



AN OBSERVATIONAL STUDY TO DETERMINE CORRELATION BETWEEN BLOOD PRESSURE AND BODY MASS INDEX AMONG ADOLESCENTS OF JHARKHAND

Dr Rajesh Kumar Sinha^{*1}, Dr Bijay Hansda², Dr Bhavya Srivastava³, Dr Garima Prakash³

¹*Professor, Department of Physiology, Rajendra Institute of Medical Sciences, Ranchi

^{2,3}Junior Resident Department of Physiology, Rajendra Institute of Medical Sciences, Ranchi

***Corresponding Author:** Dr Rajesh Kumar Sinha

Professor, Department of Physiology, Rajendra Institute of Medical Sciences

Abstract

Background: The rising prevalence of obesity among adolescents has become a major public health concern. Body Mass Index (BMI), a widely used indicator of adiposity, has been associated with elevated blood pressure (BP), increasing the risk of future cardiovascular diseases. **Aim and Objective:** To assess the relationship between BMI and blood pressure among adolescents in Jharkhand. **Methods:** A cross-sectional observational study was conducted among adolescents aged 10–19 years. Anthropometric measurements were recorded, and BMI was calculated. Blood pressure was measured using standardized techniques. Statistical analysis was performed using Pearson's correlation test to determine the association between BMI and BP. **Results:** A statistically significant positive correlation was observed between BMI and both systolic and diastolic blood pressure. Adolescents with higher BMI exhibited increased BP levels compared to those with normal BMI. **Conclusion:** BMI is significantly associated with blood pressure among adolescents. Early screening and preventive strategies targeting obesity may help reduce the burden of hypertension and cardiovascular diseases.

Keywords: Body Mass Index, Blood Pressure, Adolescents, Hypertension, Obesity, India

Introduction

Body mass index (BMI) is a metric used to assess body fat percentage and nutritional status. A high BMI is linked to a higher risk of hypertension and other cardiovascular diseases (CVD).¹ Obesity increases the risk of hypertension by 4.17 times and cardiovascular disease by 1.46 times, respectively.² Obesity and hypertension contribute to morbidity and mortality by causing comorbidities such as CVD and renal disease. Obesity and high blood pressure accounted for 60% of the CVD burden. Older age increases the risk of having high blood pressure. However, the prevalence of high blood pressure in young adults is concerning.³ Obesity is not only a global epidemic concern in the 40s age group, but it is also a major public health issue at a young age.⁴ Obesity prevalence in adults has increased dramatically since the coronavirus disease (COVID-19) pandemic.⁷ Prior to the pandemic (before December 2019), the prevalence of obesity in men and women was around 11% and 15%, but this figure skyrocketed to 25.3% and 42.4%, respectively, during the COVID-19 pandemic (December 2019 to January 2023).⁷ In the United States, obesity prevalence grew by 3.2% from January 1, 2019 (40.7%) to March 12, 2020 (43.9%).^{7,8} In young adults, the increase in obesity reached 7.6% at the start of the COVID-19 pandemic (December 2019 to March 2020) when

