 mm Hg) than females (113 ± 1 mm Hg). The overall prevalence of pre-elevated SBP and elevated SBP was 11.5% (9.6% to 12.4%) and 17.8% (16.3% to 19.7%), respectively. Collectively, males had a higher ($P < .01$) prevalence of pre-elevated SBP (14.4%; [11.8% to 16.2%] vs 8.4%; [7.1% to 10.9%]) and elevated SBP (25.5%; [22.3% to 27.7%] vs 9.4%; [8.1% to 12.0%]) than females, respectively (Figures 2A and 2B). Accounting for ethnicity/race, the prevalence of elevated SBP was higher ($P < .001$) in males than their female cohorts (Figure 2B). Among males, the prevalence of pre-elevated SBP and elevated SBP was not different from non-Hispanic whites (Figure 2A). However, the prevalence of elevated SBP was approximately 2-fold greater ($P < .001$) than that of pre-elevated SBP among all groups of males (Figure 2A).

Among females, the prevalence of pre-elevated SBP was not different among any of the groups; however, the prevalence for elevated SBP in African-Americans (13.2%; 10.8% to 15.2%) was higher ($P < .05$) than that in non-Hispanic whites (9.2%; 5.4% to 12.6%; Figure 2B).

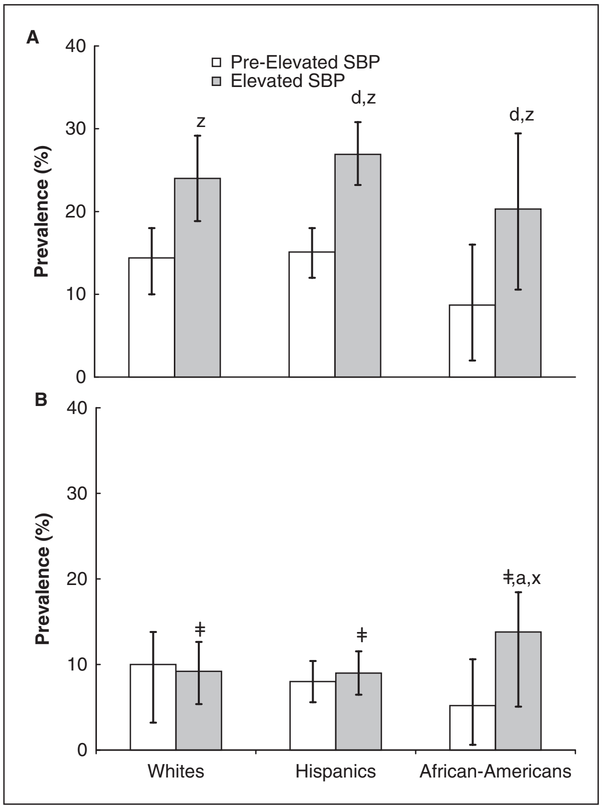

Figure 2. Prevalence (lower-upper 95% confidence intervals) of pre-elevated systolic blood pressure (SBP; open bars) and elevated SBP (shaded bars) in adolescents by ethnicity/race for (A) males and (B) females

‡Different (*P* < .0001) from male cohorts; a = different (*P* < .05) from non-Hispanic Whites; x = different (*P* < .05) from pre-elevated SBP; z = different (*P* < .0001) from pre-elevated SBP.

