ORIGINAL RESEARCH

Prevalence and Anthropometric determinants of Hypertension among Children aged 6-15 years- A cross-sectional Study

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ABSTRACT

Background: The obesity in children is reaching at unprecedented levels secondary to two remarkable changes in the habits of millennial children: consumption of high calorieand highly processed food (with higher salt content). **Aim:** To determine the prevalence of asymptomatic hypertension and study the relationship of blood pressure with biophysical variables- age, gender, weight, height, BMI, and waist-to-height ratio among children aged 6-15 years. **Material and Methods:** This was a single-centre, field-based, cross-sectional, observational study conducted at urban areas of Bhopal over a period of 18 months among a total of 351 children aged 6-15 years. **Results:**Among the 351 participants: 11.68% were categorized to have elevated BP and 9.69% children had stage-I hypertension. Among 168 girls, 7.7% had elevated BP and hypertension respectively and among 183 boys; 14.7% and 11.5% children had elevated BP and hypertension respectively (p=0.416). The difference in the BMI categories among the children with normal BP and elevated BP or hypertension was statistically significant (p< 0.0001).Most children with elevated BP and hypertension had a high waist to height ratio(p = 0.0012). There was a linear relationship between the weight of the children and blood pressure. **Conclusion:** One in five children had blood pressure that was high for their age. Elevated blood pressure were substantially more common among overweight and obese children. The blood pressure especially among obese children should be measured on a compulsory basis at least once every year.

INTRODUCTION

Epidemiological transition has affected people from all walks of life, ranging from the geriatric population to neonates(1,2). As the prevalence of communicable diseases continues to decline among children and young people, non-communicable diseases are encountered with increasing frequency every day(1,2). In addition, these days the paediatric population has a double burden of malnutrition i.e., undernutrition and overnutrition(3–6). Now a days, a paediatrician may encounter more children who are overweight or obese than undernourished children(3–6). These grave changes in the pattern of risk factors and diseases have forced healthcare providers and policymakers to rethink their approach to the provision of healthcare to all segments of the population including children(3–6).

Traditionally, Hypertension (HT) in children and adolescents has been defined as blood pressure (BP) ≥95th percentile of the age, sex and height-adjusted BP(7–9). Screening studies indicate that the prevalence of hypertension in children in India is approximately between 0.46-11.7%(10).There are at least five critical as well as logical arguments for a universal screening of blood pressure among children and young adults on an annual basis(11,12). Firstly, similar to several habits of ours including likes and dislikes, many diseases acquired during childhood are continued into adulthood(13). Empirical evidence from several large-scale, life-course, cohort studies that followed participants from their birth to adulthood have reported that high blood pressure in childhood continues to increase in magnitude throughout adolescence to be ultimately diagnosed as

primary hypertension among adults(14–16). A strong relationship exists between the blood pressure status at 7 years of age and early mid-life, demonstrating that blood pressure status from childhood can be carried over into adulthood(17–19).

Secondly, there have been two remarkable changes in the habits of millennial children: consumption of high-calorie & highly processed food (with higher salt content) and increased screen time(3,5,20). Consequently, with every passing year, the prevalence of obesity among children & adolescents is continuously increasing(3,5,20). The childhood obesity epidemic has made a substantial impact on the prevalence of elevated BP and hypertension in children and adolescents. A study by Ferreira et al. spanning ages 13–36 years detected greater carotid artery stiffness in adulthood among those with higher BP and greater central adiposity in their adolescence(21). Thirdly, the findings from life course studies also provide insights into potential cardiovascular health benefits of early interventions on modifiable risk factors such as preventing or correcting childhood obesity and other related health behaviours(22). Fourthly, blood pressure during adolescence and adulthood is also determined by birth events viz. birth weight, prematurity etc(23,24). Both prematurity and LBW, especially small for gestational age, are associated with the development of metabolic abnormalities and elevated blood pressure(25–27). Lastly, the measurement of blood pressure and interpretation of findings are very complex among children and adolescents in comparison to adults(11,12,28,29).

