



## Association Between Body Mass Index and Blood Pressure Among Urban and Rural School-Going Children in Chennai District: A Comparative Cross-Sectional Study

Dr Chethan S<sup>1</sup>, Dr Elilarasi S<sup>2</sup>, Dr Radha Kumar<sup>3</sup>, Dr Vidhyasagar K<sup>4</sup>, Dr Varun Muddasani<sup>5</sup>, Dr Shapna Lakshmi Thirumurugesan<sup>6</sup>, Dr Dhanasangari Manivannan<sup>7</sup>, Dr Lavanya Panchatcharam<sup>8</sup>

<sup>1</sup>Postgraduate, Department of Paediatrics, Saveetha Institute of Technical and Medical Sciences, Chennai, Tamil Nadu, India (Corresponding author)

<sup>2</sup>Professor and HOD, Department of Paediatrics, Saveetha Institute of Technical and Medical Sciences, Chennai, Tamil Nadu, India

<sup>3</sup>Professor, Department of Paediatrics, Saveetha Institute of Technical and Medical Sciences, Chennai, Tamil Nadu, India

<sup>4</sup>Associate Professor, Department of Paediatrics, Saveetha Institute of Technical and Medical Sciences, Chennai, Tamil Nadu, India

<sup>5</sup>Assistant Professor, Department of Paediatrics, Saveetha Institute of Technical and Medical Sciences, Chennai, Tamil Nadu, India

<sup>6</sup>Associate Professor, Department of Paediatrics, Saveetha Institute of Technical and Medical Sciences, Chennai, Tamil Nadu, India

<sup>7</sup>Assistant Professor, Department of Paediatrics, Saveetha Institute of Technical and Medical Sciences, Chennai, Tamil Nadu, India

<sup>8</sup>Senior Resident, Department of Paediatrics, Saveetha Institute of Technical and Medical Sciences, Chennai, Tamil Nadu, India

(Received: 16 June 2025

Revised: 20 July 2025

Accepted: 19 August 2025)

### KEYWORDS

Body mass index, blood pressure, hypertension, obesity, urban, rural, school children

### ABSTRACT:

**Background:** Childhood obesity and hypertension are growing public health concerns, with evidence suggesting that elevated blood pressure in children is strongly associated with increased body mass index (BMI). However, urban–rural differences in this association have not been extensively studied in South Indian schoolchildren.

**Objectives:** To determine the prevalence of overweight, obesity, and hypertension among school-going children in urban and rural areas of Chennai district, and to assess the association between BMI and blood pressure.

**Methods:** This cross-sectional study included 660 school children aged 6–16 years, with 330 each from urban and rural schools, selected using stratified random sampling. Anthropometric measurements were recorded using standardized techniques, and BMI was classified according to NCHS percentiles. Blood pressure was measured thrice at 10-minute intervals in the right arm, and mean values were classified as normal, pre-hypertensive, or hypertensive based on age-, sex-, and height-specific percentiles. Data were analyzed using SPSS v21, with descriptive statistics, unpaired t-tests, and Pearson's correlation.

**Results:** The prevalence of overweight and obesity was 12.1% and 4.5% in urban children, compared to 6.4% and 2.1% in rural children ( $p < 0.01$ ). Hypertension was observed in 6.7% of urban children and 3.3% of rural children ( $p = 0.04$ ). BMI showed a significant positive correlation with both systolic blood pressure ( $r = 0.42$ ,  $p < 0.001$ ) and diastolic blood pressure ( $r = 0.35$ ,  $p < 0.001$ ). Overweight and obese children had a 3.8-fold higher risk of hypertension compared to children with normal BMI.

**Conclusion:** Urban school children in Chennai district have a higher prevalence of overweight, obesity, and hypertension compared to rural counterparts. BMI is strongly associated with blood pressure, highlighting the need for early screening and lifestyle interventions in school health programs.



## Introduction

Hypertension and obesity are increasingly recognized as major public health challenges in both developed and developing nations. While systemic hypertension in childhood has historically received less attention than in adults, its prevalence is rising, with estimates ranging from 0.8% to 3.2% in developed countries and comparable trends now observed in India (1). The rise in paediatric blood pressure levels is multifactorial, influenced by obesity, sedentary lifestyle, dietary changes, and psychosocial stressors (2,3).

Essential hypertension, long regarded as an adult condition, can be detected during adolescence and often persists into adulthood, contributing to elevated risks of myocardial infarction, stroke, and premature cardiovascular mortality (4). Even mild, asymptomatic blood pressure elevation in children has been linked to early target organ damage, underscoring the importance of early detection (5). The Fourth Report from the National High Blood Pressure Education Program Working Group recommends that all children aged three years and older have their blood pressure measured during routine medical visits (6).