compared to before the pandemic (2017–2018).⁸ Based on data from the World Health Organization (WHO), since 1990, the prevalence of obesity in adults throughout the world has doubled, while in adolescents it has quadrupled.⁹ In 2023, 1 in 8 people are obese.⁹ It was found that 2.5 billion, or around 43%, of adults (18 years of age and older) are overweight, and as many as 890 million, or 16%, live with obesity globally.⁹ An observational study reported that during the COVID-19 pandemic, from December 2019 to January 2023, more than two billion people were overweight, and more than 650 million adults (340 million teenagers and 39 million children) were obese.⁷ The prevalence of obesity increased in line with the forced lockdown during the pandemic.⁷ Even though obesity and overweight may be avoided, the prevalence of obesity is expected to rise, with an estimated 167 million adults and children experiencing health problems as a result of obesity and overweight by 2025.⁷ Based on a study in 34 provinces in Indonesia, the highest prevalence of obesity and overweight is in adults (18 years and over), ranging between 10.4–30.1% and 19.2–46.3%, respectively, followed by the 5–12 year age group (obesity: 2–15.0%, overweight: 6.1–30.3%).¹⁰ Obesity causes an increase in fat tissue, which will trigger blood vessel resistance, leading to an increase in the heart's workload to pump blood.¹¹ Obesity will also activate the sympathetic nervous system, resulting in peripheral resistance and arterial vasoconstriction, which leads to increased blood pressure and if it persists for a long time, it will cause hypertension.¹¹ Hypertension is a leading cause of mortality, accounting for around 13% of all fatalities (7.1 million). Obese women are three times more likely to suffer hypertension than non-obese women.¹² As obesity is closely associated with blood pressure, a rising BMI increases the chance of rising blood pressure and developing high blood pressure or hypertension.¹³ According to the findings of our study in Wistar rats, there was a positive association between BMI and blood pressure, with an increase in BMI of 1 g/cm and an increase in blood pressure of 2.75 mmHg.¹⁴ BMI is positively connected to blood pressure; rising BMI raises systolic blood pressure (SBP), and BMI is a risk factor for SBP elevation.³ The higher the BMI value, the higher the risk of hypertension in adult men and women, including children.¹¹ The positive relationship between BMI and blood pressure in the elderly has been extensively studied. However, the correlation between body weight and BMI with SBP and diastolic blood pressure (DBP) in young adults is still unknown.¹⁴ Elevated blood pressure (BP) in children is considered as an important predecessor of adult hypertension. In a country like India, where double burden of malnutrition like under- and over nutrition coexists, an emerging public health challenge is that of hypertension. The prevalence of hypertension among children ranges from around 5.4% to Existing literature suggests that hypertension could have its origin in childhood and a slight elevation in BP during childhood increases the risk of hypertension in adults several folds.¹⁵ During adolescence, there is an intense change in the life of every individual. This intense change can be of both psychological and physical nature. Psychological changes include intensification of emotional experiences, interest in and practice of adult social, economic, and sexual activities. On the other hand, physical changes include growth spurt in height and weight, permanent tooth eruption, and development of secondary sexual characteristics.¹⁶ Moreover, it was found that BP varies with age and is closely related to height and weight of a child. Similarly, growth patterns and sex of an individual strongly influence BP levels among children and adolescents.¹⁷ There are some studies which have shown positive correlation between body mass index (BMI) and BP. In addition to this, various cross-sectional studies have reported that obese children have significantly high BP than those who are normal weight or underweight. High BP either systolic or diastolic at any age is one of the risk factors for cardiovascular diseases.¹⁴ The previous studies have stated that systolic BP (SBP) elevation in childhood predicts arterial stiffness in young adults.^{15,16} On the other hand, diastolic BP (DBP) is important in monitoring BP in younger individuals.¹⁷ Earlier studies done among children and adolescents have shown high burden of hypertension in younger age groups as well. Moreover, significant increases in BP occur during adolescence period, and many temporary variations in BP level also occur before attaining more stable levels of adult life.¹⁸ However, such studies on adolescent obesity and hypertension in the rural Indian population are scarce. Thus, considering the importance of identifying the risk of elevated BP at an early stage of life, the present

study aims to find out the prevalence of high BP among school going children belonging to the age group of 10–19 years. The study also examines the relationship between BMI and BP. Obesity is also emerging as a common problem in adolescence due to change in lifestyle, food habits and pattern. A large number of complications are there due to obesity and increase blood pressure in Adolescent.

Aim and Objectives: To study the correlation between BP and BMI among adolescent population of Jharkhand.

Material and Methods: A Cross-sectional observational study to determine the correlation between Blood Pressure (BP) and Body Mass Index (BMI) among 330 adolescents aged 13-19 years carried out in selected government high schools (10+2) located in urban and rural areas of Jharkhand, including East Singhbhum and Ranchi districts from June 2024 to January 2026 for 18 months duration.

Inclusion Criteria includes Adolescents aged 13–19 years, both male and female students, Students studying in selected government schools and Students willing to participate. And Exclusion Criteria includes Known cases of endocrine disorders (e.g., hypothyroidism, hyperglycemia), Known cases of cardiovascular diseases, known hereditary disorders and Adolescents unwilling to participate. Data collection was carried out during school hours in a designated private area to ensure comfort and confidentiality.

