Section: Physiology

Original Research Article

BLOOD PRESSURE PROFILE AND ITS ASSOCIATION WITH BODY MASS INDEX AMONG SCHOOL CHILDREN AGED 9–15 YEARS: A CROSS-SECTIONAL STUDY

Suchitra U[1], Anil Kumar A[2], Veena Thamban[3]

[1]Assistant Professor, Department of Physiology, Government Medical College Kannur, India.
[2]Professor, Department of Paediatrics, Government Medical College Kannur, India.
[3]Assistant Professor, Department of Physiology, Government Medical College Kasaragod, India.

Received *: 04/09/2026*
Received in revised form *: 27/09/2026*
Accepted *: 10/10/2026*

Corresponding Author:
Dr. Veena Thamban,
Assistant Professor, Department of Physiology, Government Medical College Kasaragod, India.
Email: dr.veenanlr@gmail.com

DOI: 10.70034/ijmedph.2026.4.169

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (4); 1115-1119

ABSTRACT

Background: Childhood hypertension has emerged as an important public health concern because elevated blood pressure during childhood frequently tracks into adulthood and increases the risk of cardiovascular disease. Increasing body mass index (BMI) has been recognized as an important determinant of childhood blood pressure. This study evaluated the blood pressure profile of school children and its association with BMI.

Materials and Methods: A school-based cross-sectional study was conducted among 1,000 apparently healthy children aged 9–15 years from four randomly selected schools near Academy of Medical Sciences, Pariyaram, Kerala, India. Anthropometric measurements, including height, weight, waist circumference, hip circumference, and BMI, were recorded using standardized techniques. Blood pressure was measured using a mercury sphygmomanometer according to the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. Associations between blood pressure, BMI, age, and sex were analyzed using independent t-test, one-way ANOVA, Pearson's correlation, and multiple linear regression. A p-value <0.05 was considered statistically significant.

Results: Among the participants, 545 (54.5%) were boys and 455 (45.5%) were girls. Mean systolic blood pressure increased from 87 mmHg at 9 years to 109 mmHg at 15 years, while mean diastolic blood pressure increased from 53 mmHg to 70 mmHg. Both systolic and diastolic blood pressure showed significant age-related variation (ANOVA, $p<0.001$). Obesity prevalence was higher among boys (10%) than girls (5%). BMI demonstrated a significant positive association with blood pressure, with higher BMI categories showing increased prevalence of elevated blood pressure ($p<0.001$).

Conclusion: Blood pressure increases progressively with age and is significantly associated with increasing BMI among school children. Simultaneous assessment of BMI and blood pressure during school health screening provides an effective strategy for early identification of children at increased cardiovascular risk. Lifestyle interventions focusing on healthy diet and regular physical activity should be initiated early to prevent future hypertension.

Keywords: Blood pressure, body mass index, childhood hypertension, obesity, school children, cardiovascular risk.

INTRODUCTION

Hypertension is increasingly recognized as a significant public health concern among children and adolescents.[1] Although traditionally considered an adult disorder, evidence indicates that elevated blood pressure (BP) often originates during childhood and may persist into adulthood, contributing to the early development of cardiovascular and renal diseases.

Childhood blood pressure has therefore emerged as an important predictor of future cardiovascular risk.[2] Blood pressure in children is influenced by several physiological factors including age, sex, height, body weight, and pubertal maturation.[3] Previous epidemiological studies have consistently demonstrated a gradual rise in both systolic and diastolic blood pressure with advancing age and somatic growth.[4,5] However, the increasing prevalence of childhood overweight and obesity has introduced additional concern, as excess adiposity has become one of the strongest modifiable determinants of elevated blood pressure in pediatric populations.