Childhood obesity, once considered a concern of affluent societies, has become a global epidemic, with rapid growth in prevalence noted across urban and rural India (7). Historically, malnutrition dominated the public health agenda in developing countries; however, rising income levels, urbanization, and lifestyle shifts have led to increasing rates of overweight and obesity in children (8). The relationship between excess weight and elevated blood pressure in children is well established, with BMI being a strong, independent predictor of hypertension in multiple studies (9–12).

While several Indian studies have explored the link between BMI and blood pressure, most have focused on either urban or rural cohorts in isolation (9,10). Comparative data that examine urban-rural differences in the same geographical region are limited, particularly in South India. Such data are essential as lifestyle, socioeconomic status, dietary patterns, and physical activity levels differ significantly between urban and rural populations, potentially influencing both obesity and hypertension risk (11,12).

This study aims to address this gap by evaluating and comparing BMI and blood pressure profiles among urban and rural school-going children in Chennai district and assessing the strength of association between these parameters. Findings from this study may inform school health screening strategies and guide targeted preventive measures to reduce the long-term burden of cardiovascular disease.

## Materials and Methods

**Study Design and Setting:** A school-based comparative cross-sectional study was conducted between January and December 2024 in Chennai district, Tamil Nadu, India. The study compared BMI and blood pressure profiles among children from urban and rural schools.

**Study Population and Sampling:** A total of 660 school-going children aged 6–16 years were enrolled, with equal representation from urban (n=330) and rural (n=330) schools. Schools were selected by stratified random sampling to ensure coverage across socioeconomic strata, and within each selected school participants were chosen by simple random sampling from the roster. Eligibility required that children be 6–16 years old, enrolled in the selected schools, present on the day of data collection, and have written informed consent from a parent or guardian, with child assent where applicable. Exclusions included acute illness at the time of examination; any past or current cardiovascular, respiratory, or other systemic illness; physical or developmental disabilities that could affect anthropometric measurements; and being anxious, crying, or immediately post-physical activity at the time of blood pressure measurement.

**Method of data collection:** A pretested structured proforma was used to record demographic details, family history of obesity or hypertension, and socioeconomic status. Height was measured to the nearest 0.1 cm using a stadiometer, with children standing barefoot, heels together, and the head aligned in the Frankfurt plane; weight was measured to the nearest 0.1 kg using a calibrated mechanical scale, and body mass index (BMI) was calculated as weight (kg) divided by height squared ( $m^2$ ). Nutritional status was classified according to NCHS guidelines as follows: normal if BMI was below the 85th percentile for age and sex, overweight if between the 85th and 95th



percentiles, and obese if at or above the 95th percentile. Blood pressure was recorded on the right arm with a mercury sphygmomanometer using an appropriately sized cuff (bladder width approximately 40% of arm circumference), with the child seated and the arm supported at heart level; three readings were obtained at 10-minute intervals after a minimum 5-minute rest, and the mean value was used for analysis. Blood pressure categories followed the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents, defining normal as below the 90th percentile, prehypertension as between the 90th and less than the 95th percentile, and hypertension as at or above the 95th percentile for age, sex, and height.

**Statistical Analysis:** Data were analyzed using SPSS version 21. Continuous variables were presented as mean  $\pm$  standard deviation (SD) and categorical variables as frequencies and percentages. Comparisons between urban and rural groups were made using independent sample t-tests for continuous variables and chi-square tests for categorical variables. Correlations between BMI and blood pressure were assessed using Pearson's correlation coefficient. Binary logistic regression was performed to assess the independent association between BMI category (normal, overweight, obese) and hypertension, adjusting for age, sex, and urban/rural residence. A p-value  $<0.05$  was considered statistically significant.

**Ethical Considerations:** Ethical approval was obtained from the Institutional Ethics Committee of Saveetha medical college nad hospital. Written informed consent was obtained from parents/guardians, and assent was obtained from children aged  $\geq 7$  years.

## Results

All 660 selected children completed the study (response rate 100%). The mean age was  $11.4 \pm 2.8$  years, with 51.2% males. Urban children had a slightly higher mean BMI compared to rural children ( $18.7 \pm 3.2$  vs  $17.4 \pm 2.8$  kg/m<sup>2</sup>,  $p < 0.001$ ).

Overweight and obesity prevalence was significantly higher in urban children (12.1% and 4.5%) compared to rural children (6.4% and 2.1%) ( $p = 0.004$ ). Hypertension was detected in 6.7% of urban children and 3.3% of rural children ( $p = 0.04$ ).