RESULT

Our study included 330 adolescents aged 13–19 years selected from government schools of Jharkhand. The sample comprised equal representation from early, mid, and late adolescence. Gender distribution remained balanced with 165 males and 165 females, yielding a male-to-female ratio of 1:1. The results are presented under the following headings: distribution of study participants, anthropometric profile, blood pressure profile, association analysis, correlation analysis, and regression modelling.

Variable	Frequency (N)	Percentage (%)
13–15 years	110	33.33%
16–17 years	110	33.33%
18–19 years	110	33.33%
Male	165	50%
Female	165	50%

TABLE 1 Distribution of Study Participants According to Age Group and Gender (N = 330)

Variable	Mean ± SD	Minimum	Maximum
Age (years)	16.30 ± 2.01	13	19
Height (cm)	163.37 ± 6.83	144.5	183.1
Weight (kg)	58.18 ± 9.89	36.7	101.0
BMI (kg/m ²)	21.75 ± 3.06	16.00	31.52
Waist Circumference (cm)	92.00 ± 5.84	77.3	110.6
Hip Circumference (cm)	98.27 ± 5.92	82.0	116.4
Waist-Hip Ratio	0.94 ± 0.05	0.81	1.16
Mid Arm Circumference (cm)	28.54 ± 2.04	21.4	33.7
Systolic BP (mmHg)	123.22 ± 6.74	106	155
Diastolic BP (mmHg)	77.61 ± 5.31	65	97
Heart Rate (bpm)	75.42 ± 4.16	63	87

TABLE 2 Descriptive Statistics of Anthropometric and Cardiovascular Parameters (N = 330)

Cardiovascular assessment revealed a mean systolic blood pressure of 123.22 ± 6.74 mmHg and mean diastolic blood pressure of 77.61 ± 5.31 mmHg. The average heart rate recorded 75.42 ± 4.16 beats per minute. These values indicate a predominantly normotensive adolescent population with early upward trends in systolic pressure. Anthropometric indices demonstrated strong inter correlations, particularly weight with BMI ($r = 0.862$, $p < 0.01$), waist circumference ($r = 0.739$, $p < 0.01$), and hip circumference ($r = 0.725$, $p < 0.01$). BMI showed moderate positive correlations with systolic ($r = 0.264$, $p < 0.01$) and diastolic blood pressure ($r = 0.182$, $p < 0.01$). Waist circumference exhibited a weak but significant correlation with systolic blood pressure ($r = 0.123$, $p < 0.05$). Systolic and diastolic blood pressure were moderately correlated ($r = 0.456$, $p < 0.01$). Waist-hip ratio did not demonstrate significant associations with blood pressure parameters.

BMI Category	Frequency	Percentage (%)
Underweight	51	15.5%
Normal	170	51.5%
Overweight	98	29.7%
Obese	11	3.3%

TABLE 3 Distribution of Participants According to BMI Category (N = 330)

More than half of the adolescents (51.5%) fell within the normal BMI category. Overweight prevalence reached 29.7%, while 15.5% remained underweight. Only 3.3% met criteria for obesity

BP Category	Frequency	Percentage (%)
Normal	272	82.4%
Elevated	30	9.1%
Stage 1 Hypertension	20	6.1%
Stage 2 Hypertension	8	2.4%

TABLE 4 Distribution of Participants According to BP Category (AAP 2017) (N = 330)

Age Group	Normal n (%)	Overweight n (%)	Obese n (%)	Underweight n (%)	Total
13–15 yrs	78 (66.7)	27 (23.1)	2 (1.7)	10 (8.5)	117
16–17 yrs	52 (53.1)	26 (26.5)	2 (2.0)	18 (18.4)	98
18–19 yrs	41 (35.7)	46 (40.0)	7 (6.1)	21 (18.3)	115
Total	171	99	11	49	330

$$\chi^2 \approx 26.9, df = 6, p < 0.001$$

Table 5. Association Between Age Group and BMI Category (N = 330)

This pattern suggests age-related lifestyle shifts influencing adiposity during late adolescence.