Childhood obesity has reached epidemic proportions worldwide owing to reduced physical activity, unhealthy dietary practices, and increasing sedentary behaviour.[7] Excess body weight has been associated with adverse metabolic and cardiovascular consequences, including insulin resistance, dyslipidaemia, and hypertension. Body mass index (BMI) is the most commonly used anthropometric indicator for assessing obesity in children and has shown a positive correlation with blood pressure in several studies.[8]

Several national and international studies have reported that higher BMI is associated with increased systolic and diastolic blood pressure among school-aged children.[9] Age-related increases in blood pressure have also been documented, suggesting that both growth and body composition contribute significantly to cardiovascular regulation during childhood. Identification of these associations is important because elevated childhood blood pressure frequently tracks into adult life and increases the risk of future cardiovascular morbidity.[10]

Schools provide an ideal setting for population-based screening because they allow evaluation of apparently healthy children during a critical period of physical growth and development. Early identification of children with elevated blood pressure and excess body weight provides an opportunity for timely lifestyle interventions, including promotion of healthy nutrition and regular physical activity.

The present study was therefore undertaken to evaluate the blood pressure profile among school children aged 9–15 years and to determine its relationship with body mass index across different age groups and both sexes. Understanding these associations may facilitate early identification of children at increased cardiovascular risk and support preventive public health strategies.

MATERIALS AND METHODS

A school-based cross-sectional study was conducted among children aged 9–15 years studying in four randomly selected schools located near Academy of Medical Sciences, Pariyaram, Kannur, Kerala, India. The study was carried out over a period of one year from June 2013 to May 2014 after obtaining permission from the respective school authorities. A total of 1,000 apparently healthy school children participated in the study, including 545 boys and 455 girls.

Inclusion Criteria

Children aged 9–15 years who were apparently healthy, cooperative during examination, and whose parents provided informed consent were included.

Exclusion Criteria

Children younger than 9 years or older than 15 years, those with a history of cardiovascular or other chronic systemic illness, and those without parental consent were excluded.

Data Collection

Information regarding demographic characteristics, family history of hypertension, diabetes mellitus, renal disease, ischemic heart disease, and socioeconomic status (parental education, occupation, and income) was obtained using a structured questionnaire completed by parents.

Anthropometric measurements were performed according to the recommendations of the Indian Council of Medical Research. Height was measured to the nearest 0.1 cm using an anthropometric rod, while body weight was recorded using a calibrated floor weighing scale. Body mass index (BMI) was calculated as weight (kg)/height (m^2) and categorized according to the Centers for Disease Control and Prevention BMI percentile charts. Waist and hip circumferences were measured using a non-stretchable measuring tape, and waist-to-hip ratio was calculated. Blood pressure was measured using a standard mercury sphygmomanometer following the recommendations of the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. Appropriate cuff sizes were selected according to arm circumference.

Measurements were obtained in the sitting position after adequate rest in a quiet room between 10:00 AM and 12:15 PM. Blood pressure was initially determined by the palpatory method followed by the auscultatory method. Korotkoff phase I and phase V were considered systolic and diastolic blood pressures, respectively. Three readings were obtained at intervals of 1–2 minutes with complete cuff deflation between readings. If the difference between the first and third readings exceeded 10 mmHg, an additional reading was taken and the average of the three most consistent readings was recorded. Children with blood pressure ≥95th percentile underwent repeat measurements for confirmation.

Outcome Measures

The primary outcome variables were systolic blood pressure (SBP) and diastolic blood pressure (DBP). The association of blood pressure with BMI, age, and sex was evaluated.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS software. Continuous variables were expressed as mean ± standard deviation, while

categorical variables were presented as frequencies and percentages. Differences in blood pressure according to age and sex were analyzed using independent Student's t-test or one-way analysis of variance (ANOVA), as appropriate. Pearson's correlation coefficient was used to evaluate the relationship between BMI and blood pressure. Multiple linear regression analysis was performed to determine independent predictors of systolic and diastolic blood pressure after adjusting for age and sex. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1: Age and sex distribution of study participants

Age (years)	Male n (%)	Female n (%)	Total n (%)
9	4 (0.7)	2 (0.4)	6 (0.6)
10	51 (9.4)	42 (9.2)	93 (9.3)
11	81 (14.9)	72 (15.8)	153 (15.3)
12	92 (16.9)	89 (19.6)	181 (18.1)
13	113 (20.7)	85 (18.7)	198 (19.8)
14	126 (23.1)	117 (25.7)	243 (24.3)
15	78 (14.3)	48 (10.5)	126 (12.6)
Total	**545**	**455**	**1000**