An analysis of risk factors associated with the development of hypertension showed that BMI, waist circumference, and dietary sodium intake were each independently associated with elevated BP and hypertension(22,30–32). Considering all the arguments mentioned above, it becomes critical to measure the blood pressure among children and identify the determinants of high blood pressure. As mentioned above, the elimination of several modifiable risk factors viz. adiposity, increased salt consumption, smoking etc. can reduce the risk of developing hypertension in childhood and adult life. Hence, we conducted this study to determine the prevalence of hypertension in children residing in our community and to identify its determinants including biophysical profile.

MATERIAL AND METHODS

STUDY DESIGN

This was a single-centre, field-based, cross-sectional, observational study(33,34). **Study Settings:** The present study was conducted at the Department of Paediatrics, Chirayu Medical College and affiliated Hospitals, Bhopal. The participants for the present study were enrolled from the field catchment area of the Urban Health and Training Center affiliated to Chirayu Medical College, Bhopal. **Study Duration:** The total duration of the study was 18 months; from 1st January 2021 to 30th June 2022. **Ethical Clearance:** The present study was approved by Institutional Ethical Committee.**Study Outcomes: i.** The blood pressure (systolic and diastolic) of the participants, ii. Relationship of blood pressure with- Anthropometric parameters- weight, height, BMI, waist-to height ratio.

STUDY PROCEDURE

i. **Blood Pressure:** The measurement of blood pressure was carried at the house of the participants in a quite atmosphere, using aneroid based sphygmomanometer (Device -Diamond Dial Deluxe BP apparatus and Littmann classic III stethoscope). The methodological recommendations by American Academy of Pediatrics clinical Practice guidelines for screening of blood pressure in children and adolescents (2017) were followed for measuring and recording blood pressure(35). In case of an elevated BP, two additional readings were taken during the same visit after an interval of 1 hour each. The average value was then calculated for the categorization of participants.

ii. The weight of the participants was taken using a digital weighing machine (manufacturer- Eagle industries). The weight was recorded in Kilograms up to one digit after decimal point.

iii. The waist circumference was measured at the midpoint between the lower border of the rib cage and the iliac crest by using a flexible inch tape.

iv. The height of the participants was measured using a portable stadiometer (Prime Surgical) up to nearest measurement in centimetres using standard procedure.

v. **Sample Size Calculation:** The minimum required sample size for the study was calculated using the prescribed formula for cross-sectional study using the prevalence of 19.8% hypertension among children as reported by Singh N et al., in Bhopal(36,37). The minimum required sample size for this study was estimated to be 308 participants.

PARTICIPANTS RECRUITMENT CRITERIA

INCLUSION CRITERIA

i. Apparently Healthy children aged 6-15 years.

ii. Parents /guardian who consented for their child to participate in the study.

EXCLUSION CRITERIA

i. Children with cardiac disorders, renal disorders, severe anemia, endocrinological disorder or any other diagnosed medical illness.

ii. Children with any acute/chronic illness or on any ongoing medication or history of any chronic medication being taken.

iii. Parents/guardian who did not consent for their child to participate in the study.

SAMPLING METHODOLOGY(38–40)

Simple, random, sampling methodology was used to recruit participants for the present study. The UHTC unit of Chirayu Medical College maintains demographic records of all the families residing in their catchment area.

OBTAINING INFORMED CONSENT

The consent form was given to all the parent(s) /guardian accompanying the children/prospective participants. Thereafter, the contents of the consent form were explained to them in their preferred language. The participant's guardians were explicitly informed that they have the right to withdraw from the study at any point in time.

DATA COLLECTION

All the data were collected in a paper-based proforma.

SOURCE OF DATA

All the data for the present study were collected from the following two sources. The first source was the interview with the child's parents/guardian. The second source of the data was findings of the clinical and anthropometric assessment of child.

STATISTICAL ANALYSIS PLAN

The primary objective was to determine the prevalence of elevated BP and hypertension among the participants. For the continuous data, the author calculated the mean, median, mode, and standard deviation. For discrete data, the author calculated and reported frequency, proportion, and percentage. The comparison of continuous variables was done using a student's t-test. Categorical variables were analysed using chi-square (χ^2) tests. A *P*-value < 0.05 was considered statistically significant(41–43).

FUNDING

The study received no outside funding.

