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A cross-sectional study on the relationship between the risk of hypertension and obesity status among pre-adolescent girls from rural areas of Southeastern region of the United States

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ABSTRACT

This study investigated early indications of hypertension risk and the association of overweight and obesity in young girls from a low socioeconomic region of the rural South. 139 females (*M* age = 8.85 ± 1.67 years) from a rural school in the Southeastern region of the United States served as participants. Body mass index was calculated based on the child's height and weight measurements (kg/m^2) and resting blood pressure measurements were taken with calibrated, automatic oscillations devices. Girls who were overweight or obese were 2.81 times more likely to have a systolic blood pressure indicative of being at-risk/hypertensive (i.e., pre-hypertension and/or hypertension stage 1) than girls who were not overweight/obese. In fact, the percentage of overweight/obese girls who were at-risk/hypertensive was double that of girls who were not overweight/obese (43.2% versus 21.3%), respectively. Being overweight or obese is associated with almost three times a higher risk of hypertension than girls who are not overweight or obese.

In the United States, various social determinants such as socioeconomic status, poverty, discrimination, residential segregation, and unequal access to health care greatly affect our health (Barr, 2014). Some of the greatest health disparities observed in the United States are in women of color (i.e., Black, Hispanic, and American Indian/Alaskan Native) (Barr, 2014). Diseases such as heart disease, stroke, diabetes, and cancer are among the leading causes of death for women of color (Barr, 2014; CDC, n.d.).

One factor that contributes to an increased risk of these diseases is weight and girls tend to be at a greater risk of being overweight or obese compared to boys, particularly as they approach puberty (Govindan et al., 2013). There has been a recent stabilization in the incidence of pediatric obesity in the United States (Ogden et al., 2014). However, historically, the prevalence of obesity and overweight children and youth has tripled over the past 30 years (Ogden et al., 2014). It is estimated that one out of three girls between the ages of 2–19 years are overweight or obese (Ogden et al., 2014). In Alabama, 35% of children are overweight or obese; placing the state among one of the ten states with the highest rates of childhood obesity (Robert Wood Johnson Foundation, n.d.).

Due to the fact that girls have a higher incidence of overweight and obesity, it is highly likely that these overweight and obese girls will become obese adults (Freedman et al., 2005), which places them at a higher risk for health complications that contribute to premature death (e.g., heart disease, type-2 diabetes, stroke, cancer, and hypertension) (Daniels, 2006). Hypertension, an adult-onset disease, is a condition where pressure in the arteries is elevated. Hypertension is rare in children, but there has been a rise in the prevalence in pediatric populations over the past two decades (Chorin et al., 2015; Freedman et al., 2012; Perng et al., 2016; Raitakari et al., 1994; Muntner et al., 2004; Robinson et al., 2013; Bao et al., 1995). Hypertension is a risk factor for coronary artery disease and an early warning sign for the development of atherosclerosis (Keramati et al., 2013; Luma and Spiotta, 2006). Recent studies have identified a clear link between weight and hypertension in children and youth (Friedmann et al., 2012; Hanevold et al., 2004; Angelopoulos et al., 2006; Ataei et al., 2009; Moore et al., 2006; Salvadori et al., 2008; Falkner et al., 2006). Children who are overweight or obese have higher values of systolic blood

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pressure (SBP) and diastolic blood pressure (DBP) compared to their normal weight peers (Friedmann et al., 2012; Falkner et al., 2006; Macdonald-Wallis et al., 2017; Sánchez-Zamorano et al., 2009; Hlaing et al., 2006). Additionally, these elevated values are maintained longitudinally (Juhola et al., 2011), highlighting the need for early detection for individuals at a greater risk for hypertension, like those who are overweight or obese.

There is a growing concern for obesity in United States girls, especially those exposed to negative social determinants (e.g., lower socioeconomic status, lower-income communities, communities with mostly racial minority populations, states in the South and Midwest, and populations with lower education levels) that places them at a greater risk of long-term health complications (Barr, 2014). This need supports investigations to explore risk factors that are associated with increased weight status, particularly in diseases that until recently have been primarily observed in adults. This knowledge will help inform researchers and clinicians as they intervene and provide health behavior and educational programs that could aid in reducing the long-term health complications associated with hypertension. National data support that this concern and health disparities might be a greater problem in Southern and rural populations (Freedman et al., 2012; Robinson et al., 2013).

This study aimed to investigate early indications of hypertension risk and the association of overweight and obesity in children who were primarily from ethnic minority backgrounds living in a low socioeconomic region of the rural South. We hypothesized that youth who are overweight and obese would be at greater risk of having a hypertensive classification than those who are not overweight or obese. To further illustrate the impact of weight status on risk of having a hypertensive classification, we present exploratory analyses indicating the probability of a nine-year-old female (approximate mean age of our sample) having a hypertensive classification when their body mass index (BMI) is at 50th, 85th, 95th, and 99th percentile.