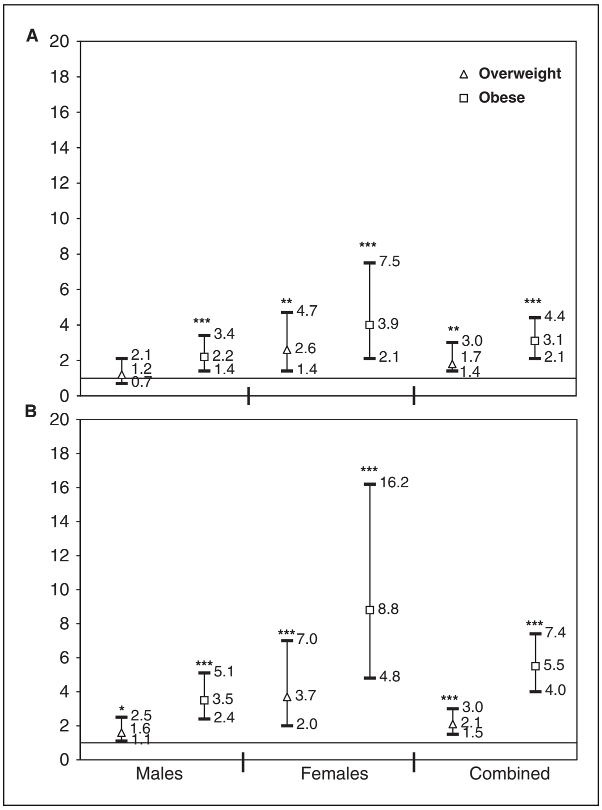

Figure 3. Adjusted odds ratio (lower-upper 95% confidence intervals) of logistic regressions for (A) pre-elevated systolic blood pressure (SBP) and (B) elevated SBP resulting from overweight and obesity (as defined by body mass index [BMI]) by gender

SBP ≤ 90th percentile was used as the baseline outcome. **P* < .05, ***P* < .01, ****P* < .001.

A difference ($P < .05$) in the prevalence between pre-elevated SBP and elevated SBP among females was only detected in African Americans (Figure 2B).

The adjusted odds ratio logistic regressions identified significant gender and weight category effects for both pre-elevated and elevated SBP (Figures 3A and 3B). Whereas overweight males did not exhibit increased odds of developing pre-elevated SBP, the odds were increased in overweight females (2.2-fold), and obese males (2.6-fold) and females (3.9-fold; Figure 3A). Independent of gender, overweight adolescents were only 1.7-fold more likely ($P < .01$), but obese adolescents were more than 3-fold more likely ($P < .001$) of developing pre-elevated SBP (Figure 3A). The odds of developing elevated SBP were greatest ($P < .001$) in overweight and obese females, with the odds nearly 9-fold in obese females (Figure 3B). Independent of gender, the odds of developing elevated SBP were 2.1-fold greater in overweight adolescents, and the odds increase to 5.5-fold greater in obese adolescents (Figure 3B).

Correlations

WC and BMI were both correlated with SBP in all male and female adolescent groups with the exception of African American females. Because *y*-intercepts and slopes were not different among different ethnicities/race and gender, the data were combined (excluding that for African American females) to generate the following correlations: SBP = 95 + 0.297 ∗ WC ($R = .333$; $P < .01$) and SBP = 102 + 0.702 ∗ BMI ($R = .312$; $P < .001$).

Discussion

Childhood and adolescent obesity are critical public health concerns because of the comorbidity with other metabolic pathologies. Unfortunately, the data on obesity and elevated blood pressure are virtually nonexistent for adolescents from rural predominantly minority communities. A major contribution of the present study is the prevalence data of overweight, obesity, abdominal obesity, and elevated SBP in adolescents from a rural, predominately minority population because the majority of anthropometric data of children and adolescents come from sample populations in large metropolitan areas or national surveys. It was expected that minority groups in a rural community would have a greater prevalence of both overweight and obesity. Because of the scarcity of data on WC in adolescents, and the relationships between BMI, WC, and SBP, we also examined these relationships to better ascertain how these measures of body condition correlate with elevated SBP. The present study demonstrates that the overall prevalence of overweight and obesity in adolescents in our study population was 41.2%, which is 21.2% higher than the highest, and 3.6-fold higher than the lowest reported values from national surveys of large metropolitan sample populations, California sample populations and international sample populations.[1-3,5,6, 11-13]

An important finding of the present study is that the prevalence of obesity is greater than that for overweight in adolescent males, regardless of ethnicity/race. The prevalence of obesity (29.4%) surpassed the prevalence of overweight (17.5%) in all males. This difference was greatest in African Americans followed by Hispanics, and non-Hispanic whites. Regardless of ethnicity/race, the prevalence of obesity was consistently nearly 2-fold greater than that for overweight in males, suggesting that factors beyond culture are contributing to this disturbing trend. To the best of our knowledge this is the first study to report such a difference in adolescent males across racial/ethnic groups. A previous study that only examined Latino adolescents of mostly El Salvadorian descent demonstrated similar results, but with a smaller magnitude of difference.[30] Because of this greater prevalence of obesity than overweight, minority adolescent males from a rural population may be at a greater risk of weight-dependent metabolic disorders later in life. The interesting finding that the prevalence of obesity was greater than that of overweight only in males regardless of race/ethnicity suggests that the disparity is gender specific and not likely the result of cultural differences.

