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Original Research Article

Adolescent hypertension: a growing public health concern in western Maharashtra

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ABSTRACT

Background: As change in lifestyle and food habits in recent years, increased prevalence of high blood pressure among adolescents is observed. Multiple studies have demonstrated that elevated blood pressure in childhood often persist into adulthood. Therefore, early screening is essential to identify adolescents at increased risk of developing hypertension later in life. The study was conducted with objective to estimate proportion of high blood pressure and to identify factors influencing blood pressure.

Methods: A cross-sectional analytical study was conducted among 254 adolescents from 5th to 10th grade at secondary schools at Malakapur, Karad, using systematic sampling technique. Data collection was done using a structured questionnaire, a digital sphygmomanometer, an inelastic tape to measure height, an elastic tape to measure waist circumference and weighing machine. Data entry was performed by using Microsoft Excel for Microsoft 365 for windows. Descriptive statistics (percentage/proportion) and Analytical statistics (chi square test) were applied using SPSS Version 27.0.

Results: Among 254 adolescents aged 10-17 years, 13% had elevated blood pressure, 7.1% had stage 1 hypertension (HTN), and 5.9% had stage 2 hypertension. Hypertension was significantly more common among male adolescents (17.9% elevated BP and 16.9% HTN) compared with females (9.2% elevated BP and 9.8% HTN) ($p=0.017$). Overweight and obese adolescents had a significantly higher proportion of HTN compared with those with normal BMI ($p<0.001$).

Conclusions: School based evaluation offers a practical platform to detect influencing lifestyle and behavioral factors. Early identification enables targeted health education and preventive interventions.

Keywords: Adolescents, Blood pressure, Hypertension, Obesity

INTRODUCTION

Hypertension has become one of the most significant global public health concerns, as it is a leading yet largely preventable contributor to cardiovascular disease and premature death.[1] Physiologically, blood pressure is the force exerted by circulating blood against the arterial walls during cardiac contraction. Persistently elevated blood pressure places excessive stress on blood vessels and increases the workload on the heart, thereby raising the risk of chronic diseases, disability, and early mortality.[2] Traditionally regarded as condition of adulthood, elevated blood pressure is now increasingly observed among the children and adolescents, signalling an earlier onset of cardiovascular risk.[1,3] The World Health Organization highlights that early identification and management of high blood pressure are critical to reduce long term burden of cardiovascular diseases.[1] Adolescence is pivotal developmental stage marked by rapid physical growth, hormonal changes, and evolving lifestyle behaviours, all of which can influence blood pressure regulation.[4] Evidence indicates that blood pressure patterns established during childhood and adolescence often persistent to adulthood, thereby heightening the risk of sustained hypertension and

cardiovascular disease later in life.[2] Primordial prevention strategies initiated during childhood and adolescence offer a unique opportunity to prevent the development of hypertension and its complications.[4]

Despite growing evidence on adolescent hypertension, data from semi-urban regions of Maharashtra remain limited. Local environmental, dietary, and socioeconomic factors may influence blood pressure patterns among adolescents. Therefore, this study was conducted with objectives to assess blood pressure levels and identify factors influencing blood pressure among adolescents at Malakapur, Karad.

METHODS

It was cross-sectional analytical study conducted among 254 adolescents from 5th to 10th grade who were willing to participate, from 5th to 10th grade students from government aided and unaided schools at Malakapur, Karad, chosen by systematic sampling technique (Figure 1), data was collected during July 2024 to August 2025.

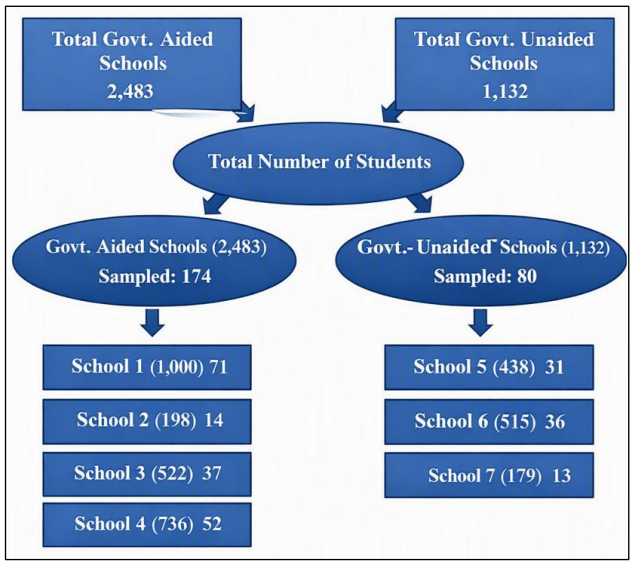

Figure 1: Flow diagram showing the systematic sampling procedure for selection of study participants.

