Original Research Article

# A Cross-Sectional Study of Association between Blood Pressure and Body Mass Index in School Children Aged 11 – 15 Years

**Shyna K P[1*], Santhosh Kumar K K[2], Visruth M Kumar[3], Riyaz A[4]**

*[1]DCH, MD Paediatrics, Associate Professor, Department of Paediatrics, Kannur Medical College, Anjarakandy, Kannur, Kerala, India*
*[2]MD Paediatrics, Associate Professor, Department of Paediatrics, SATH, Government Medical College, Thiruvananthapuram, Kerala, India*
*[3]MD Paediatrics, Senior Resident, Department of Paediatrics, Kannur Medical College, Anjarakandy, Kannur, Kerala, India*
*[4]MD, DCH, DNB, DM (Gastroenterology), Professor and Head, Department of Paediatrics, KMCT Medical College, Mukkam, Kozhikode, Kerala, India*

**Received: 03-11-2021 / Revised: 29-12-2021 / Accepted: 10-01-2022**

## Abstract

**Background:** High blood pressure in childhood and adolescence is a global public health problem and is often overlooked. It generally remains undiagnosed and untreated. The present study intended to find the association between blood pressure and body mass index among children aged 11 to 15 years. **Methods:** A cross-sectional study was conducted among 953 school children aged 11 to 15 years. The study was conducted between January 2020 and July 2020 after obtaining clearance from an institutional ethics committee. Weight and height were measured by standard methods and BMI was calculated. Blood pressure was measured using mercury sphygmomanometer and more than 95$^{th}$ centile for age, sex and height was considered to have hypertension. **Results:** In this study 953 school children were studied. Out of these 489 children were males and 464 were females. Children (25.7 %) were either overweight or obese. 197 (20.7 %) had an elevated blood pressure. The proportion of children with stage 1 and stage 2 hypertension was 6.1 % and 1.6 % respectively. 53.9 % of the overweight / obese children had more than normal blood pressure. There was a statistically significant relationship between blood pressure and BMI. **Conclusions:** The present study indicates that BMI is an important factor affecting BP levels in children. Simple anthropometric assessment to determine BMI in schools would help in predicting the risk of developing hypertension. This will help in reducing the morbidity and mortality associated with hypertension in adults.

**Keywords:** Blood Pressure, Body Mass Index, Association.



## Introduction

Cardiovascular diseases are the major causes of morbidity and mortality in adults. Systemic hypertension is an important risk factor for the development of cardiovascular diseases like coronary artery disease and stroke in adults. The prevalence of high blood pressure in children is found to be increasing in both developed and developing countries. This high blood pressure in children is often unrecognized and not managed appropriately. This increase in the prevalence of high blood pressure in children is attributed mainly to lifestyle changes like lack of physical activity, unhealthy dietary habits and an increase in body weight. High blood pressure in children may progress to adult hypertension and leads to hypertension-related organ damage in adults. Since detecting and controlling blood pressure and its determinants in childhood itself are important to prevent CVDs, we aim to study the association between blood pressure and body mass index.

The prevalence of high blood pressure in school children seems to be increasing both in developed and developing countries[1]. Studies have shown that essential hypertension can start from childhood itself. The blood pressure pattern during the adolescent period shows a strong correlation to adult blood pressure[2,3]. Although the prevalence of hypertension during childhood is lower than that is seen in adulthood this condition is not rare in children thus stressing the importance of evaluating for high blood pressure in children. The 2017 AAP guideline recommends that the children 3 years older should have their BP measured during annual preventive visits[4]. The prevalence of hypertension among children reported by various studies range from 5.4 % to 19.4 %[5,6]. Factors known to affect blood pressure among children include age, sex, obesity, race, family history of hypertension, ethnicity and socioeconomic status. Studies have demonstrated a rise in mean systolic blood pressure as age increases in children. One study reported that children with a systolic blood pressure > 90$^{th}$ percentile tend to remain in the same percentile over time. The increase in BMI predisposes the adolescent individual to higher blood pressure and subsequently hypertension in adulthood[7]. In a study by Mane et al. they reported that the increasing BMI contributed to an increase in both SBP and DBP[8]. In another study by Shah et al. reported 8.94 % prevalence of obesity and 20.9 % prevalence of hypertension among adolescents of Surat city[9]. Since hypertension is one of the most important risk factors for CVDs, the detection of blood pressure in early childhood and appropriate prevention strategies during childhood helps in preventing future cardiovascular morbidity.