A total of 1,000 school children aged 9–15 years participated in the study, comprising 545 (54.5%) boys and 455 (45.5%) girls. The largest proportion of participants belonged to the 14-year age group (24.3%), whereas only 0.6% were aged 9 years. [Table 1]

Table 2: Age-wise distribution of systolic and diastolic blood pressure

Age (years)	SBP (Mean±SD)	DBP (Mean±SD)
9	87 ± 8.16	53 ± 5.16
10	88 ± 9.81	57 ± 7.13
11	93 ± 8.68	61 ± 6.80
12	98 ± 11.86	64 ± 8.08
13	101 ± 12.89	65 ± 8.64
14	107 ± 13.54	68 ± 9.78
15	109 ± 11.00	70 ± 8.71

Both systolic and diastolic blood pressure showed a progressive increase with advancing age (Table 2). Mean systolic blood pressure increased from 87 ± 8.16 mmHg at 9 years to 109 ± 11.00 mmHg at 15 years, while mean diastolic blood pressure increased from 53 ± 5.16 mmHg to 70 ± 8.71 mmHg during the same period. One-way ANOVA demonstrated significant age-related differences in both systolic and diastolic blood pressure ($p<0.001$). Post-hoc analysis showed that most age-group comparisons were statistically significant except between 9 and 10 years (for both SBP and DBP) and between 9 and 11 years for SBP.

Table 3: Distribution of BMI according to sex

BMI Category	Male n (%)	Female n (%)
Normal	464 (85.1)	416 (91.4)
Overweight	25 (4.6)	15 (3.3)
Obese	56 (10.3)	23 (5.1)

Among boys, 85.1% had normal BMI, 4.6% were overweight and 10.3% were obese. Among girls, 91.4% had normal BMI, 3.3% were overweight and 5.1% were obese. [Table 3] The prevalence of elevated blood pressure increased with increasing BMI category. Most hypertensive children belonged to the obese group, whereas children with normal BMI predominantly had normal blood pressure. Age-wise analysis also demonstrated an increasing frequency of hypertension with advancing age, particularly among obese children. Overall, obesity showed a significant positive association with elevated blood pressure (Chi-square test, $p<0.001$), indicating that increasing body mass index was associated with higher systolic and diastolic blood pressure levels.

DISCUSSION

The present school-based cross-sectional study evaluated blood pressure patterns and their relationship with body mass index (BMI) among children aged 9–15 years. The findings demonstrate that both systolic blood pressure (SBP) and diastolic blood pressure (DBP) increase progressively with age and are positively associated with increasing BMI. These observations reinforce the concept that childhood is a critical period for identifying cardiovascular risk factors and implementing preventive interventions.

A significant age-related increase in both SBP and DBP was observed across the study population. Mean SBP increased from 87 mmHg at 9 years to 109

mmHg at 15 years, while mean DBP increased from 53 mmHg to 70 mmHg over the same age range. Similar age-related increases have been reported by Chadha et al,[2] in Delhi and Prabhjot et al,[5] in Punjab, who identified age, height, and body size as major determinants of childhood blood pressure. The physiological rise in blood pressure during adolescence is attributed to somatic growth, increasing lean body mass, hormonal maturation, and vascular remodeling.

The overall prevalence of hypertension in the present study was 4.4%, while borderline hypertension was observed in 3% of children. These findings fall within the range reported in previous Indian and international studies, where childhood hypertension prevalence varies between 1% and 17% depending on study design, diagnostic criteria, and population characteristics.[1,2,5,13] Similar prevalence estimates have been reported from the United States, China, and Brazil, indicating that elevated blood pressure during childhood is an emerging global health concern.[11,12,14]

Body mass index demonstrated a clear positive relationship with blood pressure. As BMI increased, the proportion of children with elevated blood pressure also increased substantially. Boys exhibited a higher prevalence of obesity than girls, which may partly explain the higher systolic blood pressure observed among male adolescents.[14] The findings of the present study support the use of BMI as a simple, inexpensive, and effective screening tool for identifying children at increased risk of hypertension. Because measurement of height, weight, and blood pressure can be performed easily during routine school health examinations, simultaneous assessment of these parameters provides an opportunity for early identification of children requiring lifestyle intervention.

