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ORIGINAL ARTICLE

Relation Between Childhood Obesity and Blood Pressure Among School Aged Children

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ABSTRACT

Background: Childhood obesity has become an important public-health problem and is becoming more associated with cardiovascular risk factors at a young age. Complications of obesity in children include, but are not limited to, elevated blood pressure and hypertension, which if identified early, can decrease the burden of cardiovascular disease later in life.

Objective: To determine the relationship between childhood obesity and blood pressure among school-aged children.

Material and Methods: This cross-sectional study was conducted at HBS Medical and Dental College, Islamabad, from January 2023 to June 2023. A total of 82 School-aged children were included. Demographic data and anthropometric data, namely weight, length, and BMI (body mass index) were collected. The participants were divided into three groups: normal weight, overweight, and obese, based on the BMI-for-age criterion. Blood pressure was measured according to standard procedures, with the result being the systolic blood pressure (SBP) and the diastolic blood pressure (DBP). Blood pressure was classified as normal, elevated or hypertension based on paediatric criteria. Appropriate statistical tests, correlation analysis and multivariable logistic regression were used to determine the relationship between BMI and blood pressure. A p value less than 0.05 was deemed to be statistically significant.

Results: The mean age of participants was 10.46 ± 2.18 years, and 44 (53.7%) were boys. Of the 82 children, 43 (52.4%) had normal weight, 17 (20.7%) were overweight, and 22 (26.8%) were obese. Mean SBP increased significantly from 103.72 ± 8.94 mmHg in normal-weight children to 110.41 ± 9.76 mmHg in overweight children and 120.59 ± 11.18 mmHg in obese children ($p < 0.001$). Mean DBP also increased from 65.81 ± 6.72 mmHg to 70.76 ± 7.13 mmHg and 75.77 ± 8.42 mmHg, respectively ($p < 0.001$). Abnormal blood pressure was observed in 11.6% of normal-weight, 41.2% of overweight, and 77.3% of obese children ($p < 0.001$). BMI was positively correlated with both SBP ($r = 0.61$, $p < 0.001$) and DBP ($r = 0.49$, $p < 0.001$). Obesity remained independently associated with abnormal blood pressure after adjustment for age and sex (AOR = 5.82, 95% CI: 2.01–16.84; $p = 0.001$).

Conclusion: Increasing BMI was significantly associated with higher systolic and diastolic blood pressure among school-aged children. Obese children had a markedly greater frequency of elevated blood pressure and hypertension than normal-weight children. Routine assessment of BMI and blood pressure may facilitate early identification of children at increased cardiovascular risk.

Keywords: Childhood obesity; body mass index; blood pressure; hypertension; overweight; school-aged children.

INTRODUCTION

Childhood obesity is a growing health issue as obesity gained in childhood can be associated with metabolic and cardiovascular abnormalities that persist well into adulthood. Early onset obesity is correlated with insulin resistance, dyslipidaemia, abnormal glucose metabolism, endothelial dysfunction and high blood pressure. The relation between obesity and hypertension is especially important as both can end up lasting into old age and may be responsible for early cardiovascular morbidity. Recent reviews have determined that obesity is one of the most significant modifiable risk factors for hypertension in children and adolescents[1-3].

Blood pressure varies in children as blood pressure in the adult population, and is related to growth and development. Accurate anthropometric assessment is especially important in younger children, in whom measurements of blood pressure are usually used to refer to age, sex, and height. Pediatric hypertension can be completely asymptomatic for long periods of time and high blood pressure might otherwise go undiagnosed if blood pressure is not taken as part of routine care. There is recent evidence to show that a significant proportion of children suffer from occasional and chronic hypertension worldwide, highlighting the need for suitable blood-pressure assessment in children [4-6].

There are multiple factors that link obesity with hypertension. Obesity can lead to an increase in sympathetic nervous system activity and the regulation of the renin–angiotensin–aldosterone system (RAAS), resulting in vasoconstriction, sodium retention, and a rise in circulating blood volume. Insulin resistance, systemic inflammation, endothelial dysfunction, changes in blood vessel structure and impaired pressure natriuresis may also play a role in the increased blood pressure associated with obesity. Obesity, its severity, distribution, duration, and dietary sodium intake, sedentary lifestyle, age, and pubertal development may alter the risk of hypertension[7-9].