RESULTS

During the field survey for the present study, the principal investigator approached 458 households in the survey area. Of these 458 households, 27 were locked, 28 households refused to participate in the survey, 52 were disqualified from participation after screening them with selection criteria and the remaining 351 children aged 6-15 years were included in the present study. Among the 351 participants included in the present study; 78.6% had normal blood pressure for their age, 11.68% were categorized to have elevated BP and remaining 9.69% children had hypertension (Stage I).

Table 1: Categorization of Blood Pressure among participants (n=351)

Categories	n	%
Normal	276	78.63
Elevated BP	41	11.68
Stage I Hypertension	34	9.69
Stage II Hypertension	0	0.0
Total	351	100.00

There was a linear increase in both systolic and diastolic blood pressure with the increasing age of the children (Table 2). In our study, we observed a spurt in SBP and DBP in both boys and girls between 13-15 years of age. In addition, there was no statistically significant difference between the SBP and DBP among the boys and girls of the same age. In the present study, it was observed that as the age of the participants increased, the prevalence of both elevated BP and hypertension increased. None of the children younger than 10 years of age had hypertension in the present study. In the present study there were 168 girls: 8.3% and 7.7% had elevated BP and hypertension respectively. Similarly, in the present study there were 183 boys; 14.7% and 11.5% children had elevated BP and hypertension respectively. The difference in the distribution of elevated BP and hypertension values among boys and girls was statistically not significant (p=0.416).

Table 2: Age and Gender wise BP categorization of participants (n=351)

Age	Normal		Elevated BP		Stage I HT	
	Boys (n=135)	Girls (n=141)	Boys (n=27)	Girls (n=14)	Boys (n=13)	Girls (n=21)
6	1	**2**	0	0	0	0
7	2	**3**	0	0	0	0
8	2	**2**	0	0	0	0
9	5	**6**	0	0	0	0
10	6	**6**	0	0	2	0
11	20	**24**	1	**1**	3	**1**
12	13	**15**	5	**2**	2	**1**
13	23	**24**	5	**2**	4	**3**

14	40	**34**	6	**4**	3	**2**
15	25	**25**	10	**5**	7	**6**
Total	135	**141**	27	**14**	21	**13**

In our present study, it was observed that as the height increases, mean SBP and DBP also increase proportionally.In the present study, the difference in height for age percentile among the participants with normal BP and hypertension was statistically insignificant (p = 0.082). We observed a linear relationship between the weight of the children and blood pressure in the present study.

Table 3: Height for Age Percentile & BP category (n=351)

	Normal		Elevated BP		Stage I HT	
Percentile	**n**	**%**	**n**	**%**	**n**	**%**
<3	7	**33.3**	4	**19.0**	10	**47.6**
3 to10	10	**47.6**	5	**23.8**	6	**28.6**
11 to 50	10	**55.5**	6	**33.3**	2	**11.1**
51 to 80	125	**89.9**	10	**7.2**	4	**2.9**
81 to 90	94	**85.5**	10	**9.1**	6	**5.5**
>90	30	**71.4**	6	**14.2**	6	**14.2**
P-value = 0.082						

Table 4: BMI and BP categories among participants (n=351)

BMI	**Normal**		**Elevated BP**		**Stage I HT**	
	n	**%**	**n**	**%**	**n**	**%**
Underweight	26	96.30	1	3.70	0	0.00
Normal	235	89.02	19	7.20	10	3.79
Overweight	10	27.03	12	32.43	15	40.54
Obesity	5	21.74	9	39.13	9	39.13
P value< 0.0001						

In the present study, hypertension was more prevalent among obese and overweight children. The difference in the BMI categories among the children with normal BP and elevated BP or hypertension was statistically significant (p< 0.0001).

Table 5: Waist to Height ratio and BP category among participants (n=351)

WHtR	**Normal**		**Elevated BP**		**Stage I HT**	
	n	**%**	**n**	**%**	**n**	**%**
<0.5	260	**90.28**	19	**6.60**	9	**3.13**
0.50-0.60	11	**24.44**	17	**37.78**	17	**37.78**
>0.60	5	**27.78**	5	**27.78**	8	**44.44**
P value = 0.0012						

Out of the 351 children included in the present study, most of them with elevated BP and hypertension had high (>0.5) waist to height ratio. The difference in the waist to height ratio categories among the children with normal BP and elevated BP or hypertension was statistically significant (p = 0.0012).