A majority of studies report that African American and Hispanic adolescents have a higher incidence and prevalence of overweight and obesity compared to non-Hispanic white adolescents.[1,3-6] Our prevalence data for obesity in males supports this claim and is further reinforced by the logistic regressions, which demonstrates that both Hispanic and African American adolescents have greater odds of being obese than non-Hispanic whites. However, the fact that the prevalence of obesity was nearly twice that for overweight in all males suggests that non-Hispanic white adolescents in rural, disadvantaged communities may have increased risk of developing metabolic and CV complications than cohorts from urban communities. The similarities in the prevalence of overweight across the multiple ethnic groups suggests that community factors and not just genetic and/or cultural differences are contributing to *early progression* of increased body mass, which from the perspective of public health warrants further investigation.

Another important finding is the relatively high prevalence of abdominal obesity (18.4%). African Americans and Hispanics had higher prevalence compared with non-Hispanic whites, suggesting that health disparities may exist in our population using WC as the metric. These values are approximately 2-fold greater than those previously reported (7.6% for African Americans; 11.4% for Hispanics; 6% for White, non-Hispanics),[28] suggesting that the prevalence of abdominal obesity is much greater in our population that may not be well represented in large national surveys. This same study reported that abdominal obesity accounted for part of the upward trend in high blood pressure.[28] Increased WC and BMI both positively correlated with SBP in all male and female adolescent groups with the exception of African American females. This supports the growing body of evidence that WC may provide a reliable index of CV risk in certain adolescent groups.[15,18,19,31] Although increased WC is a strong predictor of CV disease in adult African Americans,[16,17] neither WC nor BMI correlated with SBP in adolescent African American females suggesting that other factors contribute to their prevalence of elevated SBP (13.8%). We suggest that because certain anthropometric measurements may not possess the same predictive value for obesity in adolescents across ethnicities/races, it highlights the need to evaluate the multitude of potential factors that contribute to the risk of CV disease and metabolic disorders in adolescents from minority populations.

We also demonstrate that the prevalence of obesity among different groups of adolescents can be skewed based on how obesity is defined. When obesity was assessed using BMI ≥95th percentile, the collective prevalence was 22.3%, with males higher than females (29.4% vs 14.5%, respectively). When abdominal obesity was assessed using WC ≥90th percentile, the collective prevalence was 18.4%, with males greater than females (19.5% vs 15.5%, respectively). Assessing the prevalence of obesity using WC consistently underestimated the prevalence of obesity when compared to using BMI. This suggests the need to develop a new metric that incorporates both BMI and WC measurements to create a better assessment of adiposity.

The prevalence of hypertension in adolescents ranges between 2.2% and 7.4% when based on multiple measurements.[5,13,32] Although we report values based on a single measurement, we are cognizant of the fact that multiple measurements over time provide a better diagnostic value. Nonetheless, the collective prevalence of elevated SBP in our study was 17.8%, with the highest prevalence (18.1%) among Hispanic adolescents. This is consistent with previous research where the prevalence of elevated blood pressure was 19.4% overall, and the highest prevalence among Hispanics (25%) and non-Hispanic whites (18%) after the first screening.[5] Combined, these data demonstrate a relatively high prevalence of pre-elevated and elevated SBP in adolescents. This is disconcerting because studies have shown that high blood pressure early in life is associated with the manifestation of hypertension and coronary heart disease in adulthood.[33,34] Obese females also had the highest odds of developing pre-elevated (4-fold) and elevated SBP (8-fold) compared to normal-weight cohorts suggesting that adiposity may exert a greater impact on SBP in adolescent females than males.