1. Methods

For this cross-sectional study, 139 female children and pre-adolescents (M age = 8.85 ± 1.67 years) from a rural school (i.e., Kindergarten through 6th grade) in the Southeastern region of the United States served as participants. African-American/Black children comprised the largest portion (82%) of the sample (Table 1). The median household income in the school district was $30,000 USD and all participants qualified for free or reduced lunch. The project protocol was approved by the Institutional Review Board. Before data collection, written informed consent from the parent/legal guardian and verbal assent from the participant were obtained. The exclusion criteria for the study was that no participant could already be on anti-hypertensive medication. This was confirmed with the school nurse and during the consent process. No participants were excluded from the study.

Table 1
Participant characteristics.

	Mean ± SD		
	Total sample	Normal weight	Overweight/ obese
N	139	94	45
Age	8.85 ± 1.67	8.71 ± 1.65	9.13 ± 1.70
Race/ethnicity			
White/Caucasian	5.8%	6.38%	4.44%
Black/African-American	82.0%	80.85%	84.44%
Hispanic	11.5%	12.77%	8.89%
Bi-racial/multi-racial	0.7%	0.00%	2.22%
Systolic blood pressure category			
Normal	71.3%	78.72%	55.56%
Pre-hypertension	12.9%	9.57%	20.00%
Hypertension Stage 1	15.2%	11.70%	22.22%
Hypertension Stage 2	0.0%	0.00%	0.00%
Missing Data (n = 1)	0.7%	0.00%	2.22%
Diastolic blood pressure category			
Normal	79.9%	87.23%	64.44%
Pre-hypertension	10.1%	7.45%	15.56%
Hypertension Stage 1	7.9%	3.19%	17.78%
Hypertension Stage 2	2.2%	2.13%	2.22%

1.1. Demographic/anthropometric measures

Sex, date of birth, and racial/ethnic classifications were collected from the school records and parents/legal guardians. Height and weight measurements were taken during the school day by trained research assistants. Digital medical scales were used to measure height to the nearest 0.1 cm (Seca Stadiometer 220; SECA Corp. Hanover, MD) and weight to the nearest 0.1 kg (Seca Floor Scale 769, SECA Corp. Hanover, MD). Shoes and heavy outerwear were removed for both measurements and children were instructed to stand in a relaxed position with arms hanging freely to the side.

BMI was calculated based on the child's height and weight measurements (kg/m^2) and compared to the Centers for Disease Control and Prevention sex-specific BMI-for-age normative growth charts to determine BMI percentile (Kuczmarski et al., 2002). These growth charts provide a representative sample to determine BMI percentile based on a child's age and sex. From these growth charts, children are classified as overweight if their BMI percentile is determined to be equal to or above the 85th percentile and obese if equal to or above the 95th percentile.

1.2. Hypertension

Resting blood pressure was used to indicate hypertension classification. Resting blood pressure measurements were taken by two trained research assistants with calibrated, automatic blood pressure monitors (Omron HEM-711 DLX, Omron Healthcare, Inc., Vernon Hill, IL) using a cuff size appropriate for each participant's upper arm size. Auscultation is considered the gold standard for resting blood pressure readings (USDHHS, 2005). But results from an automated oscillometric devices (AOD) are highly correlated with auscultation readings when calibrated and observer error and bias are minimized (USDHHS, 2005). Readings were taken while the participant was in a relaxed and seated position, feet flat on the floor, and arm resting at heart level with their palm facing upward. The right arm was used for all measurements.

Three measurements were taken from each participant. Before taking resting blood pressure, participants were seated in a private area. During this time, participants engaged in a relaxing activity for 5 min that included looking at magazines or coloring. After the relaxing activity, blood pressure measurements were taken with a one-minute rest period between each reading. This one-minute rest period was in accordance with established guidelines by the National High Blood Pressure Education Program Working Group (Falkner et al., 2004) on High Blood Pressure in Children and Adolescents. Based on previous work, resting blood pressure was reassessed one week later if there were any outliers (i.e., ≤ 10 mmHg difference in the final two readings or SBP was ≤120 mmHg) (Robinson et al., 2013).

For data analysis, the final two SBP and DBP readings were averaged to determine SBP and DBP percentile and classification using the United States Department of Health and Human Services (USDHHS) (2005) blood pressure classification tables. These tables take into consideration a child's sex, age, and height to classify, based on a representative sample, a child's SBP and DBP percentile (USDHHS, 2005). SBP and DBP classification are based on the following percentiles: 90th to the 95th percentile (prehypertension); 95th percentile to 5 mmHg above the 99th percentile (Stage 1 hypertension); equal to or > 5 mmHg above the 99th percentile (Stage 2 hypertension) (USDHHS, 2005).