BMI showed a significant positive correlation with systolic BP ( $r = 0.42$ ,  $p < 0.001$ ) and diastolic BP ( $r = 0.35$ ,  $p < 0.001$ ) in the overall cohort.

After adjusting for age, sex, and urban/rural residence, overweight children had 2.1 times higher odds of hypertension (AOR 2.12, 95% CI 1.06–4.24,  $p = 0.03$ ), while obese children had 3.8 times higher odds (AOR 3.82, 95% CI 1.48–9.85,  $p = 0.006$ ) compared to children with normal BMI.

## Discussion

This comparative cross-sectional study assessed the relationship between BMI and blood pressure among school-going children in urban and rural areas of Chennai district. We found that urban children had a significantly higher prevalence of overweight, obesity, and hypertension compared to their rural counterparts. Additionally, BMI demonstrated a strong positive correlation with both systolic and diastolic blood pressure, and overweight/obese children were nearly four times more likely to have hypertension than children with normal BMI.

Our findings align with global evidence indicating that elevated BMI is a major risk factor for childhood hypertension. The Bogalusa Heart Study demonstrated a strong linear association between BMI and both systolic and diastolic blood pressure in children and adolescents, independent of age, sex, and ethnicity (1). Similar trends have been reported in Indian cohorts, with studies from Delhi (2), Kerala (3), and Tamil Nadu consistently documenting higher blood pressure among overweight and obese children.(4)

The urban–rural disparity observed in our study is consistent with previous research showing higher prevalence of cardiometabolic risk factors in urban settings (5,6). Rapid urbanization, sedentary lifestyle, increased consumption of processed foods, and reduced physical activity contribute to higher BMI in urban children (7). In contrast, rural children often engage in greater physical activity and have diets richer in traditional, home-cooked meals, which may explain their lower BMI and blood pressure levels.

Several pathophysiological mechanisms explain the observed relationship between BMI and blood pressure. Excess adiposity increases cardiac output and systemic vascular resistance, contributing to sustained elevation



in blood pressure (8). Furthermore, obesity is associated with activation of the renin–angiotensin–aldosterone system, sympathetic nervous system overactivity, and endothelial dysfunction, all of which promote hypertension (9). Childhood obesity also induces low-grade chronic inflammation, which can impair vascular compliance and contribute to early vascular ageing (10).

The prevalence of hypertension in our study—6.7% in urban and 3.3% in rural children—is comparable to reports from other parts of India, where figures range from 2–8% depending on diagnostic criteria and population characteristics (11). Notably, our results indicate that overweight and obese children are disproportionately affected, echoing findings from an Andhra Pradesh study where the odds of hypertension were over four times higher in overweight/obese children (12).

Importantly, hypertension in childhood often tracks into adulthood, predisposing individuals to early onset of cardiovascular diseases (13,14). This underscores the urgency of identifying at-risk children and implementing preventive strategies during school years. Our findings support the integration of regular BMI and blood pressure screening into school health programs, a recommendation echoed by the American Academy of Pediatrics and the Indian Academy of Pediatrics (15,16).

The public health implications of these results are substantial. Addressing childhood overweight and hypertension requires a multi-pronged approach, including promoting physical activity, implementing school-based nutrition education, and encouraging parental involvement in healthy lifestyle practices. Urban planning policies that facilitate safe play spaces and regulate the sale of high-calorie, nutrient-poor foods near schools could also have a meaningful impact (17,18).

While the association between BMI and blood pressure is well-established, it is important to consider that not all hypertensive children are overweight, and not all overweight children are hypertensive. This suggests that other factors—such as genetic predisposition, dietary sodium intake, stress, and environmental exposures—may also contribute to blood pressure variation in children (19). Further longitudinal research is needed to elucidate these complex interactions and to assess

whether reducing BMI in overweight children leads to sustained improvements in blood pressure.

The strengths of our study include the use of standardized measurement protocols, a relatively large sample size, and the inclusion of both urban and rural cohorts, which allowed for meaningful comparisons. Additionally, blood pressure classification was based on age-, sex-, and height-specific percentiles, improving diagnostic accuracy. However, the cross-sectional design precludes causal inference, and single-point measurements may not capture variability in blood pressure over time. Moreover, dietary intake, physical activity levels, and socioeconomic status were not quantitatively assessed, which could have provided deeper insights into the determinants of BMI and hypertension.

## Conclusion

Our findings confirm a significant positive association between BMI and blood pressure among school children in Chennai district, with a higher burden observed in urban settings. These results emphasize the need for early preventive strategies targeting modifiable lifestyle factors, particularly in urban areas undergoing rapid lifestyle transitions. Addressing these risk factors during childhood could play a critical role in curbing the future burden of cardiovascular disease.

