

Original research article**Relationship between body mass index and blood pressure: A study among school going children**

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Abstract

Background: Body Mass Index (BMI) is believed to be an acceptable indicator of the risk of overweight in children and adolescents. Present study was aimed to study relationship between body mass index and blood pressure among school going children.

Material and Methods: Present study was cross-sectional observational study, conducted among 600 school-going urban children aged between 6 to 14.

Results: Among 600 students studied, 300 were from 6-10 years age-group & 300 were from 11-14 years age-group with equal distribution of boys & girls. Majority were from < 25 kg/m² group (70.66%), 21.5% were overweight & 47 children were obese (7.83%). We noted that, among 6-10 years age group, incidence of Prehypertension & Hypertension was 3% & 1.5% respectively. While among 11-14 years age group, incidence of Prehypertension & Hypertension was 3.5% & 1.83% respectively. Hypertension and prehypertension were observed in a higher proportion of obese and overweight children. In present study, we compared blood pressure readings among Underweight, Normal, and Overweight & Obese children. A statistically significant difference was noted among various BMI categories in boys as well as girls.

Conclusion: Overweight and obese children are at a significantly higher risk for hypertension than are normal weight children. Body mass index is highly associated and linearly related with both systolic and diastolic blood pressures among school going children.

Keywords: Body mass index, blood pressure, overweight, obese, prehypertension, hypertension

Introduction

Obesity is perhaps the most prevalent form of malnutrition in developing countries, both among adults and children. Studies have demonstrated that obesity is related to elevated systolic blood pressure (SBP) and diastolic blood pressure (DBP) elevation, dyslipidemia, diabetes, etc^[1,2].

Body Mass Index (BMI) is believed to be an acceptable indicator of the risk of overweight in children and adolescents^[3]. Several studies have demonstrated increasing mean BP with increasing age in children^[4]. Obesity is the main determinant of BP in children and adolescents.

High blood pressure (BP) and obesity among adolescents, in conjunction with many of their health consequences such as dyslipidaemia, abnormal plasma glucose and metabolic disorders, have dramatically increased over the past two decades worldwide due to the rapid socioeconomic, nutritional and epidemiological transitions^[4]. Blood pressure studies in children provide crucial epidemiological information helpful in the modification of risk factors for coronary heart diseases and other non-communicable diseases later in life^[5]. Present study was aimed to study relationship between body mass index and blood pressure among school going children.

Material and Methods

Present study was cross-sectional observational study, conducted among school-going urban children aged between 6 to 14 years, under Department of Physiology, at Department of Physiology, SRTR Government Medical College, Ambajogai, India. Study duration was of 6 months (July 2021 to December 2021). Study was approved by institutional ethical committee.

We visited 3 different private schools and 600 healthy students aged between 6-14 years from each school, included by random sampling method. Study discussed & consent was obtained from school authorities and their parents. Children having present or past history suggestive of cardiovascular, respiratory or any other systemic illness, family history of HT, asthma, diabetes, or having any physical disability were excluded from the study.

On inclusion, height was measured with a metallic non-stretchable tape measure (fixed to a plane surface wall) as well as weight was measured (in kilograms using standard electronic weighing scale to the nearest decimal fraction of 0.1 kg.). BMI was calculated using the formula: $BMI = \text{Mass (kg)}/\text{Height (m}^2\text{)}$.

Systemic examination was also done to exclude cardiovascular, renal, and other diseases which could affect blood pressure (BP). Standard methodology was employed to measure BP. BP was recorded in sitting position with his/her back supported, uncrossed feet on the floor, and right arm supported with cubital fossa at heart level to avoid parallax error. Standard clinical sphygmomanometer and stethoscope were used to record BP by auscultatory method. Appropriate size cuff bearing a width approximately 40%, and length of at least 80% of arm circumference was used^[6]. Appearance of Korotkoff sounds, K1 was noted as SBP reading and disappearance of sounds K5 was noted as DBP reading. All the recordings were taken on the same time of the day and recorded by the same person with the same instrument to avoid bias.