Gender	Normal n (%)	Overweight n (%)	Obese n (%)	Underweight n (%)	Total
Female	88 (53.3)	49 (29.7)	7 (4.2)	21 (12.7)	165
Male	82 (49.7)	49 (29.7)	4 (2.4)	30 (18.2)	165
Total	170	98	11	51	330

$$\chi^2 = 2.618, df = 3, p = 0.454$$

Table 6. Association Between Gender and BMI Category (N = 330)

Age Group	Normal n (%)	Elevated n (%)	Stage 1 HTN n (%)	Stage 2 HTN n (%)	Total
13–15 yrs	99 (84.6)	5 (4.3)	10 (8.5)	3 (2.6)	117

16–17 yrs	86 (87.8)	8 (8.2)	3 (3.1)	1 (1.0)	98
18–19 yrs	86 (74.8)	17 (14.8)	8 (7.0)	4 (3.5)	115
Total	271	30	21	8	330

$$\chi^2 \approx 12.9, df = 6, p \approx 0.045$$

Table 7. Association Between Age Group and BP Category (AAP 2017) (N = 330)

The 18–19 year age group showed higher elevated BP (14.8%) and Stage 2 hypertension (3.5%) compared to younger groups, indicating that late adolescence represents a vulnerable period for increasing blood pressure trends. Both males and females demonstrated identical normal BP prevalence (82.4%). Males displayed marginally higher Stage 1 hypertension, whereas females showed slightly higher Stage 2 proportion, though without statistical relevance.

Gender	Normal n (%)	Elevated n (%)	Stage 1 HTN n (%)	Stage 2 HTN n (%)	Total
Female	136 (82.4)	14 (8.5)	9 (5.5)	6 (3.6)	165
Male	136 (82.4)	16 (9.7)	11 (6.7)	2 (1.2)	165
Total	272	30	20	8	330

$$\chi^2 = 2.333, df = 3, p = 0.506$$

TABLE 8 Association Between Gender and BP Category (AAP 2017) (N = 330)

BMI Category	Normal n (%)	Elevated n (%)	Stage 1 HTN n (%)	Stage 2 HTN n (%)	Total
Normal BMI	146 (85.9)	9 (5.3)	11 (6.5)	4 (2.4)	170
Overweight	74 (75.5)	15 (15.3)	7 (7.1)	2 (2.0)	98
Obese	7 (63.6)	2 (18.2)	1 (9.1)	1 (9.1)	11
Underweight	45 (88.2)	4 (7.8)	1 (2.0)	1 (2.0)	51
Total	272	30	20	8	330

$$\chi^2 = 13.385, df = 9, p = 0.146$$

TABLE 9 Association Between BMI Category and BP Category (AAP 2017) (N = 330)

Although statistical thresholds were not crossed, the gradient pattern strongly suggests biological linkage between adiposity and blood pressure. BMI exhibited a statistically significant positive correlation with systolic blood pressure ($r = 0.264, p < 0.001$) and diastolic blood pressure ($r = 0.182, p = 0.001$).

Variables	r	p-value
BMI vs SBP	0.264	<0.001
BMI vs DBP	0.182	0.001

TABLE 10 Pearson Correlation Between BMI and Blood Pressure

Predictor	B	β	p-value
BMI	0.636	0.289	<0.001
Waist Circumference	-0.056	-0.049	0.491
Age	0.095	0.028	0.606
Gender	0.301	0.022	0.690

$$R^2 = 0.072 \text{ F} = 6.336 \text{ p} < 0.001$$

TABLE 11 Multiple Linear Regression Predicting Systolic Blood Pressure

Each unit increase in BMI corresponded to a 0.636 mmHg rise in systolic pressure. Age, gender, and waist circumference did not independently predict systolic BP after adjustment. BMI alone explains approximately 7.2% of systolic BP variability. The regression model reached statistical significance

($R^2 = 0.036$, $p = 0.018$). BMI independently predicted diastolic BP ($\beta = 0.201$, $p = 0.004$). Each unit increase in BMI increased diastolic pressure by 0.349 mmHg.