Conclusions

The prevalence of obesity in adolescent males is greater (in some cases almost 2-fold) than that of overweight in our study population, which represents a rural, disadvantaged community. This suggests that adolescent males from small rural communities may be at greater risk for developing CVD and other metabolic disorders during adulthood. The relatively high prevalence of elevated SBP in these groups exacerbates the risk of metabolic and CV complications. Adolescents in our study population also exhibited a higher prevalence of abdominal obesity than adolescents from urban or nationally representative samples suggesting that adolescents from rural communities may be at even a greater risk for developing CV complications than their counterparts in larger metropolitan communities. The implementation of intervention and prevention strategies early in life is imperative to decrease the chances of this population from developing weight-dependent metabolic disorders. The present study also highlights the importance of WC to identify the potential risk for developing CV complications in minority males from rural populations. Implementing the routine measure of WC in adolescents may also prove to be valuable when assessing the risk of developing metabolic disorders. A newly defined metric that incorporates both BMI and WC values may provide a better representation of body condition (adiposity) than either term independently, and a better assessment of developing metabolic complications.

Author's Note

This research was approved by the University of California, Merced, Institutional Review Board.

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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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References

1. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999-2000. *JAMA*. 2002;288:1728-1732.
2. OgdenCL,CarrollMD,CurtinLR,McDowellMA,TabakCJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA*. 2006;295: 1549-1555.
3. Ogden CL, Carroll MD, Flegal KM. High body mass index for age among US children and adolescents, 2003-2006. *JAMA*. 2008;299:2401-2405.
4. Lutfiyya MN, Garcia R, Dankwa CM, Young T, Lipsky MS. Overweight and obese prevalence rates in African American and Hispanic children: An analysis of data from the 2003-2004 National Survey of Children's Health. *J Am Board Fam Med*. 2008;21:191-199.
5. Sorof JM, Lai D, Turner J, Poffenbarger T, Portman RJ. Overweight, ethnicity, and the prevalence of hypertension in school-aged children. *Pediatrics*. 2004;113:475-482.
6. Ahn MK Juon HS, Gittelsohn J. Association of race/ ethnicity, socioeconomic status, acculturation, and environmental factors with risk of overweight among adolescents in California, 2003. *Prev Chronic Dis*. 2008; 5:A75.