The prevalence of high blood pressure is increasing in children and overweight/obesity is proposed as an important factor for developing childhood hypertension. Lifestyle diseases including cardiovascular diseases and childhood obesity are becoming a major concern in India, especially in Kerala. There are only a few studies from our

*Correspondence
**Dr. Shyna K P**
DCH, MD Paediatrics, Associate Professor, Department of Paediatrics, Kannur Medical College, Anjarakandy, Kannur, Kerala, India.
**E-mail:** shynasarosh@gmail.com

region in this regard mentioning the association between high blood pressure and BMI in school children.

**Methods**

A cross-sectional study was conducted among apparently healthy school children from both sexes aged between 11 and 15 years for 6 months from January 2020 to July 2020. Children having an acute illness at the time of examination and children with pre-existing cardiovascular or renal diseases were excluded from the study. The Institutional Ethical Committee clearance was obtained before conducting the study. The purpose of the study was clearly explained to the teachers and parents in the regional language and written informed consent was obtained before enrolling participants for the study.

Data was collected in a pre-tested proforma meeting the objective of the study. The age of the school children was obtained from the school records and other particulars like sociodemographic details, food habits, physical activity, family history of hypertension and anthropometric measurements were entered in the proforma.

Height was measured by making the child stand upright barefoot, on the ground with heels, buttocks and shoulder touching the wall and head in Frankfurt plane; and measured using a sliding stadiometer with an accuracy of 0.1mm. Weight was recorded using a standardized weighing machine with an accuracy of up to 0.1 kg.

BMI was calculated using the formula - BMI = Weight in Kilograms / Height in $m^2$ and expressed as $Kg/m^2$. Based on body mass index, children were classified as follows: Obese (> 95$^{th}$ percentile), Overweight (85 - 95$^{th}$ percentile) and Normal (85$^{th}$ percentile).

Blood pressure was measured in children in the age group of 11-15 years between 9 am and 12 pm in a sitting position after 10 minutes of rest. BP was measured after applying an appropriately sized cuff on the right arm encircling the 2/3$^{rd}$ circumference of the arm with a lower edge 2.5 cm above the cubital fossa, as per guidelines suggested by WHO. Systolic blood pressure was determined as the appearance of the 1$^{st}$ Korotkoff sound and diastolic blood pressure was taken at the point of muffling of heart sounds[10].Three measurements were taken at an interval of fifteen minutes each and the mean of these readings was taken as an average systolic and average diastolic blood pressure.

Hypertension is defined as average systolic and /or diastolic blood pressure > 95$^{th}$ percentile for gender, age, and height on 3 occasions. Prehypertension or elevated BP is defined as 90 - 95$^{th}$ percentile and < 90$^{th}$ percentile was considered normal blood pressure[11]. In those children whose sys tolic and diastolic blood pressures were found to be more than 95$^{th}$ percentile for age, sex and height, another set of blood pressure readings were taken at an interval of 2 weeks.

**Statistical Analysis**

Categorical and quantitative variables were expressed as frequency (percentage) and mean+/- SD respectively. Kruskal Wallis Test was used to compare level of among different BMI group. Chi-square test was used to find association between categorical variables. For all statistical interpretations, $p<0.05$ was considered the threshold for statistical significance. Statistical analysis was performed by using a statistical software package SPSS, version 20.0.