There have been several epidemiological studies that have shown an increasing trend of blood pressure with BMI. Children who are overweight or obese have much higher chances of having raised blood pressure than children who are of normal weight. The prevalence of high blood pressure was seen to increase as the level of obesity increased, with increasingly higher obesity levels in children ages 3-12 years in a recent study. When population-based research was used to assess the relationship between excess body weight and blood pressure differences among children, overweight and obesity was found to be a key determinant of blood pressure differences[10, 11].

The recognition of elevated blood pressure in obese children is important because cardiovascular alterations associated with obesity may begin early and potentially progress over time. Obesity, along with hypertension, could be a risk factor for cardiovascular disease in childhood, and a child's hypertension, combined with obesity, might be a risk factor for cardiovascular disease in the long term during adolescence and adulthood. However, for the reduction of obesity-related blood-pressure abnormalities early lifestyle intervention is key, in particular improvements in diet, physical activity, reduction in sedentary behavior and healthy weight management. There is also recent evidence that structured exercise interventions have the potential to lower blood pressure among overweight or obese children and adolescents[12, 13].

Despite increasing international evidence, locally generated information examining the relationship between body weight and blood pressure among school-aged children remains valuable because patterns of diet, physical activity, socioeconomic

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conditions, and childhood obesity may vary between populations. Assessing both BMI and blood pressure in school-aged children can help identify high-risk individuals at an earlier stage and provide evidence for preventive school and community health interventions. Therefore, the present study was conducted at HBS Medical and Dental College, Islamabad, to determine the relationship between childhood obesity and blood pressure among school-aged children, with particular emphasis on differences in systolic and diastolic blood pressure across BMI categories and the association of overweight and obesity with abnormal blood pressure.

MATERIAL AND METHODS

This cross-sectional study was conducted at HBS Medical and Dental College, Islamabad, from January 2023 to June 2023. The study was designed to determine the relationship between childhood obesity and blood pressure among school-aged children. A total of 82 children were included during the study period. Children of school-going age who were available during data collection and whose parents or guardians provided consent for participation were considered eligible. Children with known chronic renal disease, congenital or acquired heart disease, endocrine disorders, chronic systemic illnesses, or those receiving medications known to affect body weight or blood pressure were excluded to minimize the influence of underlying medical conditions on the study findings. HBS Medical and Dental College is an established medical education institution in Islamabad.

The subjects were selected by a non-probability consecutive sampling technique until the desired sample size was obtained (82 subjects). Prior to data collection, the appropriate institutional authorities were contacted. Parents and/or guardians provided written informed consent and children provided assent as appropriate. Participant confidentiality was maintained because the data set used for analysis did not contain participants' identifying information but rather a unique study identification number. A structured data collection proforma was used to record the demographic data such as age and sex.

Standardized procedure was used to undertake anthropometric measurements. The child's weight was taken in light clothing and without shoes on a calibrated weighing scale. The height was determined in centimeters, standing erect, heels together, and head in proper position without shoes. Body mass index (BMI) was determined from weight (kg) divided by height2 (m2). BMI was then converted using age and sex based paediatric reference values. The participants were classified as normal weight, overweight, or obese based on the classification of BMI-for-age used for this study. Waist circumference and other anthropometric measurements were also taken, if available, to give further details about central adiposity.

BP was obtained after 5 minutes of resting and relaxation under standardised conditions. A suitable-sized cuff for children was used based on the size of the upper arm. Blood pressure was taken while the child was seated, back supported, feet comfortably flat on the floor, and the arm supported at about heart level. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured in millimeters of mercury (mmHg). Two readings were taken at short intervals and the average value was analysed. Using age-, sex- and height-appropriate pediatric criteria, blood pressure status was considered to be normal blood pressure, elevated blood pressure, or hypertension. Other factors, including family history of hypertension, physical activity, diet, screen time and family history of obesity were also documented when available.