7. Butte NF, Cai G, Cole SA, Comuzzie AG. Viva la Familia Study: genetic and environmental contributions to childhood obesity and its comorbidities in the Hispanic population. *Am J Clin Nutr.* 2006;84:646-654.
8. Robert GM, Joanne SH, Shrikant IB, Shibing D. Cardiovascular disease risk factors and obesity of rural and urban elementary school children. *J Rural Health.* 1999;15: 365-374.
9. Jackson JE, Mark PD, Anthony FJ, Hart LG. A national study of obesity prevalence and trends by type of rural county. *J Rural Health.* 2005;21:140-148.
10. Nelson MC, Gordon-Larsen P, Song Y, Popkin BM. Built and social environments: associations with adolescent overweight and activity. *Am J Prev Med.* 2006;31:109-117.
11. Freedman DS, Dietz WH, Srinivasan SR, Berenson GS. The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. *Pediatrics.* 1999;103:1175-1182.
12. Kim HM, Park J, Kim H-S, Kim DH, Park SH. Obesity and cardiovascular risk factors in Korean children and adolescents aged 10-18 years from the Korean National Health and Nutrition Examination Survey, 1998 and 2001. *Am J Epidemiol.* 2006;164:787-793.
13. Salvadori M, Sontrop JM, Garg AX, et al. Elevated blood pressure in relation to overweight and obesity among children in a rural Canadian community. *Pediatrics.* 2008;122: e821-e827.
14. Janssen I, Katzmarzyk PT, Ross R. Body mass index, waist circumference, and health risk: evidence in support of current National Institutes of Health guidelines. *Arch Intern Med.* 2002;162:2074-2079.
15. Janiszewski PM, Janssen I, Ross R. Does waist circumference predict diabetes and cardiovascular disease beyond commonly evaluated cardiometabolic risk factors? *Diabetes Care.* 2007;30:3105-3109.
16. Okosun IS, Boltri JM, Hepburn VA, Eriksen MP, Davis-Smith M. Regional fat localizations and racial/ethnic variations in odds of hypertension in at-risk American adults. *J Hum Hypertens.* 2006;20:362-371.
17. Okosun IS, Liao Y, Rotimi CN, Prewitt TE, Cooper RS. Abdominal adiposity and clustering of multiple metabolic syndrome in white, black and Hispanic Americans. *Ann Epidemiol.* 2000;10:263-270.
18. Moreno LA, Pineda I, Rodriguez G, Fleta J, Sarria A, Bueno M. Waist circumference for the screening of the metabolic syndrome in children. *Acta Paediatr.* 2002;91: 1307-1312.
19. Sung RYT, Yu CCW, Choi KC, et al. Waist circumference and body mass index in Chinese children: cutoff values for predicting cardiovascular risk factors. *Int J Obes.* 2006;31:550-558.
20. Freedman DS, Serdula MK, Srinivasan SR, Berenson GS. Relation of circumferences and skinfold thicknesses to lipid and insulin concentrations in children and adolescents: the Bogalusa Heart Study. *Am J Clin Nutr.* 1999;69: 308-317.
21. Cruz ML, Weigensberg MJ, Huang TTK, Ball G, Shaibi GQ, Goran MI. The metabolic syndrome in overweight Hispanic youth and the role of insulin sensitivity. *J Clin Endocrinol Metab.* 2004;89:108-113.
22. Lurbe E, Torro I, Aguilar F, et al. Added impact of obesity and insulin resistance in nocturnal blood pressure elevation in children and adolescents. *Hypertension.* 2008;51:635-641.
23. Li C, Ford ES, Mokdad AH, Cook S. Recent trends in waist circumference and waist-height ratio among US children and adolescents. *Pediatrics.* 2006;118:e1390-e1398.
24. Kuczmarski RJ Ogden CL, Guo SS, et al. 2000 CDC growth charts for the United States: methods and development. *Vital Health Stat 11.* 2002;246:1-190.
25. Barlow SE; Expert Committee. Expert Committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. *Pediatrics.* 2007;120(Suppl 4):S164-S192.
26. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics.* 2004(2 Suppl 4th Report);114: 555-576.
27. Ostchega Y, Carroll M, Prineas RJ, McDowell MA, Louis T, Tilert T. Trends of elevated blood pressure among children and adolescents: data from the National Health and Nutrition Examination Survey 1988-2006. *Am J Hypertens.* 2008;22:59-67.
28. Din-Dzietham R, Liu Y, Bielo M-V, Shamsa F. High blood pressure trends in children and adolescents in national surveys, 1963 to 2002. *Circulation.* 2007;116:1488-1496.
29. Janssen I, Katzmarzyk PT, Boyce WF, King MA, Pickett W. Overweight and obesity in Canadian adolescents and their associations with dietary habits and physical activity patterns. *J Adolesc Health.* 2004;35:360-367.
30. Mirza NM, Kadow K, Palmer M, Solano H, Rosche C, Yanovski JA. Prevalence of overweight among inner city Hispanic American children and adolescents. *Obesity.* 2004;12:1298-1310.
31. Janssen I, Katzmarzyk PT, Ross R. Waist circumference and not body mass index explains obesity-related health risk. *Am J Clin Nutr.* 2004;79:379-384.
32. Chiolero A, Cachat F, Burnier M, Paccaud F, Bovet P. Prevalence of hypertension in schoolchildren based on repeated measurements and association with overweight. *J Hyperten.* 2007;25:2209-2217.
33. Pletcher MJ, Bibbins-Domingo K, Lewis CE, et al. Prehypertension during young adulthood and coronary calcium later in life. *Ann Intern Med.* 2008;149:91-99.
34. Chen X, Wang Y. Tracking of blood pressure from childhood to adulthood: a systematic review and meta-regression analysis. *Circulation.* 2008;117:3171-3180.