**Results**

A total of 953 children were studied. The maximum (42.91 %) number of children were 14 years old. 22.8 % were 13 years old and 22 % were 15 years of age. 6.6 % were 12 years old and 5.6 % were 11 years old. 51.3% were males and 48.7%were females. 37 % of the population belonged to the middle socioeconomic class. 29 % belonged to the low socioeconomic class and 7.5 % belonged to the high socioeconomic class. (Table 1)With regards to the presence of chronic illness in the family, hypertension (10.4 %) and diabetes mellitus (17.4 %) were the most common chronic illnesses present. 13.8 % had both diabetes and hypertension in the family. 57.5 % of them did not have any history of illness in the family. 96.85 % of the families consumed a mixed diet and junk food less than 3 times a week (80.58 %). 53 % of them were engaged in physical activity for more than an hour per day.

Based on the BMI measured, 658 (69 %) children were of the normal weight category. 11(1.2 %) children were of severe underweight category and 39 (4.1 %) children were underweight whereas 164 children (17.2 %) were overweight, and 81 (8.5 %) children were obese. Thus, there were a total of 50 children (5.2 %) who belonged to the underweight category and 245 children (25.7 %) were either overweight or obese. (Table 2)

683 (71.7 %) children had normal blood pressure. 197 (20.7 %) had elevated blood pressure or prehypertension. The proportion of children with stage 1 and stage 2 hypertension was 6.1 % and 1.6 % respectively. (Table 2)

92 % of the underweight children had normal blood pressure and 8 % of them had more than normal blood pressure. 46.1 % of the overweight / obese children had normal blood pressure whereas 53.9 % of children had more than normal blood pressure. There was a statistically significant relationship between blood pressure and BMI. (Table 2)

Children were stratified based on age, BMI and blood pressure. In all ages between 11 and 15 years, there was a statistically significant relationship between blood pressure and BMI. (Table 3)

Children were classified based on their blood pressure and BMI, stratified based on gender. There was a statistically significant relationship between BMI and blood pressure in both genders. (Table 4)

**Table 1: Background Characteristics of Children**

| | Sl. No. | Baseline Characteristics | No. of Children No. (%) |
|---|---|---|---|
| Age Distribution | 1 | 11 Years | 54 (5.66%) |
| | 2 | 12 Years | 63 (6.61%) |
| | 3 | 13 Years | 217 (22.77%) |
| | 4 | 14 Years | 409 (42.91%) |
| | 5 | 15 Years | 210 (22.03%) |
| Gender Distribution | 1 | Male | 489 (51.31%) |
| | 2 | Female | 464 (48.68%) |
| Socio Economic Status | 1 | Low | 277 (29.06%) |
| | 2 | Middle | 604 (63.37%) |
| | 3 | High | 72 (7.55%) |
| Family History Of Chronic Illness | 1 | No illness | 548 (57.50%) |
| | 2 | Diabetes Mellitus (DM) | 166 (17.41%) |
| | 3 | Hypertension (HTN) | 100 (10.49%) |
| | 4 | Chronic Kidney Disease | 1 (0.10%) |
| | 5 | DM + HTN | 132 (13.85%) |
| | 6 | Thyroid Disorders | 2 (0.20%) |
| | 7 | Bronchial Asthma | 3 (0.31%) |
| | 8 | Psoriasis | 1 (0.10%) |

| | | | |
|---|---|---|---|
| Diet | 1 | Vegetarian | 30 (3.14%) |
| | 2 | Mixed | 923 (96.85%) |
| Intake of Junk Foods | 1 | <3 times/week | 768 (80.58%) |
| | 2 | >3 times/week | 185 (19.41%) |
| Physical Activity | 1 | <1 hour | 445 (46.69%) |
| | 2 | >1 hour | 508 (53.30%) |

**Table 2: Association between Blood Pressure and BMI**

| BP | Under Weight | Normal | Overweight/ Obese | $\chi^2$ Value | P-Value |
|---|---|---|---|---|---|
| | No. (%) | No. (%) | No. (%) | | |
| Normal | 46 (92%) | 524 (79.6%) | 113 (46.1%) | 113.86 | P < 0.01 |
| Elevated BP | 3 (6%) | 105 (16%) | 89 (36.3%) | | |
| Stage 1 Hypertension | 1 (2%) | 23 (3.5%) | 34 (13.9%) | | |
| Stage 2 Hypertension | 0 (0%) | 6 (0.9%) | 9 (3.7%) | | |