Data were collected and analyzed with IBM SPSS Statistics. All continuous variables were summarized as mean and standard deviation, and the categorical variables as frequencies and percentages. The difference between mean systolic and diastolic blood pressure between the normal weight, overweight and obese groups was analyzed with an appropriate parametric or non-parametric test depending on the distribution of data. The association between BMI category with abnormal blood pressure was evaluated by chi-square test or Fisher's exact test, as appropriate. Pearson or Spearman correlation analysis was used to determine the relationship between BMI and continuous blood pressure measurements. After adjusting for potential confounding factors (age and sex), the association of overweight (and obesity) with elevated blood pressure or hypertension was evaluated using multivariable logistic regression. Odds ratios (OR) with 95% confidence intervals (CI) were reported and a p value <0.05 was used to identify statistical significance.

RESULTS

Overall 82 school aged children participated in this study. The mean age of the participants was 10.46 ± 2.18 years, ranging from 6 to14 years. Of the total participants, 44 (53.7%) were boys and 38 (46.3%) were girls. The mean body mass index (BMI) was 19.42 ± 4.11 kg/m². The proportions of children who were normal weight, overweight and obese based on BMI-for-age were 43 (52.4%), 17 (20.7%) and 22 (26.8%) respectively. The overall mean systolic blood pressure was 109.63 ± 12.48 mmHg, while the mean diastolic blood pressure was 69.51 ± 8.76 mmHg.

When considering weight status, just over half of children were in the normal weight range. 17 (20.7%) children were overweight and 22 (26.8%) were obese. Sixteen (19.5%) participants had elevated blood pressure and 13 (15.9%) children had hypertension. 53/53 (64.6%) subjects had normal blood pressure.

There was a gradual rise in mean blood pressure between the BMI categories. The mean systolic blood pressure was 103.72 ± 8.94 mmHg, 110.41 ± 9.76 mmHg and 120.59 ± 11.18 mmHg in the normal weight, overweight and obese children, respectively. Systolic blood pressure mean was statistically different between the three BMI groups ($p < 0.001$). In the case of diastolic blood pressure, the non-normal weight children (70.76 ± 7.13 mmHg for overweight children, 75.77 ± 8.42 mmHg for obese children) also exhibited significant differences from the normal weight children ($p < 0.001$).

Elevated blood pressure or hypertension was also found to be significantly different by weight status. There were 43 children with normal weight, of which 38 (88.4%) were also found to have normal blood pressure, and 5 (11.6%) children with elevated blood pressure/hypertension. Abnormal BP was noted in seven (7) of the overweight children (41.2%) and 17 of the obese children (77.3%). Association between BMI category and abnormal BP was statistically significant ($p<0.001$).

Correlation analysis showed that there is a significant positive relationship between BMI and systolic blood pressure (SBP), and a significant positive relationship between BMI and diastolic blood pressure (DBP). BMI was moderately to highly correlated with both systolic ($r = 0.61$, $p < 0.001$) and diastolic ($r = 0.49$, $p < 0.001$) blood pressure. These results have shown a trend of an increase in blood pressure with increased BMI.

After adjusting for age and sex in the multivariable logistic regression analysis, obesity stayed significantly associated with abnormal blood pressure. The odds of elevated blood pressure or hypertension were significantly increased by 5.82 times (95% CI: 2.01–16.84, $p = 0.001$) among obese children compared to children of normal weight. Children who were overweight also had higher odds of abnormal blood pressure, but with a smaller association (AOR = 2.71, 95% CI: 1.01–7.29, $p = 0.048$). Upward direction of the age was modestly related to high blood pressure and sex was not independently related to the outcome.

Overall, the findings showed a clear relationship between increasing body weight and higher blood pressure among school-aged children. Both systolic and diastolic blood pressure increased progressively from normal-weight to overweight and obese categories, while the proportion of children with elevated blood pressure or hypertension was substantially greater among those with obesity. Obesity remained an independent predictor of abnormal blood pressure after controlling for age and sex.

