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Relationship between Systolic and Diastolic Blood Pressure Loads on ABPM and BMI Percentiles in Children

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Abstract

Ambulatory blood pressure monitoring is widely used in pediatric patients to identify hypertension and its complications. Previous studies correlating obesity and hypertension using ABPMs showed increasing blood pressure loads with increasing BMI. However, BMI percentiles are more reliable indicators of obesity in children. Our study aimed to describe the association between BMI percentiles and systolic and diastolic blood pressure load using ABPM in children and adolescents. Retrospective analysis of ABPMs (Welch Allyn) was performed on a total of 115 patients between 7 and 18 years of age who were referred for elevated BP without a diagnosis of hypertension at our institution from Jan 2011 to Oct 2013. Patients were divided into 4 groups based on BMI percentile: <94th percentile, 94–98th percentile, 98–99th percentile, and >99th percentile. Analysis between blood pressure loads and BMI percentiles revealed greater mean systolic and diastolic loads with increasing BMI percentiles, but the P value was not statistically significant. Analysis of the systolic loads between children from different racial backgrounds revealed higher values in African American children than in Hispanic and Caucasian children, but the P value was not statistically significant.

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Introduction

The obesity epidemic in childhood has led to increased emphasis on hypertension and early cardiovascular disease. Approximately 1 in 3 deaths in the United States have been due to cardiovascular disease. Evidence of target end-organ damage has been observed in children with hypertension. Obesity has replaced renal causes as the most common cause of hypertension in children. Ambulatory blood pressure monitoring (ABPM) allows for more realistic and accurate monitoring of blood pressure during normal daily activities, offering a more nuanced understanding of blood pressure patterns compared to single office measurements. By providing a comprehensive assessment of both systolic and diastolic blood pressure loads over a 24-hour period, ABPM allows for a more accurate

evaluation of hypertension and its variability in children.

Previous research has demonstrated a correlation between obesity, as measured by body mass index (BMI), and hypertension in children [1,2,3]. However, these studies often relied on traditional BMI measurements rather than BMI percentiles, which are considered more accurate in reflecting obesity levels in pediatric populations. Moreover, while BMI-based studies have highlighted an association between increased body fat and higher blood pressure, there is a need for more detailed investigations that consider the variability of blood pressure across different ethnicities and BMI percentiles.

This study aims to bridge this gap by exploring the relationship between BMI percentiles and both systolic and diastolic blood pressure loads using ABPM in a cohort of children and adolescents. By conducting a retrospective analysis of ABPM data from 115 patients aged 7 to 18 years, referred for elevated blood pressure without a formal diagnosis of hypertension, we seek to assess how varying levels of obesity—stratified by BMI percentiles—affect blood pressure loads. Additionally, this study examines potential racial differences in the relationship between obesity and blood pressure. This research is important because it helps us better understand how obesity affects blood pressure in different groups of children. Unlike previous studies, which used single measurements and didn't consider BMI percentiles or racial differences, our study looks at continuous blood pressure data and BMI percentiles. While our initial findings weren't statistically significant, they set the stage for further research to explore the reasons behind these links and to find ways to address the cardiovascular risks related to childhood obesity.

In sum, this study contributes to the growing body of evidence on pediatric hypertension and obesity, emphasizing the need for further investigation into these complex relationships to improve public health strategies and preventive measures.

Aim

Our study aimed to describe the association between BMI percentiles and systolic and diastolic blood pressure loads during normal daily activities using ABPM in children and adolescents.