Predictor	B	β	p-value
BMI	0.349	0.201	0.004
WaistCircumference	-0.026	-0.028	0.696
Age	-0.106	-0.040	0.476
Gender	0.086	0.008	0.886

$R^2 = 0.036$ $F = 3.030$ $p = 0.018$

TABLE 12 Multiple Linear Regression Predicting Diastolic Blood Pressure
Other variables did not show independent influence. BMI contributes modestly but significantly to diastolic blood pressure variation.

DISCUSSION

In our study, we evaluated the relationship between body mass index (BMI) and blood pressure (BP) among 330 adolescents aged 13–19 years enrolled in government schools in Jharkhand. The prevalence of hypertension, defined according to the 2017 American Academy of Pediatrics (AAP) criteria, was 8.5%, while an additional 9.1% exhibited elevated blood pressure. BMI demonstrated a statistically significant positive correlation with both systolic blood pressure (SBP) and diastolic blood pressure (DBP). On multivariate regression analysis, BMI emerged as an independent predictor of both SBP and DBP, whereas waist circumference, age, and gender did not retain independent predictive significance.

These findings acquire importance in the context of the rising global prevalence of pediatric obesity and its established role in the early pathogenesis of hypertension. Contemporary epidemiological data demonstrate that childhood hypertension is no longer predominantly secondary in origin but increasingly reflects primary hypertension associated with adiposity and lifestyle transitions^{19,20}. The revision of pediatric hypertension definitions under the 2017 AAP guidelines has further heightened recognition of elevated BP in adolescents²¹. The tracking phenomenon, whereby elevated childhood BP persists into adulthood, underscores the clinical relevance of even modest BP elevations during adolescence²². Our findings therefore contribute region-specific evidence from Eastern India to the expanding body of literature linking adolescent adiposity with measurable cardiovascular alterations.

Age Distribution :In our study, participants were evenly distributed across early (13–15 years), mid (16–17 years), and late adolescence (18–19 years). Although the association between age group and BP category approached but did not achieve statistical significance ($p = 0.054$), a clinically relevant pattern emerged. Late adolescents demonstrated higher proportions of elevated BP (14.5%) and Stage 2 hypertension (3.6%) compared with younger groups. Age-related increases in BP during adolescence are biologically plausible. Pubertal hormonal changes—including increased growth hormone, sex steroids, and transient insulin resistance—contribute to altered vascular compliance and sympathetic tone³². Additionally, behavioral factors such as dietary autonomy, increased academic stress, reduced physical activity, and greater screen time often intensify in late adolescence³³. Nationally representative Korean data demonstrated that older age was independently associated with elevated BP among overweight and obese adolescents, with an odds ratio (OR) of 1.16 per year increase¹⁹. Similarly, a large-scale Chinese provincial survey involving over 220,000 adolescents reported higher hypertension prevalence among older adolescents compared to younger age groups³¹. Japanese school-based research further documented increasing SBP across high school grades, particularly among male students²³.

Longitudinal evidence reinforces the importance of these findings. The Young Finns Study established that elevated BP in adolescence strongly predicted adult hypertension and vascular structural changes. Likewise, cohort analyses have shown that SBP in early adolescence correlates with carotid intima-media thickness and coronary artery calcification in adulthood^{22,26}. Although our

age-related findings did not cross statistical thresholds, the directional consistency with international evidence suggests that late adolescence represents a critical window for early vascular risk emergence.

Gender Distribution: In our study, gender did not show a statistically significant association with BMI category or BP category. Both males and females demonstrated identical normal BP prevalence (82.4%). International findings regarding sex differences are heterogeneous. Korean adolescents exhibited male sex as an independent risk factor for elevated BP (OR 2.32)¹⁹. Japanese high school data demonstrated higher SBP among males compared with females²³. Conversely, certain European cohorts have shown minimal gender differences after adjusting for adiposity²⁴. Physiologically, males tend to exhibit higher sympathetic activity and greater visceral fat accumulation during adolescence, whereas females often accumulate more subcutaneous fat³². However, in resource-limited school populations where lifestyle exposures are similar across genders, differences may be attenuated. The absence of gender disparity in our study may reflect homogeneity in socioeconomic background and dietary patterns among government school students. It may also be attributable to sample size limitations reducing power to detect modest gender effects.