DISCUSSION

From the elderly to newborn, people from all walks of life and age groups have been impacted by the epidemiological and demographic transition and rapid urbanization(1,2). Non-communicable illnesses are becoming more common every day as the prevalence of communicable diseases among children and young people continues to fall(1,2). The prevalence of high blood pressure and hypertension in children and adolescents has significantly increased as a result of the juvenile obesity pandemic. To determine the factors that influence blood pressure, including biophysical profile, we performed this study with 351 children aged 6-15 years in a community environment.

PREVALENCE OF HYPERTENSION

Among the 351 participants included in the present study; 78.6% had normal blood pressure for their age, 11.68% were categorized to have elevated BP and remaining 9.69% children had hypertension (Stage I). None of the participants in the present study had stage II HT. With this prevalence rate, one out of every five children would require some intervention to control high Blood Pressure, in order to reduce the risks associated with it during childhood and adult life.In a similar study conducted by **Singh N et al.** in Bhopal city, the prevalence of hypertension among adolescents was found to be 15.3 % and the prevalence of prehypertension was 19.8%(37). In

other similar studies, the prevalence of prehypertension and hypertension was reported to be **(3.6%, 7.2%) Vedavathy et al.(2016)**(44), (7.6% HT) **Borah et al.**(45), (12.3%, 5.9%) **Sharma et al.**(46), (6.2%, 7.2%) **Kumar PK et al**.,(47)(14.1% HT) **Zhao W et al.** (48)respectively**.** In systematic review and meta-analysis of data conducted by **Daniel et al.**, (2009)(10), **de Moraes et al.,**(21)**Meena J et al.,**(49) the prevalence of hypertension was reported to be 7.6%, 11.2% and 7% respectively.

Age and Blood Pressure: In the present study, it was concluded that there was a linear increase in both systolic and diastolic BP with the increasing age of the children. All the children that had elevated blood pressure or hypertension in our study were older than 10 years of age. Several authors have also observed and reported a connection between age and blood pressure. They have concluded that an increase in body mass might be the reason for the age-related increase in blood pressure. The literature that is currently available on HT in children indicates that the relationship between age and BP epidemiology is a key factor in both adult and younger populations. Age-related increase in mean systolic and diastolic blood pressure is widely known, and the current study provides more evidence for this trend. **Valiyaparambil AT et al.** reported that the prevalence of hypertension increased with age in both sexes(50).

Gender and Blood Pressure: In the present study there were 168 girls, out of which 8.3% had elevated BP and 7.7% had hypertension. Similarly, out of the 183 boys in the present study; 14.7% and 11.5% of them had elevated BP and hypertension respectively. We did not observe any statistically significant difference in the prevalence of hypertension among boys and girls in our study. **Singh N et al.** reported the prevalence of hypertension and prehypertension to be 14.04% and 19% among boys and 17.3 % and 20.9% among girls respectively(37). In other similar studies conducted by **Chadha et al**(51)(11.9%, 11.4%), **Patel A et al.**(52)(6.8%, 7.0%)(52), **Meena J et al.**(49)(7%, 8%)(49). **Kumar PK et al.**(47) (6.6 %, 7.9%) showed similar prevalence of hypertension in boys and girls respectively. Similar to our studies, **Savitha MR et al.,**(53) **Anand NK & Tandon L et al.**(54)**, and Sharmaetal.**(55)also did not find any predilection for gender and hypertension in their respective studies.

Height and Blood Pressure:Verma M, Chhatwal J, and George SM(56) conducted a study among children in the age group of 5-15 years and reported that systolic as well as diastolic BP increased with age in both sexes. Similar to our study, they also observed that mean SBP and DBP showed a significant linear relationship with increasing height. When height adjustment was made, **Voors et al.** found that the impact of age essentially disappeared, indicating that the correlation between age and blood pressure is a function of height and a component of biologic maturation(57).