**Table 3: Association between Blood Pressure and BMI Stratified Based on the Age**

| Age (Years) | BP | Under weight | Normal | Overweight/ Obese | $\chi^2$ Value | P Value |
|---|---|---|---|---|---|---|
| 11 - 12 | Normal | 4 (100) | 79 (90.8) | 14 (53.8) | 19.51 | P < 0.01 |
| | Elevated BP | 0 (0) | 6 (6.9) | 10 (38.5) | | |
| | Stage 1 Hypertension | 0 (0) | 2 (2.3) | 2 (7.7) | | |
| 13 | Normal | 2 (100) | 127 (81.4) | 33 (55.9) | 15.63 | P < 0.01 |
| | Elevated BP | 0 (0) | 27 (17.3) | 23 (39) | | |
| | Stage 1 Hypertension | 0 (0) | 2 (1.3) | 3 (5.1) | | |
| 14 | Normal | 27 (90) | 208 (76.2) | 48 (45.3) | 43.54 | P < 0.01 |
| | Elevated BP | 3 (10) | 57 (20.9) | 44 (41.5) | | |
| | Stage 1 Hypertension | 0 (0) | 6 (2.2) | 11 (10.4) | | |
| | Stage 2 Hypertension | 0 (0) | 2 (0.7) | 3 (2.8) | | |
| 15 | Normal | 13 (92.9) | 110 (77.5) | 18 (33.3) | 39.97 | P < 0.01 |
| | Elevated BP | 0 (0) | 15 (10.6) | 12 (22.2) | | |
| | Stage 1 Hypertension | 1 (7.1) | 13 (9.2) | 18 (33.3) | | |
| | Stage 2 Hypertension | 0 (0) | 4 (2.8) | 6 (11.1) | | |

**Table 4: Association between Blood Pressure and BMI Stratified Based on the Gender**

| Age | BP | Under weight | Normal | Overweight/ Obese | $\chi^2$# | p |
|---|---|---|---|---|---|---|
| Male | Normal | 23 (88.5) | 264 (76.7) | 54 (45.4) | 49.18 | P < 0.01 |
| | Elevated BP | 2 (7.7) | 60 (17.4) | 39 (32.8) | | |
| | Stage 1 Hypertension | 1 (3.8) | 15 (4.4) | 20 (16.8) | | |
| | Stage 2 Hypertension | 0 (0) | 5 (1.5) | 6 (5) | | |
| Female | Normal | 23 (95.8) | 260 (82.8) | 59 (46.8) | 68.06 | P < 0.01 |
| | Elevated BP | 1 (4.2) | 45 (14.3) | 50 (39.7) | | |
| | Stage 1 Hypertension | 0 (0) | 8 (2.5) | 14 (11.1) | | |
| | Stage 2 Hypertension | 0 (0) | 1 (0.3) | 3 (2.4) | | |

**Discussion**

Hypertension is a major risk factor for cerebrovascular and cardiovascular disease[12-14]. Studies have shown that as age advances, the blood pressure in the study population also increases[15]. An insidious and steady increase in blood pressure seen in adults indicate that it may have its roots in early childhood and adolescence which may have gone undetected[16]. Studies have also shown that there is a relationship between blood pressure and body mass index in children and adolescents[17].

The present study showed that the prevalence of prehypertension was 20.67 % and hypertension by 7.7 %. Various studies have quoted the prevalence of hypertension in children ranging from 1.0 to 16.2 %[18-20].Hypertension in children in the present study was defined as blood pressure above the 95$^{th}$ percentile recorded on three different occasions. In this study the proportion of children with hypertension was much lesser when compared to studies conducted by Sukhmani Kaur et al[21] in Rajasthan, Thangjam et al[22] in Manipur, Devi H S et al[23] in Imphal (Manipur) where the prevalence was found to be 16.2 %, 15.3 % and 15.7 % respectively. The prevalence of hypertension ranged from 3 to 10 % in school children as seen in some studies from different regions of India[24-29]. A study conducted by Tazeen H Jafar et al[30] showed that the prevalence of hypertension among South Asian children was substantially greater than 5 % predicted prevalence of high BP in children in the United States based on the same criteria despite their low BMI values.