Inclusion criteria

Adolescents aged 10-19 years studying in the selected schools during the study period, students present in the school on the day of data collection, students who provided assent to participate in the study along with written informed consent from parents/guardians were included.

Exclusion criteria

Students with known chronic illnesses such as congenital heart disease, renal disease, endocrine disorders or other medical conditions that may affect blood pressure were excluded. Students who were absent during the data collection period or declined to participate in the study were also excluded. Students with acute illness at the time of examination, such as fever or infection, which could temporarily alter blood pressure readings were also excluded.

Each student blood pressure was taken using digital sphygmomanometer. Study subjects were asked to seat quietly for 5 min. then blood pressure was measured in sitting position on right upper arm, with the arm supported and horizontal at the level of the heart and legs uncrossed. Three readings were taken at an interval of five minutes, appropriate cuff according to age was tied on the right arm (at a point midway between the olecranon and acromion process). Final blood pressure was obtained by taking average of three readings. The digital sphygmomanometer was chosen as it has the advantage of easy usability considering the logistic issues during work and the minimization of observer bias or digit preference. Height was taken with the use of inelastic tape. Weight was noted by standardised weighing machine. The purpose and process of the study was explained to the adolescents. The data collected using a pre tested, validated questionnaire made with reference to published articles, WHO STEP 1 and STEP 2 questionnaire and discussion with experts. Data was collected in days allotted to respective school on regular basis until the sample size was completed. Data was collected by investigator. Data collection was anonymous and privacy was maintained and data is available only to the principal investigator. Blood pressure is classified using the Indian Academy of Paediatrics 2022 guidelines.[24] Those students who were falling in hypertension category were advised to visit nearby hospital. Their parents were informed about the condition via school and advised to visit nearby hospital for further management.

Sample size is calculated by using formula: $n = 4pq \div l^2$, prevalence for hypertension (stage 1 and 2) was considered to be 18.9%, based on a previous study.[5] So minimum sample size required was 247 and 254 sample size was collected. After obtaining ethical clearance certificate from the Institutional Ethics Committee, data was collected from government aided and private schools in Malkapur, Karad. Permission was secured from the respective school heads prior to the study. Data collection from the student was carried out after obtaining informed consent from their parents and assent from each student.

Statistical analysis

Data was entered in Microsoft Excel for Microsoft 365, and analysed using SPSS version 27.00. Descriptive statistics: Frequency and percentage were calculated for categorical variables such as socio demographic characteristics, lifestyle and dietary habits, while mean and standard deviation were computed for continuous variable such as age. Inferential statistics: Associations between blood pressure status and selected variables such

as age, gender, body mass index, physical activity, socio-economic status and family history of hypertension were evaluated using the chi-square test. A p-value of <0.05 was considered statistically significant.[25]

RESULTS

The study included 254 adolescents studying from 5th to 10th standard, aged 10-17 years [mean (SD) age, 12.91 (1.69) years]; 112 (44.1%) were males and 142 (55.9%) were females. Among study participants, 188 (74.0%) were normotensive, 33 (13.0%) had elevated BP, 18 (7.1%) had Stage 1 HTN, and 15 (5.9%) had Stage 2 HTN (Figure 2).