Data was collected and compiled using Microsoft Excel, analysed using SPSS 23.0 version. Frequency, percentage, means and standard deviations (SD) was calculated for the continuous variables, while ratios and proportions were calculated for the categorical variables. Difference of proportions between qualitative variables were tested using chi-square test and Fisher exact test as applicable. P value less than 0.05 was considered as statistically significant.

Results

Among 600 students studied, 300 were from 6-10 years age-group & 300 were from 11-14 years age-group with equal distribution of boys & girls. Majority were from < 25 kg/m² group (70.66%), 21.5% were overweight & 47 children were obese (7.83%).

Table 1: Distribution of all study subjects according to BMI, age & gender

Nutritional status(BMI kg/m ²)	6-10 years of age		11-14 years of age		Total
	Boys (%)	Girls (%)	Boys (%)	Girls (%)	
Underweight (< 18.5)	18 (3%)	11 (1.83%)	20 (3.33%)	19 (3.17%)	68 (11.33%)
Normal (18.5-24.9)	88 (14.67%)	99 (16.5%)	84 (14%)	85 (14.17%)	356 (59.33%)
Overweight (25.0-29.9)	29 (4.83%)	31 (5.17%)	32 (5.33%)	37 (6.17%)	129 (21.5%)
Obese Type 1 (30.0-34.9)	7 (1.17%)	5 (0.83%)	6 (1%)	3 (0.5%)	21 (3.5%)
Obese Type 2 (35.0-39.9)	5 (0.83%)	4 (0.67%)	5 (0.83%)	3 (0.5%)	17 (2.83%)
Obese Type 3 (> 40.0)	3 (0.5%)	0	3 (0.5%)	3 (0.5%)	9 (1.5%)

We noted that, among 6-10 years age group, incidence of Prehypertension & Hypertension was 3% & 1.5% respectively. While among 11-14 years age group, incidence of Prehypertension & Hypertension was 3.5% & 1.83% respectively. Hypertension and prehypertension were observed in a higher proportion of obese and overweight children.

Table 2: Distribution of subjects according to BMI grade and Blood Pressure recording

Body mass index grade	Normal blood pressure	Prehypertension	Hypertension	Total
6-10 years age				
BMI < 25	209 (34.83%)	5 (0.83%)	2 (0.33%)	216 (36%)
Overweight	50 (8.33%)	7 (1.17%)	3 (0.5%)	60 (10%)
Obese	14 (2.33%)	6 (1%)	4 (0.67%)	24 (4%)
Total	273 (45.5%)	18 (3%)	9 (1.5%)	300 (50%)
11-14 years age				
BMI < 25	199 (33.17%)	6 (1%)	3 (0.5%)	208 (44.67%)
Overweight	57 (9.5%)	8 (1.33%)	4 (0.67%)	69 (11.5%)
Obese	12 (2%)	7 (1.17%)	4 (0.67%)	23 (3.83%)
Total	268 (44.67%)	21 (3.5%)	11 (1.83%)	300 (50%)

In present study, we compared blood pressure readings among Underweight, Normal, and Overweight & Obese children. A statistically significant difference was noted among various BMI categories in boys as well as girls.

Table 3: Comparison of blood pressure readings

Variables	Underweight	Normal	Overweight	Obese	P value
Boys					
Systolic blood pressure (mmHg/ mean \pm SD)	97.4 \pm 13.5	98.7 \pm 10.3	100.1 \pm 9.4	103.1 \pm 13.5	0.01
Diastolic blood pressure (mmHg/ mean \pm SD)	54.8 \pm 7.5	55.5 \pm 6.8	55.1 \pm 11.8	57.2 \pm 9.5	0.04
Girls					
Systolic blood pressure (mmHg/ mean \pm SD)	90.6 \pm 9.9	94.2 \pm 10.8	97.1 \pm 9.2	99.3 \pm 12.5	0.02
Diastolic blood pressure (mmHg/ mean \pm SD)	51.4 \pm 4.8	50.7 \pm 6.9	52.1 \pm 4.5	55.4 \pm 11.4	0.01

Discussion

Childhood Obesity is a growing problem in India. Changes in diet habit, consumption of fast foods, sugar additive drinks and shifting to sedentary lifestyle have affected children and made them vulnerable to the risk of chronic diseases among adolescents^[7, 8]. A systematic review on epidemiology of childhood overweight and obesity in India reported prevalence data from 52 studies conducted in 16 of the 28 States in India. The pooled data after 2010 estimated a combined prevalence of 19.3 per cent of childhood overweight and obesity which was a significant upsurge from the earlier prevalence of 16.3 per cent reported in 2001-2005^[9].