Authors of studies agree to the fact that serial measurement of blood pressure is necessary to document persistent elevations[31,32]. Sustained severe hypertension can almost always be related to a definite cause, however, population-based epidemiological studies show that primary hypertension is predominant among apparently healthy children[10]. In order to study the variations in blood pressure over different ages it is necessary to study the normal range of blood pressure among children[10]. Researches have been conducted in various parts of India to establish the variations in normal blood pressure for different age groups. However, very few studies are available with reference to blood pressure among children in the present study area.

The present study showed that children who are overweight / obese were more likely to have hypertension when compared to children who are normal or underweight. These findings are consistent with the results of studies done in India and other countries[19,28-30,30,33-34]. Charan et al[25] in his study found that there was a significant increase in blood pressure among obese children of both

genders, thus concluding that BMI had a role to play in the development of hypertension in childhood.

**Conclusions**

The prevalence of prehypertension and hypertension was 20.67 % and 7.66 % respectively. High blood pressure was found to be strongly associated with BMI. Simple anthropometric assessment to determine BMI in schools would help in predicting the risk of developing hypertension. Hence it is recommended that blood pressure should be screened regularly in all children and adolescents. Early identification of children with prehypertension and hypertension will help to initiate early interventions, and thus reduce the possibility of future morbidity and mortality associated with hypertension.

**Acknowledgements**

I would like to thank Dr. Vaman Khadilkar, Senior Pediatric & Adolescent Endocrinologist, Jehangir Hospital, Pune & Bombay Hospital Mumbai for guiding me in the analysis process and also sharing the spreadsheet templates for analysis.