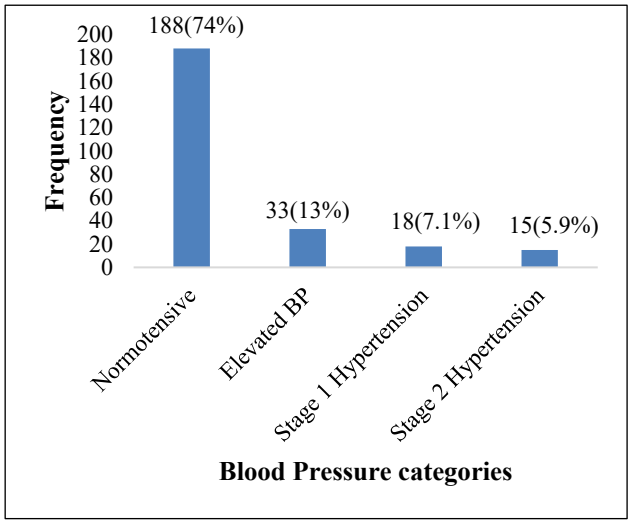

Figure 2: Distribution of hypertension stages among adolescents based on IAP.

The majority of adolescents were classified as having a normal body weight (143; 56.3%). A considerable proportion exhibited thinness (45; 17.7%) or severe thinness (31; 12.2%), together accounting for nearly one-third of the study population. In contrast, 27 participants (10.6%) were categorized as overweight, while 8 participants (3.1%) were classified as obese (Figure 3).

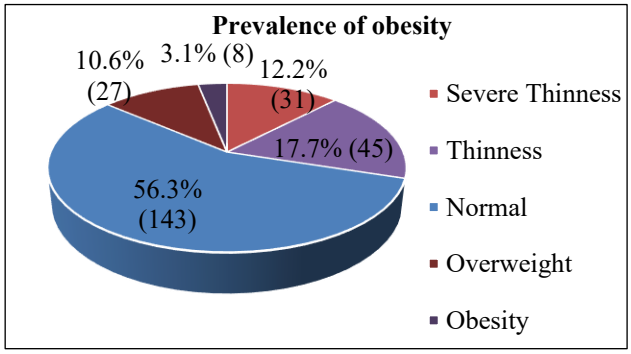

Figure 3: Distribution of BMI categories among adolescents according to WHO.

The majority (53.9%) were aged ≥13 years, and females constituted 55.9% of the study population. Most participants belonged to socioeconomic Classes I and II (32.3% and 34.6%, respectively). Nuclear families were predominant (57.1%). Tobacco and alcohol use were relatively low (3.9% and 1.6%, respectively), while 18.9% of adolescents reported a parental history of hypertension. A large proportion (93.3%) had insufficient physical activity (Table 1).

Table 1: Socio demographic distribution of study population.

Variable	Category	Frequency(n)	Percentage (%)
Age category	< 13 years	117	46.1
	≥ 13 years	137	53.9
Sex	Male	112	44.1
	Female	142	55.9
SE class	Class 1	82	32.3
	Class 2	88	34.6
	Class 3	57	22.4
	Class 4	23	9.1
	Class 5	4	1.6
Type of family	Nuclear	145	57.1
	Joint	59	23.2
	Three generation	50	19.7
Alcohol use	no	250	98.4
	yes	4	1.6
Tobacco use	No	244	96.1
	yes	10	3.9
Parenteral H/o HTN	no	206	81.1
	yes	48	18.9
Physical activity	Sufficient	17	6.7
	Insufficient	237	93.3

With respect to blood pressure status, the majority of adolescents were normotensive across most categories. However, variations were observed across different variables in study. Gender was significantly associated with blood pressure (χ^2=8.196, p=0.017), with males showing higher proportion of both elevated blood pressure (17.9%) and hypertension (16.9%) compared to females (9.2% and 9.8%, respectively). A statistically significant association was found between BMI and blood pressure categories (χ^2=21.206, p<0.001). Overweight/obese adolescents had a markedly higher proportion of hypertension (28.6%) compared to those with normal BMI (11.9%) and thin adolescents (7.9%). Although adolescents aged ≥13 years showed a higher proportion of hypertension (16.8%) compared to those <13 years (8.5%), the association was not statistically significant (p=0.139). No statistically significant associations were observed between blood pressure categories and socioeconomic status (p=0.391), type of family (p=0.988), parental history of hypertension

(p=0.418), physical activity (p=0.637), tobacco use (p=0.908), or alcohol use (p=0.544) (Table 2).

Table 2: Association between socio-demographic, behavioural and anthropometric factors with blood pressure categories among adolescents.