Methods

A retrospective chart review was performed on children seen at our clinic between Jan 2011 and Oct 2013. Children with blood pressure readings above the 95th percentile on three separate occasions were referred to our clinic for evaluation. ABPM was performed with a Welch Allyn 6100 using an appropriately sized cuff. ABPM was performed at our clinic in children above 7 years of age and with a weight of 40 kg at the initial visit. The ABPM machine was programmed to record every 20 minutes during waking hours and every 30 minutes between 11:00 PM and 6:00 AM during sleeping hours. Studies with less than 24 readings over a 24-hour period and studies with multiple error readings and wide fluctuations were excluded because they were considered unreliable. Patients who had preliminary investigations for hypertension and children with secondary hypertension were excluded from the review. All the children underwent initial cardiac evaluation for cardiac anomalies and left ventricular hypertrophy. The children's anthropometric data and blood pressure data were recorded on the date of the study and documented in the EPIC. BMI was automatically calculated and recorded on the BMI percentile curve. ABPM was performed on children with appropriately sized cuffs. Standardized instructions were given to parents and children. A total of 225 children with hypertension were identified by ABPM during the study period, 115 of whom fulfilled the study criteria for a

diagnosis of primary hypertension. The data were analyzed with SPSS software. Patients were divided into 4 groups based on BMI percentiles: below the 94th percentile, between the 94th and 97th percentiles, between the 98th and 99th percentiles and above the 99th percentile. Bivariate analysis between the mean systolic and diastolic loads in ABPM and BMI percentiles was performed.

Results

Body mass index analysis of ABPM revealed 25 children with a BMI less than the 94th percentile, 31 children with a BMI between the 94th and 97th percentiles, 19 children between the 98th and 99th percentiles and 39 children above the 99th percentile for age. There were a total of 30 African American [26%], 45 Hispanic [39%] and 40 Caucasian [34%] children in the analyzed data.

Children with a BMI below the 94th percentile had a mean systolic load of 34.15% and a mean diastolic load of 8.65%; children with a BMI between the 94th and 97th percentiles had a mean systolic load of 37.13 and a mean diastolic load of 8.87; children with a BMI between the 98th and 99th percentiles had a mean systolic load of 37.95 and a mean diastolic load of 10.00%; and children with a BMI above the 99th percentile had a mean systolic load of 46.88% and a mean diastolic load of 10.23% [Table 1].

The mean systolic and diastolic loads were highest in children with a BMI above the 99th percentile, but the difference was not statistically significant [p=0.2176 and p=0.9762, respectively] (Table 1).

Bivariate analysis comparing blood pressure in children from different ethnicities revealed that African American children had a greater mean systolic load than Hispanic and Caucasian children, but this difference was not statistically significant. [p=0.2744 [table 2].

Table 1. Mean Systolic and Diastolic loads corresponding to different BMI percentiles and the associated P values

BP load	**BMI <94 % ile**	**BMI 94-97 %ile**	**BMI 98-99 %ile**	**BMI> 99% ile**	**P value**
Mean systolic load (SD)	34.15 (29.40)	37.13 (24.40)	37.95 (29.45)	46.87 (26.07)	0.21
Mean diastolic load (SD)	8.65 (11.15)	8.87 (11.37)	10.00 (16.42)	10.23 (13.26)	0.97

Table 2. Mean systolic loads among different ethnic subgroups.

Race	**Number of children**	**Mean systolic load**	**Standard deviation (SD)**
African American	30	43.70	27.11
Hispanic	45	42.24	28.11
Caucasian	40	34.40	24.71

Discussion

Our study investigated the relationship between obesity and hypertension in children and adolescents using ambulatory blood pressure monitoring (ABPM). Ambulatory blood pressure monitoring is considered the gold standard for the diagnosis of hypertension in children. ABPM studies allowed us to assess systolic and diastolic loads and compare them with body mass index. This allowed us to better assess the relationship between the severity of obesity and the severity of hypertension. Most studies have used single blood pressure measurements and body mass indices to assess the relationship between obesity and hypertension. Our study is unique since we were able to look at systolic and diastolic loads as opposed to single point blood pressure checks.