BMI and Blood Pressure: In the current study, children and adolescents who were overweight or obese based on the BMI categorization, had a greater prevalence of elevated BP and hypertension than their peers who were of normal weight. Among 264 children with normal BMI, the prevalence of normal BP, elevated BP and HT was 89%, 7.2%, and 3.9%, respectively. Among 23 obese children, the prevalence of normal BP, elevated BP and HT was 21%, 39%, and 39%, respectively. A higher prevalence of hypertension among overweight and obese children and adolescent have been reported by several authors who measured the blood pressure values among children and adolescent. For example, **Maldonado and colleagues**(58)**,Verma M et al.**(56)**, Meena J et al.**(49)**,Kumar PK et al.**(59)**, Valiyaparambil AT et al.**(50)**,Zhao W et al.**(48)**,Bhuvaneshwari M et al.**(60)**, Ma J et al.**(61)**, Rosa et al.**(62)**, Ribeiro et al.**(63)**, He Q et al.**(64)**, and Sacheil et al.**(65)also reported that prevalence of hypertension was significantly higher in overweight and obese group when compared to children with normal BMI.

Waist to Height Ratio (WHtR) and Blood Pressure: A newer parameter for measuring the adiposity among children is waist to height ratio. Among healthy children this ratio is < 0.5. In the present study, 13.3% of all participants had high WHtR. **Mishra PE** reported that in their study 13.9% children had high WHtR(66). In the present study, 65.5% with elevated BP and 82.2% with hypertension had high (>0.5) waist to height ratio ($p = 0.0012$)(66). Similar findings were also reported by **Verma M et al.**(56), **Chen TL et al.**(67), and Zhou **B et al**(68)**.**

Taken as a whole, the disparity between the prevalence of hypertension seen in our study and other studies of similar nature could be attributed to the heterogeneity in a number of factors, such as the different sampling strategy, blood pressure measurement methodology, regional variations, and varied cut-off criteria used to diagnose hypertension. Other explanations include inherent disparities among the study participants, such as age, gender, and physical activity levels, given that socioeconomic and cultural inequalities exist between various cities and states.

STRENGTHS OF STUDY

In this study, we used the recently updated AAP Clinical Practice guidelines for screening of high blood pressure in children and adolescent published in the year 2017. Three blood pressure measurements were taken at predetermined intervals and the participants were divided into groups based on the mean of the three SBP and DBP measurements. In our community based study, we assessed children's blood pressure in a neighbourhood near or surrounding their homes. According to some recommendations, when

blood pressure is taken in a school context, several factors may have an impact on the children and hence, community studies are preferred over school-based settings for the evaluation of children's blood pressure.

LIMITATIONS OF THE STUDY

In the current study, we only assessed blood pressure in urban children living in the institute's Urban Health and Training Center's catchment region. According to the existing body of research, studies in urban areas of India showed a greater prevalence of hypertension than those conducted in rural areas, which may be related to the sedentary lifestyles of urban participants. We classified BP as normal, elevated BP, or hypertension based on the average of three BP reading taken on a single day. Multiple studies have shown that repeated measurements on different occasions lead to a reduction in proportion of hypertensive patients.

CONCLUSION

In the current study, one in five children, or about 20% of the children, had blood pressure readings that were unusually high for their age. The systolic and diastolic blood pressure increased linearly with age, weight and height in both sexes.There was a linear increase in the prevalence of hypertension with age of the children.The prevalence of elevated blood pressure and hypertension was not significantly different among boys and girls.The difference in height-for-age percentile among the participants with hypertension and normal BP was statistically insignificant. Elevated blood pressure and hypertension were significantly more common among the overweight and obese children. Children with a high waist-to-height ratio were more likely to have high blood pressure and hypertension.

RECOMMENDATIONS

In light of the startingly high prevalence of elevated BP and hypertension observed among children (one in five children) in the current study, the author is of the opinion that blood pressure of children should be measured on a compulsory basis by a paediatrician at every chance that presents itself. Annual health check up by a paediatrician should be mandatory in all schools to detect high blood pressure in children at the earliest. Obesity, family history of hypertension, diabetes mellitus and IHD are risk factors for childhood hypertension, and such kids should particularly be monitored regularly. Findings of our study suggest a need for larger population-based studies to accurately estimate the prevalence and risk factors for hypertension among children in our country.

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