Variable	Blood pressure categories			Total	Significance
	Normotensive, N (%)	Elevated BP, N (%)	HTN, N (%)		
BMI					
Thin	62 (81.6)	8 (10.5)	6 (7.9)	76 (100.0)	χ^2=21.206, df=4, p= <0.001*
Normal	111 (77.6)	15 (10.5)	17 (11.9)	143 (100.0)	
Overweight/obese	15 (42.9)	10 (28.6)	10 (28.6)	35 (100.0)	
Age group (in years)					
<13	90 (76.9)	17 (14.5)	10 (8.5)	117 (100.0)	χ^2 =3.942, df=2, p=0.139
≥13	98 (71.5)	16 (11.7)	23 (16.8)	137 (100.0)	
Gender					
Male	73 (65.2)	20 (17.9)	19 (16.9)	112 (100.0)	χ^2 =8.196, df=2, p=0.017*
Female	115 (81.0)	13 (9.2)	14 (9.8)	142 (100.0)	
SE class					
Class I	63 (76.8)	9 (11)	10 (12.2)	82 (100.0)	χ^2=8.447, df=8, p=0.391
Class II	61 (69.3)	16 (18.2)	11 (12.5)	88 (100.0)	
Class III	46 (80.7)	6 (10.5)	5 (8.8)	57 (100.0)	
Class IV	15 (65.2)	2 (8.7)	6 (26.1)	23 (100.0)	
Class V	3 (75.0)	0 (0.0)	1 (25.0)	4 (100.0)	
Type of family					
Nuclear	106 (73.1)	20 (13.8)	19 (13.1)	145 (100.0)	χ^2=0.322, df=4, p=0.988
Joint	45 (76.3)	7 (11.9)	7 (11.9)	59 (100.0)	
Three generation	37 (74.0)	6 (12.0)	7 (14.0)	50 (100.0)	
Parenteral h/o HTN					
No	155 (75.2)	27 (13.1)	24 (11.7)	206 (100.0)	χ^2 =1.743, df=2, p=0.418
Yes	33 (68.8)	6 (12.5)	9 (18.8)	48 (100.0)	
Physical activity					
Sufficient activity	14 (82.4)	2 (11.8)	1 (5.9)	17 (100.0)	χ^2=0.901, df=2, p=0.637
Insufficient activity	174 (73.4)	31 (13.1)	32 (13.5)	237 (100.0)	
Tobacco use					
Yes	8 (80)	1 (10)	1 (10)	10 (100)	χ^2=0.194, df=2, p=0.908
No	180 (73.8)	32 (13.1)	32 (13.1)	244 (100)	
Alcohol use					
Yes	2 (50)	1 (25)	1 (25)	4 (100)	χ^2=1.219, df=2, p=0.544
No	186 (74.4)	32 (12.8)	32 (12.8)	250 (100)	

*p<0.05 is statistically significant

DISCUSSION

The present cross-sectional study was conducted among 254 adolescents to determine the proportion of hypertension and its associated risk factors. In the present study, the overall proportion of hypertension was 13.0%, with 7.1% having stage 1 hypertension and 5.9% having stage 2 hypertension. Additionally, 13.0% of adolescents were categorized as having elevated blood pressure. Thus, 26.0% of adolescents had either elevated blood pressure or hypertension. A mean systolic blood pressure was 113.13±11.69 mmHg and mean diastolic blood pressure was 76.03±5.68 mmHg. The proportion of hypertension observed in the present study (13%) was higher than that reported in several international studies, such as the global systematic review by Song P et al. (2019) which reported a pooled prevalence of approximately 4% among children and adolescents and the systematic review from Africa by Noubiap et al (2017) which reported a prevalence of 5.5% elevated blood pressure among adolescents.[7,4] However, the proportion observed in the present study is comparable to that reported by De Moraes et al (2014) which reported a pooled global prevalence of 11.2% for high blood pressure among adolescents, with significantly higher rates among males.[8]

In India, several studies have reported comparable or slightly higher prevalence rates. Tripathy et al (2022) reported a prevalence of 18.6% hypertension among adolescents in Odisha, while Singh et al (2017) observed that 15.3% of adolescents were hypertensive and 19.8% had pre-hypertension in Bhopal.[9,10]

Regional studies from Maharashtra also show similar findings. A study conducted by Banerjee et al (2021) reported a 12.9% prevalence of hypertension among school-going adolescents in Nagpur, which closely resembles the findings of the present study.[11]

Variations in prevalence between studies may be attributed to differences in study design, diagnostic criteria, measurement techniques, age distribution, lifestyle factors and geographic variations.