The figure shows a progressive increase in both systolic and diastolic blood pressure from normal-weight to overweight and obese children. Mean systolic blood pressure increased from 103.72 mmHg in normal-weight children to 110.41 mmHg in overweight children and 120.59 mmHg in obese children. Mean diastolic blood pressure also rose from 65.81 mmHg in normal-weight children to 70.76 mmHg in overweight children and 75.77 mmHg in obese children, indicating a positive relationship between increasing BMI and blood pressure.

Table 1: Demographic and anthropometric characteristics of study participants (n = 82)

Characteristics	Value
Age, years, mean ± SD	10.46 ± 2.18
Boys	44 (53.7%)
Girls	38 (46.3%)
Weight, kg, mean ± SD	39.28 ± 12.64
Height, cm, mean ± SD	139.62 ± 13.71
BMI, kg/m², mean ± SD	19.42 ± 4.11
Systolic BP, mmHg, mean ± SD	109.63 ± 12.48
Diastolic BP, mmHg, mean ± SD	69.51 ± 8.76

Table 2: Distribution of BMI and blood pressure categories among participants

Variable	Frequency (n)	Percentage (%)
BMI category		
Normal weight	43	52.4
Overweight	17	20.7
Obese	22	26.8
Blood pressure category		
Normal BP	53	64.6
Elevated BP	16	19.5
Hypertension	13	15.9

Table 3: Comparison of blood pressure according to BMI category

Blood pressure parameter	Normal weight (n = 43)	Overweight (n = 17)	Obese (n = 22)	p-value
Systolic BP, mmHg	103.72 ± 8.94	110.41 ± 9.76	120.59 ± 11.18	<0.001
Diastolic BP, mmHg	65.81 ± 6.72	70.76 ± 7.13	75.77 ± 8.42	<0.001

Table 4: Association between BMI category and abnormal blood pressure

BMI category	Normal BP, n (%)	Elevated BP/Hypertension, n (%)	p-value
Normal weight (n = 43)	38 (88.4)	5 (11.6)	
Overweight (n = 17)	10 (58.8)	7 (41.2)	
Obese (n = 22)	5 (22.7)	17 (77.3)	<0.001

Table 5: Correlation between BMI and blood pressure measurements

Variables	Correlation coefficient (r)	p-value
BMI and systolic BP	0.61	<0.001
BMI and diastolic BP	0.49	<0.001

Table 6: Multivariable logistic regression for predictors of abnormal blood pressure

Predictor	Adjusted OR	95% CI	p-value
Overweight	2.71	1.01–7.29	0.048
Obesity	5.82	2.01–16.84	0.001
Age, per year increase	1.24	1.01–1.52	0.039
Male sex	1.18	0.47–2.96	0.725

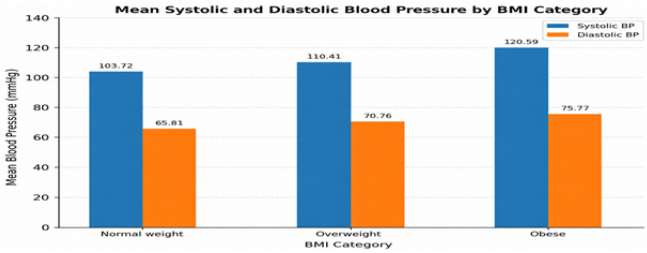

Figure 1: Mean systolic and diastolic blood pressure according to BMI category among school-aged children.

DISCUSSION

The present study demonstrated a clear relationship between increasing body mass index and higher blood pressure among school-aged children. Both systolic and diastolic blood pressure increased progressively across normal-weight, overweight, and obese categories. Mean systolic blood pressure increased from 103.72 mmHg among normal-weight children to 110.41 mmHg among overweight children and 120.59 mmHg among obese children, while mean diastolic blood pressure increased from 65.81 mmHg to 70.76 mmHg and 75.77 mmHg, respectively. These differences were statistically significant. The findings support the growing evidence that excess body weight during childhood is an important determinant of elevated blood pressure. Studies identified childhood obesity as a major risk factor for pediatric hypertension and emphasized that the prevalence of obesity-related hypertension is increasing alongside childhood obesity[14, 15].