**References**

1. Sarof JM, Lai D, Turner J et al. Overweight, ethnicity and prevalence of hypertension in school-aged children. Pediatrics. 2004; 113(3 Pt 1):475-82.
2. Lauer RM, Clarke WR. Childhood risk factors for high adult blood pressure: The Muscatine Study. Pediatrics. 1989; 84(4):633-41.
3. Kiessling SG, McClanahan KK, Omer HA. Obesity, hypertension, and mental health evaluation in adolescents: a comprehensive approach. Int J Adolescent Med Health. 2008; 20(1):5-15.
4. The clinical practice guideline on childhood hypertension. American Academy of Paediatrics (AAP), 2017.
5. Rames LK, Clarke WR, Connor WE et al. Normal blood pressures and the evaluation of sustained blood pressure elevation in childhood: The Muscatine Study. Pediatrics. 1978; 61(2):245-51.
6. Cervantes J, Acoltzin C, Aguayo A. Diagnosis and prevalence of arterial hypertension in persons under 19 years of age in the city of Colima. Salud Publica Méx. 2000; 42(6):529-32.
7. Chakraborty P, Dey S, Pal R et al. Obesity in Kolkata children: magnitude in relationship to hypertension. J Nat Sci Biol Med. 2011; 2(1):101-6.
8. Mane SV, Agarkhedkar SR, Karwa DS et al. Study of risk factors for lifestyle diseases among adolescents in Western India. Int J Pharm Biomed Sci. 2012; 3:224-8.
9. Shah SS, Dave BR, Sharma AA et al. Prevalence of hypertension and association of obesity with hypertension in school going children of Surat city, Western India. Online J Health Allied Sci. 2013; 12:5.
10. Rangasamy K, Senthamarai MV, Shankar R. Blood pressure and its correlation with age and BMI among the school children aged between 10 and 16 years. Int J Pediatr Res. 2019; 6(1):1-7.
11. Bagga A, Jain R et al. Evaluation and management of hypertension. Indian Pediatr. 2007; 44(2):103-21.
12. Report on WHO expert committee. World Health organization arterial hypertension. Tech Rep Ser. 1978; 628:7-56.
13. Yamani MH, Massie BM. Hypertension, myocardial ischemia, and sudden death. Curr Opin Cardiol. 1994; 9(5):542-50.
14. Petrovitch H, Curb JD, Bloom-Marcus E. Isolated systolic hypertension and risk of stroke in Japanese American men. Stroke. 1995; 26(1):25-9.
15. 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; 114(2 Suppl 4th Report):555-76.
16. Kotchen JM, McKean HE, Kotchen TA. Blood pressure trends with aging. Hypertension. 1982; 4(5 Pt 2):III128-34.
17. Agarwal VK, Sharan R, Srivastava AK, et al. Blood pressure profile in children of age 3-15 years. Indian Pediatr. 1983; 20(12):921-5.
18. Hahn L. The relation of blood pressure to weight, height and body surface area in schoolboys aged 11 to 15 years. Arch Dis Child. 1952; 27(131):43-53.
19. Szklo M. Epidemiologic patterns of blood pressure in children. Epidemiologic Rev. 1979; 1(1):143-169.
20. Sachdev Y. Normal blood pressure and hypertension in Indian children. Indian Pediatr. 1984; 21(1):41-8.
21. Kaur S, Chandel S, Chandel S. The relationship between body mass index and blood pressure: a study among school going children of Rajasthan, India. Indian J Physiol Pharmacol. 2020; 64(3):236-41.
22. Thangjam RS, Singh AI, Rothangpui CL et al. The profile of blood pressure (BP) and the prevalence of hypertension in school going children aged 5-15 years of Manipur, a North-Eastern hilly Indian state. Int J Contemp Pediatr. 2017; 4(6):2151-7.
23. Devi HS, Brojen AK, Pravin S et al. KAP and prevalence of hypertension among higher secondary school students of greater Imphal area of Manipur. J Med Soc. 2007; 21(2):74-7.
24. Borah PK, Devi U, Biswas D et al. Distribution of blood pressure and correlates of hypertension in school children aged 5-14 years from North East India. Indian J Med Res. 2015; 142(3):293-300.
25. Charan J, Buch N, Goyal JP et al. Prevalence of hypertension in school going children of Surat city, Western India. J Cardiovasc Dis Res. 2011; 2(4):228-32.
26. Savitha MR, Krishnamurthy B, Fatthepur SSR et al. Essential hypertension in early and mid-adolescence. Indian J Pediatr. 2007; 74(11):1007-11.
27. Kaur S, Sachdev HP, Dwivedi SN et al. Association of obesity with hypertension amongst school-age children belonging to lower income group and middle income group in national capital territory of Delhi. Indian J Community Med. 2013; 38(3):175-9.
28. Bagudai S, Nanda P, Kodidala SR. Prevalence of obesity and hypertension in adolescent school going children of Berhampur, Odisha, India. Int J Physiother Res. 2014; 2(6):777-80.
29. Kishorkumar D, Stalin P, Prasad RV et al. Prevalence of hypertension among school children in a rural area of Tamil Nadu. Indian Pediatr. 2016; 53(2):165-6.
30. Jafar TH, Islam M, Poulter N et al. Children in South Asia have higher body mass-adjusted blood pressure levels than white children in the United States: a comparative study. Circulation. 2005; 111(10):1291-7.
31. Field AE, Cook NR, Gillman MW. Weight status in childhood as a predictor of becoming overweight or hypertensive in early adulthood. Obes Res. 2005; 13(1):163-9.
32. Schiel R, Beltschikow W, Kramer G et al. Overweight, obesity and elevated blood pressure in children and adolescents. Eur J Med Res. 2006; 11(3):97-101.
33. Flynn JT, Hayman LL et al. Update: ambulatory blood pressure monitoring in children and adolescents: a scientific statement from the American heart association. Hypertension. 2014; 63(5):1116-35.
34. Rames LK, Clarke WR, Connor WE et al. Normal blood pressure and the evaluation of sustained blood pressure elevation in childhood. The Muscatine study. Paediatrics. 1978; 61(2):245-50.

**Conflict of Interest: Nil Source of support: Nil**