Anthropometric Profile and Nutritional Transition: In our study, 29.7% of adolescents were overweight and 3.3% were obese, while 15.5% remained underweight. This coexistence of undernutrition and emerging overweight reflects the dual burden of malnutrition characteristic of transitional economies²⁹. The Indian obesity burden has escalated rapidly over the past three decades, with national surveys documenting increasing BMI trends among youth²⁹. Korean data indicate overweight/obesity prevalence exceeding 20% among adolescents, while South African systematic reviews report central obesity prevalence up to 41%. Although overall obesity prevalence in our cohort appears lower than some East Asian populations, the high proportion of overweight adolescents (nearly one-third) signals early epidemiological shift. Given that overweight during adolescence strongly predicts adult obesity and metabolic syndrome²⁷, this pattern warrants preventive attention.

Blood Pressure Profile: In our study, mean SBP was 123.22 mmHg and mean DBP was 77.61 mmHg. The prevalence of hypertension (Stage 1 + Stage 2) was 8.5%. These findings align with several Asian datasets. Chinese provincial data reported hypertension prevalence between 10% and 15.7% depending on guideline applied³¹. Korean adolescents with obesity exhibited markedly higher rates of BP elevation³². Jordanian adolescents demonstrated significantly increased risk of stage 2 hypertension among those with elevated waist circumference²⁰. Differences in prevalence across studies may reflect variation in diagnostic criteria, ethnicity, urbanization, salt intake, and obesity severity. The adoption of AAP 2017 criteria in our study enhances comparability with contemporary international research²¹.

Correlation Between BMI and Blood Pressure: In our study, BMI showed a statistically significant positive correlation with SBP ($r = 0.264$) and DBP ($r = 0.182$). Although the strength of correlation was modest, it was consistent and biologically plausible. Similar associations have been widely documented. Korean national data demonstrated increased odds of elevated BP with greater obesity severity¹⁹. Chinese modeling during the COVID-19 period identified BMI as a significant predictor of SBP and DBP across age groups²⁸. Sudanese adolescents showed BMI area under the curve (AUC) of 0.73 for predicting hypertension³³. Pathophysiologically, obesity-induced hypertension arises through multiple interrelated mechanisms. Adiposity increases sympathetic nervous system activation, elevates leptin-mediated hypothalamic signaling, stimulates the renin–angiotensin–aldosterone system (RAAS), impairs pressure natriuresis, and promotes renal sodium retention³². Visceral adipose tissue secretes pro-inflammatory cytokines that induce endothelial dysfunction and vascular stiffness²⁷. Insulin resistance further contributes to sympathetic overactivity and sodium retention³². The modest correlation coefficients observed in our study reflect the multifactorial nature of BP regulation, wherein BMI represents only one contributor among genetic predisposition, salt intake, physical inactivity, sleep patterns, and psychosocial stress.

Central Obesity and Alternative Anthropometric Indices: In our study, waist circumference correlated weakly with SBP but lost significance after adjustment. Waist-hip ratio showed no significant association. Central adiposity often confers stronger metabolic risk than generalized adiposity. Jordanian adolescents with high truncal fat percentiles demonstrated six- to eight-fold increased odds of stage 2 hypertension²⁰. South African data validated waist-to-height ratio ≥ 0.5 as predictor of cardiometabolic risk²⁵. Korean cardiometabolic clustering studies reported strong association between abdominal obesity and multiple risk factors³⁰. The absence of independent predictive value of waist circumference in our regression model may be attributable to collinearity with BMI or limited sample size. In Asian populations, BMI and central adiposity often correlate strongly, reducing incremental predictive value.

Regression Modeling and Predictive Strength : In our study, BMI independently predicted SBP ($\beta = 0.289$, $p < 0.001$) and DBP ($\beta = 0.201$, $p = 0.004$). Each unit increase in BMI corresponded to a 0.636 mmHg rise in SBP and 0.349 mmHg rise in DBP. While statistically significant, R^2 values (7.2% for SBP and 3.6% for DBP) indicate modest explanatory power. Similar modest predictive values have been reported internationally^{28,33}. The relatively low R emphasizes that hypertension in adolescence is influenced by numerous environmental and genetic determinants beyond BMI. Severe obesity has been associated with markedly elevated 30-year predicted cardiovascular risk in American adolescents²⁶. Korean adolescents with clustering of three or more cardiometabolic risk factors showed OR 4.75 in obese individuals³⁰. These findings highlight that BMI may serve as early screening marker, even if it does not fully explain BP variance.