Many chronic diseases such as diabetes, hypertension and cardiovascular diseases are known to be associated with obesity. Childhood obesity is also known to be associated with high blood pressure. Increase in the prevalence of hypertension in parallel with obesity epidemic in children has become a major problem^[10]. Hypertension in childhood may remain undiagnosed, and the reasons are mostly related to the measurement and interpretation of BP, as well as complicated diagnostic criteria.

Mehta S *et al.*,^[11] studied 1000 healthy school-going children (492 males and 508 females). A significant ($p < 0.001$) and positive correlation was observed between BMI and BP irrespective of gender. Hypertension and prehypertension were observed in a higher proportion of obese and overweight study subjects. Similar findings were noted in present study.

In study by Vinaykumar S *et al.*,^[12] pre-hypertension and hypertension was seen in 1% (2 out of 195) of normal and 0% (0 out of 30) of overweight and 60.9% (9 out of 14 obese children). P value was statistically significant indicating that there is strong association between BMI and blood pressure.

Jena SK *et al.*,^[13] studied 580 students of age group 6-12 years of both boys and girls. Overweight and obesity were more in boys than girls. There was significantly more BP in overweight and obese participants than healthy weight individuals. There was positive correlation between BMI and BP both systolic and diastolic BP. Prevalence of HTN in boys is more than the girls. Odds ratio suggested that overweight and obesity was associated with HTN. Similar findings were noted in present study.

Mohan B *et al.*,^[14] noted a high prevalence of obesity (2.3% urban and 3.6% rural areas) and hypertension (6.7% urban and 2.6% rural areas) in adolescent population, with a significant increase in the prevalence of hypertension among overweight (15.3% urban and 6.82% rural areas) and obese (43.1% urban and 61.76% rural areas) population.

Stephenson B *et al.*,^[15] studied 1000 children, of age group 13 to 17 years, the incidence of obesity was 3.5%. Girls outnumbered the boys in obesity with 4% compared to 3.5%. The mean Body Mass Index in girls was 21.9 statistically significant compared to boys (21.3). The age wise mean BMI and mean systolic BP along with diastolic BP was also significant. The mean systolic BP of girls (114 mm Hg) was greater than that of boys (113.2) mm Hg (P value 0.025). The mean diastolic BP of girls (72.9 mm Hg) was greater than that of boys (72.2 mm Hg (P value 0.057). A statistically significant positive correlation was seen in both systolic and diastolic BP with BMI of each age group. A positive correlation was also seen in males and females with systolic and diastolic BP with BMI in each age group.

In study by Mahalakshmi S *et al.*,^[16] covering 1728 children 849 boys and 879 girls from age group of 3-21 years. 88.9% of children in the age group of 3-8 years were underweight and in 15-21 years of age children were relatively healthy, but are inclined to move to overweight (17.66%) and obesity (7.21%). More of boys (31%) tend to be underweight than girls. Age and gender were found to be significantly related to BMI. Similar findings were noted in present study.

Children with obesity and HTN may be accompanied by additional cardiometabolic risk factors such as dyslipidemia and disordered glucose metabolism, which may contribute their effects on BP or may represent comorbid conditions arising from the same adverse lifestyle behaviors^[17,18].

Early identification of hypertension and prehypertension translates into early interventions and possibly prevention of later morbidity and mortality. Periodic surveys should be done in schools to identify the "at risk" group of children and adolescents who can develop hypertension in future, so that preventive care

can be provided.

Conclusion

Overweight and obese children are at a significantly higher risk for hypertension than are normal weight children. Body mass index is highly associated and linearly related with both systolic and diastolic blood pressures among school going children. Obesity has positive relation with blood pressure and therefore there is an urgent need to change lifestyle pattern as well as physical activity.

Conflict of Interest: None to declare.

Source of funding: Nil.

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