In the present study, females constituted 55.9% of the study population, while males accounted for 44.1%. A significantly higher prevalence of hypertension was observed among males (16.9%) compared to females (9.8%) ($p<0.05$). This finding is consistent with previous studies, including those by De Moraes et al and Bozza et al, which reported higher blood pressure levels among male adolescents.[8,12] Similar trends have also been observed in Indian studies.[13] The higher prevalence among males may be attributed to behavioural and physiological factors such as higher body mass index, dietary patterns, and hormonal influences. However, some studies have reported no significant gender difference, indicating that sociocultural and lifestyle variations may influence these findings.[6]

Body mass index (BMI) showed a strong and statistically significant association with blood pressure ($\chi^2=21.206$, $p<0.001$). Adolescents with overweight/obesity had a substantially higher proportion of hypertension (28.6%) compared to those with normal BMI (11.9%) and thin adolescents (7.9%). This trend clearly demonstrates an increase in abnormal blood pressure with rising BMI. Similar findings have been reported in studies from China, Nigeria, and India, all of which highlight obesity as a major risk factor for hypertension among adolescents.[14-17]

Overall, the results emphasize that male gender and increased BMI are important determinants of elevated blood pressure. These findings underscore the need for early lifestyle interventions focusing on healthy diet, weight management, and physical activity to prevent hypertension and its long-term complications.[18]

In the present study, socioeconomic status and type of family were not significantly associated with blood pressure, suggesting limited direct influence, although they may affect lifestyle factors.[19,20] Parental history of hypertension showed a higher proportion of hypertension but was not statistically significant, despite its known genetic role.[21]

Similarly, physical activity, tobacco use, and alcohol consumption were not significantly associated with blood pressure, likely due to low variability in these factors within the study population. However, these remain important behavioural risk factors for hypertension.[22,23]

This study has several strengths that enhance the validity of its findings. It focused on school-going adolescents, a critical group for early identification and prevention of hypertension and future cardiovascular diseases. Blood pressure and anthropometric measurements were obtained using standardized procedures and calibrated instruments, ensuring reliability and accuracy. The study also assessed multiple determinants, including sociodemographic factors, lifestyle behaviours, physical activity and family history, providing a comprehensive understanding of associated risk factors. Furthermore, the use of appropriate statistical methods, including chi-square test, helped identify significant associations.

Despite its strengths, the study has certain limitations. The cross-sectional design limits the ability to establish causal relationships between risk factors and hypertension. Blood pressure measurements were recorded during a single visit, which may be influenced by temporary factors. Several variables were self-reported, making them susceptible to recall and reporting bias. Additionally, the study was conducted in a specific geographical area and included only school-going adolescents, which may limit the generalizability of the findings to the wider adolescent population.

CONCLUSION

The present study underscores hypertension as an emerging and significant public health concern among adolescents, with a substantial proportion exhibiting either elevated or high blood pressure levels. Male adolescents and those with overweight or obesity were identified as having a higher risk of hypertension, indicating the influence of both biological and lifestyle-related factors. Although associations with other behavioural risk factors were not statistically significant, their established role in cardiovascular health cannot be overlooked. These findings emphasize the importance of early identification and timely intervention during adolescence to prevent progression to adult hypertension and reduce the future burden of cardiovascular diseases.

Recommendations

It is recommended that routine blood pressure screening be institutionalized within school health services to enable early detection and management of hypertension among adolescents. Comprehensive school-based health programmes should focus on promoting healthy dietary practices, regular physical activity, and maintenance of optimal body weight, alongside increasing awareness of cardiovascular risk factors among students, teachers, and parents. Integration of stress management interventions, including counselling and mindfulness-based activities, is also essential. Strengthening existing national initiatives such as Rashtriya Kishor Swasthya Karyakram can further enhance screening and preventive efforts. Additionally, the implementation of innovative, participatory school-based interventions and the conduct

of large-scale longitudinal studies are warranted to generate robust evidence for targeted public health strategies.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee of Krishna Institute of Medical Sciences Deemed University (KIMSDU), dated 16th April 2024 (Ref. No. KIMSDU/IEC/05/2024)

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