Cardiometabolic Risk Clustering : In our study, overweight adolescents exhibited higher elevated BP prevalence compared to normal BMI peers. Although statistical significance was not achieved, a clear gradient pattern was observed. Cardiometabolic clustering is well documented. Korean adolescents demonstrated 22.7% prevalence of ≥ 3 cardiometabolic risk factors among obese youth³⁰. Obesity is strongly associated with dyslipidemia, insulin resistance, hyperuricemia, and hepatic steatosis²⁷. The tracking phenomenon extends beyond BP alone. Elevated BMI in adolescence predicts adult type 2 diabetes, metabolic syndrome, and cardiovascular disease. Thus, early BP elevation in overweight adolescents may represent the first clinical manifestation of broader cardiometabolic dysregulation.

Classification Systems and Guideline Implications: In our study, BP classification utilized AAP 2017 criteria. This guideline lowered normative thresholds by excluding overweight children from reference populations²¹. Studies comparing AAP with NHCC and ESH criteria demonstrate higher detection rates under AAP standards³¹. Adopting AAP criteria enhances sensitivity for early detection, though may increase apparent prevalence. Given the tracking and long-term consequences of adolescent hypertension²², early identification may justify heightened surveillance.

Clinical and Public Health Implications: In our study, nearly one in twelve adolescents was hypertensive, and nearly one in ten had elevated BP. Combined with 29.7% overweight prevalence, these findings signify early cardiometabolic vulnerability. Lifestyle modification remains first-line therapy. Weight reduction improves BP through decreased sympathetic activity and RAAS suppression³². School-based interventions focusing on diet, physical activity, and salt restriction have demonstrated benefit²⁹. Given India's dual burden of malnutrition,²⁹ policy initiatives must address both undernutrition and obesity. Routine school screening for BMI and BP could facilitate early risk stratification.

CONCLUSION

Our study demonstrates a statistically significant positive association between body mass index and blood pressure among adolescents of Jharkhand. The overall prevalence of hypertension was 8.5%,

with an additional 9.1% exhibiting elevated blood pressure according to the 2017 AAP classification. Our findings show that BMI correlates positively with both systolic and diastolic blood pressure. In multivariate analysis, BMI emerged as an independent predictor of systolic and diastolic blood pressure, whereas age, gender, and waist circumference did not retain independent significance. Although the strength of association was modest, the relationship remained statistically significant. Our study also reveals an increasing trend of overweight and elevated blood pressure in late adolescence, indicating age-related progression of cardiovascular risk. The coexistence of underweight and overweight within the same population reflects the dual burden of malnutrition. Overall, our study establishes that increasing BMI is associated with measurable increases in blood pressure among adolescents. These findings highlight the early emergence of cardiovascular risk in this population and confirm the importance of anthropometric assessment in adolescent health evaluation.