In the present study, the percentages of BP abnormality in children also showed significant linear trend with BMI. Only 11.6% of normal weight children had elevated blood pressure (hypertension) compared to 41.2% of overweight children and 77.3% of obese children. The pattern indicates that in children with excess adiposity, cardiovascular changes might be observed as early as childhood. The results of a large study of children (3-12 years) with overweight and obesity are similar, with about 31% of them having elevated or hypertensive blood pressure. The prevalence was higher as severity of obesity increased, from 27% to 49% in overweight and class III obesity children respectively. Therefore, the relationship noted in the present study is in line with greater number of pediatric patients and shows that the issue of excessive weight gain needs to be addressed before excessive obesity occurs[16, 17].

Additionally, significant positive correlations were observed using correlation analysis between BMI and both SBP and DBP, with the effect being more pronounced for SBP. There was moderate to strong correlation of BMI with systolic blood pressure (r = 0.61) and moderate correlation with diastolic blood pressure (r = 0.49). A similar pattern was seen in previous studies; blood pressure increases with greater BMI in children and adolescents, and there is greater blood pressure responsiveness to increased adiposity among children with higher BMI. Studies, obese adolescents were found to have significantly higher systolic blood pressure and a higher rate of elevated blood pressure compared to non-obese adolescents. The factors by which pediatric obesity can lead to elevated blood pressure are complex, with increased sympathetic nervous system activity, activation of the renin–angiotensin–aldosterone system, insulin resistance, sodium retention, inflammation, endothelial dysfunction and vascular changes all playing a possible role[18].

An additional important finding was that obesity was independently associated with abnormal blood pressure, after taking into account age and sex. Compared with normal weight children, the adjusted odds for elevated blood pressure or hypertension were about 5.8-fold higher in obese children and were higher in overweight children. This suggests that the association observed is not a difference in age or sex within the study sample. This is currently borne out by some modern evidence. Studies, the risk for blood hypertension progressively increased with increasing severity of obesity, even after multivariable adjustment. Likewise, studies of children and adolescents with excess weight have focused on the relationship between abdominal and general obesity and high blood pressure in children. Based on these findings, it is an easy anthropometric measure to obtain and could be useful to identify children who might benefit from more frequent cardiac monitoring[19, 20].

These findings have important clinical and public-health implications because obesity and high blood pressure that develop in childhood could persist through the adolescent years and into adulthood. Studies show that children and adolescents with obesity-induced hypertension can be at risk for childhood hypertension and adult heart disease. Routine screening of BMI

and blood pressure in children (aged 5–15) could therefore provide an opportunity for early identification of children at risk for cardiovascular disease. School-based interventions focused on healthy diets, physical activity, minimizing sedentary time and healthy body weight may help lower this risk. There are some limitations in the present study. The cross-sectional design does not provide information about the temporal or causal relationship between obesity and raised blood pressure, and the small number of children (n = 82) and the restricted geographical area in which children were recruited may limit generalizability. Furthermore, the information regarding potential relevant factors (e.g., dietary sodium intake, detailed physical activity, pubertal stage, socioeconomic status, sleep patterns, parental BMI) was not completely evaluated. Further multicenter prospective studies with larger sample sizes, multiple blood pressure determinations, comprehensive lifestyle evaluation and the tracking of blood pressure in adolescence are suggested to find the long-term effects of childhood adiposity on blood pressure trajectory.

CONCLUSION

Childhood obesity was significantly associated with higher blood pressure among school-aged children. Both systolic and diastolic blood pressure increased progressively from normal-weight to overweight and obese categories, and abnormal blood pressure was substantially more frequent among children with obesity. BMI showed significant positive correlations with systolic and diastolic blood pressure, while obesity remained an independent predictor of elevated blood pressure or hypertension after adjustment for age and sex. These findings emphasize the importance of routine assessment of BMI and blood pressure in school-aged children and the early implementation of weight-management and healthy-lifestyle interventions to reduce future cardiovascular risk.

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