We focused on BMI percentiles for a more accurate assessment of obesity. We found that as BMI increased, there was a corresponding increase in mean systolic and diastolic blood pressure. However, these associations did not reach statistical significance. Interestingly, BMI and blood pressure were more strongly correlated in African American children than in Hispanic or Caucasian children, although the difference was not statistically significant. Although our study did not find significant associations, it provides valuable insights into pediatric hypertension and the role of obesity.

Previous studies have established a significant association between child obesity and hypertension, controlling for various parameters, such as age, sex, glucose and lipid parameters (4)(5). These studies also revealed that abdominal obesity, as measured by waist circumference (WC), is significantly associated with prehypertension and hypertension. A study by Dulskiene et al(5) revealed a stronger association between obesity and elevated blood pressure in boys. They found that boys were significantly heavier and had a greater median SBP and a significantly lower DBP than girls. However, the association between BP and obesity remained significant even after adjusting for sex and age. Gender may not be a confounding variable, as a study conducted by Zuhal Gundogdu et al (8) revealed that although BMI among girls was greater than that among boys in their study sample, there were no significant differences between sexes concerning blood pressure values.

Childhood overweight and obesity may result in premature onset of cardiovascular risk factors such as hypertension. Rural populations in North America may be at increased risk for overweight (13). The prevalence of elevated BP was 11.2% in normal-weight children, 20.6% in overweight children, and 39.7% in obese children(9). High blood pressure is common in 3- to 12-year-olds with overweight/ obesity, with greater obesity associated with greater hypertension. Blood pressure is likely to be associated with sustained hypertension in children who are overweight/obese or have stage 2 disease and should be prioritized for evaluation (10). Thus, it is essential for children and adolescents to maintain a BMI within the normal range to prevent and control pediatric hypertension(12).

This study has a few limitations. As this was a cross-sectional study, there was no temporal relationship. This study focuses more on associations rather than causation. This limitation is common to the previous research conducted on this topic (4)(5)(6)(7)(8)(9)(10)(11)(12)(13). The small sample size in our study was compensated for by the optimization of study features, such as the use of ABPM instead of a single office blood pressure measurement. Ambulatory blood pressure monitoring allows us to detect white-coat hypertension, masked hypertension, and abnormal circadian variation in BP, such as isolated nocturnal hypertension and blunted dipping (11). Our study also explored the correlation between obesity and hypertension among different ethnicities.

Another limitation is the use of BMI percentiles alone as a measure of obesity. The use of BMI percentiles was believed to be appropriate for estimating CVD risk (7) in the past. However, recent

studies have shown that BMI cannot distinguish between fat in different body compartments (6) and may inaccurately categorize children (14). A study conducted by Clasey et al. revealed that some children classified as healthy weight or overweight based on BMI percentiles had higher body fat percentages and/or lower fat-free mass indices than the recommended standards. This limitation can be overcome by incorporating additional measures such as body composition assessments to enhance the sensitivity and accuracy of identifying children with obesity (14).

Despite the abovementioned limitations, our study revealed a correlation between hypertension and obesity in children and adolescents. This emphasizes the importance of children maintaining the recommended body weight and composition to prevent future cardiovascular complications. Previous studies have suggested that adequate consumption of dairy products (15), fish, fruit, and vegetables, restricted salt (sodium chloride) (16), and reduced consumption of sugar-sweetened beverages (17) can reduce the risk of hypertension and other cardiometabolic disorders. Higher levels of physical activity can also reduce the risk of CVD (18). Thus, it is essential to promote and encourage a healthy and sustainable lifestyle among young people to maintain obesity at bay and prevent associated health complications. Early detection and prompt intervention appear to offer the best solution.

Conclusion

Although our study did not reveal statistically significant associations between BMI percentiles, systolic and diastolic loads, or racial backgrounds in children, it offers valuable preliminary insights into these complex relationships. These findings underscore the importance of continued research efforts aimed at explaining the underlying mechanisms driving cardiovascular health disparities in pediatric populations and informing targeted interventions to promote optimal health outcomes for all children.

Statements and declarations

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