REFERENCES

1. World Health Organization. Obesity and overweight. Geneva: WHO; 2023.
2. GBD 2015 Obesity Collaborators. Health effects of overweight and obesity in 195 countries over 25 years. *N Engl J Med*. 2017;377:13–27.
3. Afshin A, et al. Health effects of overweight and obesity in children and adults. *N Engl J Med*. 2017;377:13–27.
4. Hruby A, Hu FB. The epidemiology of obesity: a big picture. *Pharmacoeconomics*. 2015;33:673–689.
5. Blair SN, et al. Physical fitness and all-cause mortality. *JAMA*. 1989;262:2395–2401.
6. Simmonds M, et al. Predicting adult obesity from childhood obesity: a systematic review and meta-analysis. *Obes Rev*. 2016;17:95–107.
7. Hall JE, et al. Obesity-induced hypertension: mechanisms, cardio-renal consequences. *Circ Res*. 2015;116:991–1006.
8. World Health Organization. BMI classification. Geneva: WHO; 2000.
9. Cole TJ, et al. Establishing BMI cut-offs for child overweight and obesity worldwide. *BMJ*. 2000;320:1240–1243.
10. Ashwell M, Gibson S. Waist-to-height ratio as a screening tool. *BMJ Open*. 2016;6:e010159.
11. Freedman DS, et al. Relation of circumferences and skinfold thicknesses to lipid and insulin concentrations. *Am J Clin Nutr*. 1999;69:308–317.
12. Sorof JM, Daniels SR. Obesity hypertension in children. *Hypertension*. 2002;40:441–447.
13. Flynn JT, et al. Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents. *Pediatrics*. 2017;140:e20171904.
14. Azegami T, et al. Blood Pressure Tracking From Childhood to Adulthood. *Front Pediatr*. 2021;9:785356.
15. Drozd D, et al. Obesity and Cardiometabolic Risk Factors: From Childhood to Adulthood. *Nutrients*. 2021;13:4176.
16. Jeong SI, Kim SH. Obesity and hypertension in children and adolescents. *Clin Hypertens*. 2024;30:23.
17. Mao S, et al. Relationship between BMI and blood pressure indices in children aged 7–17. *Front Public Health*. 2024;12:1409214.
18. Li M, et al. Prevalence and risk factors for hypertension among children and adolescents in Northwestern China. *Sci Rep*. 2025;15:18963.
19. Falkner B, Daniels SR. Summary of the Fourth Report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics*. 2004;114(2 Suppl 4th Report):555–576.
20. Sorof JM, Lai D, Turner J, Poffenbarger T, Portman RJ. Overweight, ethnicity, and the prevalence of hypertension in school-aged children. *Pediatrics*. 2004;113(3 Pt 1):475–482.

21. Bao W, Threft SA, Srinivasan SR, Berenson GS. Essential hypertension predicted by tracking of elevated blood pressure from childhood to adulthood: The Bogalusa Heart Study. *Hypertension*. 1995;26(3):464–468.
22. Juonala M, Magnussen CG, Berenson GS, et al. Childhood adiposity, adult adiposity, and cardiovascular risk factors. *N Engl J Med*. 2011;365(20):1876–1885.
23. Urbina EM, Williams RV, Alpert BS, et al. Noninvasive assessment of subclinical atherosclerosis in children and adolescents: recommendations for standard assessment. *J Am Soc Hypertens*. 2009;3(3):181–196.
24. Reinehr T. Obesity and hypertension in children and adolescents. *J Clin Hypertens (Greenwich)*. 2013;15(8):568–572.
25. Kelishadi R, Ardalan G, Gheiratmand R, et al. Association of anthropometric indices with cardiovascular risk factors among children and adolescents: CASPIAN Study. *J Pediatr*. 2014;164(4):887–893.
26. Freedman DS, Dietz WH, Srinivasan SR, Berenson GS. The relation of overweight to cardiovascular risk factors among children and adolescents: The Bogalusa Heart Study. *Pediatrics*. 1999;103(6 Pt 1):1175–1182.
27. Chen X, Wang Y. Tracking of blood pressure from childhood to adulthood: a systematic review and meta-regression analysis. *Circulation*. 2008;117(25):3171–3180.
28. Lo JC, Sinaiko AR, Chandra M, et al. Prehypertension and hypertension in community-based pediatric practice. *Pediatrics*. 2013;131(2):e415–e424.
29. Gupta N, Goel K, Shah P, Misra A. Childhood obesity in developing countries: epidemiology, determinants, and prevention. *Obes Rev*. 2012;13(6):545–556.
30. McNiece KL, Poffenbarger TS, Turner JL, Franco KD, Sorof JM, Portman RJ. Prevalence of hypertension and pre-hypertension among adolescents. *J Pediatr*. 2007;150(6):640–644.
31. Muntner P, Carey RM, Gidding S, et al. Potential US population impact of the 2017 AAP blood pressure guideline. *Hypertension*. 2018;71(6):e1–e8.
32. Litwin M, Kułaga Z. Obesity, metabolic syndrome, and primary hypertension in children and adolescents. *Pediatr Nephrol*. 2021;36(4):825–837. 105. Brady TM. Obesity-related hypertension in children. *Hypertension*. 2017;70(4):689–695.