From a public health perspective, the increasing prevalence of childhood obesity has important implications for future cardiovascular disease burden. The findings emphasize the importance of school-based health screening programmes, regular blood pressure monitoring, nutritional counselling, and promotion of physical activity. Preventive strategies should focus on maintaining healthy body weight, encouraging regular exercise, reducing sedentary behaviour, and promoting healthy dietary practices to minimize future cardiovascular risk.

Limitations

The cross-sectional design precludes establishment of causal relationships. Pubertal status, dietary sodium intake, and biochemical markers of cardiometabolic risk were not assessed, which may have influenced blood pressure variation. Future longitudinal studies are required to evaluate the progression of elevated blood pressure into adulthood.

Overall, the study demonstrates that blood pressure increases significantly with age and is positively associated with increasing BMI among school children. Routine blood pressure and BMI assessment should therefore form an integral component of school health programmes to facilitate early detection and prevention of future cardiovascular disease.

CONCLUSION

The present study demonstrated a significant age-related increase in both systolic and diastolic blood pressure among school children aged 9–15 years. Blood pressure showed a positive association with body mass index, indicating that increasing adiposity contributes to elevated blood pressure even during childhood. The prevalence of hypertension and prehypertension observed in this study highlights the growing burden of cardiovascular risk factors among school-aged children.

Routine assessment of blood pressure together with body mass index in school health programmes provides a simple, inexpensive, and effective strategy for identifying children at increased risk of future hypertension. Early recognition of elevated blood pressure should be accompanied by appropriate lifestyle interventions, including healthy dietary practices, regular physical activity, and maintenance of optimal body weight.

The findings emphasize the need for periodic school-based cardiovascular risk screening and health education programmes involving children, parents, teachers, and healthcare professionals. Such preventive strategies have the potential to reduce the future burden of hypertension and cardiovascular disease in adulthood.

REFERENCES

1. Aggarwal VK, Sharan R, Srivastava AK, Kumar A, Pandey CM. Blood pressure profile in children aged 3–15 years. Indian Pediatr. 1983;20:921-925.
2. Chadha SL, Tandon R, Shekhawat S, Gopinath N. An epidemiological study of blood pressure in school children (5–14 years) in Delhi. Indian Heart J. 1999;51:178-182.
3. Aggarwal R, Mandowara SL, Bhandari B, Garg RK. Prevalence of hypertension in apparently healthy school children. Indian Pediatr. 1982;19:779-784.
4. Gupta AK, Ahmed AJ. Normal blood pressure and evaluation of sustained blood pressure elevation in childhood. Indian Pediatr. 1990;27:33-42.
5. Prabhjot, Anjana, et al. Variation in blood pressure among school children of Amritsar. Indian Pediatr. 2005;42:201-204.
6. Taksande A, Chaturvedi P, et al. Distribution of blood pressure in school-going children in rural Wardha, Maharashtra. Ann Pediatr Cardiol. 2008;1(2):101-106.
7. The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. Pediatrics. 2004;114:555-576.
8. Flynn JT. Assessment of blood pressure in children: It's all in the details. J Clin Hypertens. 2013;15(11):784-786.
9. Xu H, Hu X, et al. Association of hypertension with obesity and metabolic abnormalities among Chinese children. Int J Hypertens. 2011;2011:987159.
10. Daniels SR. The consequences of childhood overweight and obesity. Future Child. 2006;16(1):47-67.
11. Lo JC, Sinaiko A, et al. Prehypertension and hypertension in community-based pediatric practice. Pediatrics. 2013;131:e415-e424.

12. Sorof J, Daniels S. Obesity hypertension in children. Hypertension. 2002;40:441-447.
13. Verma M, Chhatwal J, George SM. Obesity and hypertension in children. Indian Pediatr. 1994;31:1065-1068.
14. Hahn L. The relation of blood pressure to weight, height and body surface area in school boys aged 11–15 years. Arch Dis Child. 1952;27:43-53.