## References

1. Freedman DS, et al. The relation of overweight to cardiovascular risk factors among children and adolescents. *N Engl J Med.* 1999;338:1652–1659.
2. Sharma A, et al. Prevalence of hypertension among schoolchildren in Delhi. *Indian Pediatr.* 2010;47:873–876.
3. Raj M, et al. Body mass index and blood pressure in children from Kerala. *Indian Pediatr.* 2007;44:805–812.
4. Kumar RK, et al. Association between BMI and hypertension in Tamil Nadu school children. *Indian J Public Health.* 2015;59:93–96.
5. Gupta R, et al. Urban–rural differences in cardiovascular risk factors in India. *Indian Heart J.* 2012;64:531–536.



6. Thankappan KR, et al. Risk factor profile for chronic diseases in Kerala. *Natl Med J India*. 2006;19:306–313.
7. Misra A, et al. Nutrition transition in India: determinants and consequences. *Proc Nutr Soc*. 2010;69:1–8.
8. Hall JE. Pathophysiology of obesity hypertension. *Curr Hypertens Rep*. 2000;2:139–147.
9. Landsberg L, et al. Obesity-related hypertension: pathogenesis, cardiovascular risk, and treatment. *J Clin Hypertens*. 2013;15:14–33.
10. Sorof JM, et al. Obesity, ethnicity, and the prevalence of hypertension in school-aged children. *Pediatrics*. 2004;113:475–482.
11. Gupta N, et al. Childhood obesity and the metabolic syndrome in developing countries. *Indian J Pediatr*. 2011;78:133–140.
12. Dasgupta K, et al. Hypertension and obesity among school children in Andhra Pradesh. *Indian J Community Med*. 2011;36:178–182.
13. Bao W, et al. Essential hypertension predicted by tracking of elevated blood pressure from childhood to adulthood. *Am J Hypertens*. 1995;8:657–665.
14. Chen X, et al. Tracking of blood pressure from childhood to adulthood: a systematic review. *Circulation*. 2008;117:3171–3180.
15. Flynn JT, et al. Clinical practice guideline for screening and management of high blood pressure in children and adolescents. *Pediatrics*. 2017;140:e20171904.
16. Indian Academy of Pediatrics. Consensus guidelines on childhood hypertension. *Indian Pediatr*. 2019;56:725–733.
17. Swinburn BA, et al. The global obesity pandemic: shaped by global drivers and local environments. *Lancet*. 2011;378:804–814.
18. Story M, et al. Schools and obesity prevention: creating school environments and policies to promote healthy eating and physical activity. *Milbank Q*. 2009;87:71–100.

19. Falkner B. Hypertension in children and adolescents: epidemiology and natural history. *Pediatr Nephrol*. 2010;25:1219–1224.

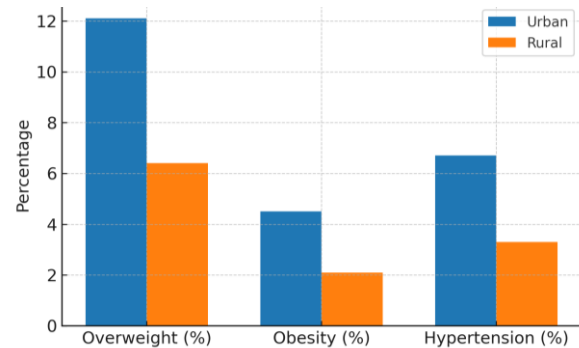


Figure 1: Prevalence of Overweight, Obesity, and Hypertension

Table 1: Correlation Between BMI and Blood Pressure

Variable	Correlation coefficient (r)	p-value
Systolic BP vs BMI	0.42	<0.001
Diastolic BP vs BMI	0.35	<0.001

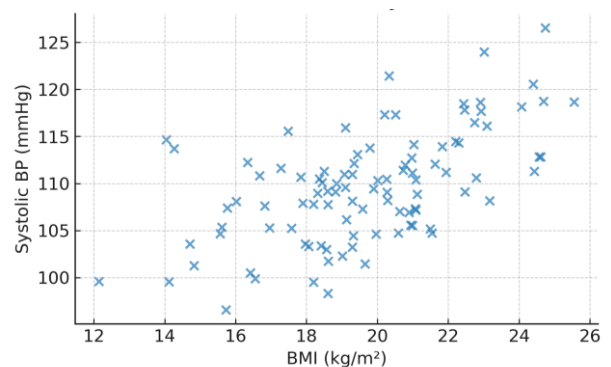


Figure 2: Correlation between BMI and Systolic Blood Pressure