

Original Article

## The relationship between body mass index and blood pressure: A study among school going children of Rajasthan, India

Sukhmani Kaur<sup>1</sup>, Shivangi Chandel<sup>2</sup>, Shivani Chandel<sup>1</sup>

<sup>1</sup>Department of Anthropology, University of Delhi, Delhi, <sup>2</sup>Jindal School of Government and Public Policy, O. P. Jindal Global University, Sonapat, Haryana, India.

**\*Corresponding author:**

Dr. Shivani Chandel  
Assistant Professor,  
Department of Anthropology,  
University of Delhi,  
Delhi-110007, India

vs.shivani@gmail.com

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### ABSTRACT

**Objectives:** Hypertension has become common in children and generally remains undiagnosed and untreated. The present study aims to find the prevalence of high blood pressure (BP) and examines the relationship between body mass index (BMI) and BP among school going children.

**Materials and Methods:** A cross-sectional study was conducted among 240 school going children aged between 10 years and 17 years of Udaipur district of Rajasthan. Data were collected using interview schedules and somatometric measurements were taken based on standardized protocols established by the International Society for the Advancement of Kinanthropometry. Data were analyzed using Statistical Package for the Social Sciences software version 20. Hypertension is considered when BP (systolic BP [SBP] and/or diastolic BP [DBP]) level is  $\geq 95^{\text{th}}$  percentile for height, age, and sex according to the Fourth Report on the Diagnosis, Evaluation, and Treatment of High BP in Children and Adolescents (2004).

**Results:** It was found that 49% children were underweight, 3% were overweight, and 2% were obese. Hypertension was seen in 39 (16.2%) children (5.4% systolic hypertension, 5.8% diastolic hypertension, and 5% both systolic and diastolic hypertension). Children who were overweight/obese were more likely to have hypertension than those who were normal or underweight.

**Conclusion:** The findings of the present study indicate that BMI is a crucial factor affecting BP levels. Simple measurements of body weight and height to determine BMI as a routine assessment in schools would help in controlling BP levels in children that might cause adulthood morbidity and mortality due to hypertension.

**Keywords:** Blood pressure, Body mass index, Hypertension, Prevalence, Children

### INTRODUCTION

Elevated blood pressure (BP) in children is considered as an important predecessor of adult hypertension.<sup>[1]</sup> 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 19.4%.<sup>[2]</sup> 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.<sup>[3-5]</sup> 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.

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On the other hand, physical changes include growth spurt in height and weight, permanent tooth eruption, and development of secondary sexual characteristics.<sup>[6]</sup> Moreover, it was found that BP varies with age and is closely related to height and weight of a child.<sup>[7]</sup> Similarly, growth patterns and sex of an individual strongly influence BP levels among children and adolescents.<sup>[8]</sup> There are some studies which have shown positive correlation between body mass index (BMI) and BP.<sup>[9-11]</sup> 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.<sup>[12,13]</sup>

High BP either systolic or diastolic at any age is one of the risk factors for cardiovascular diseases.<sup>[14]</sup> The previous studies have stated that systolic BP (SBP) elevation in childhood predicts arterial stiffness in young adults.<sup>[15,16]</sup> On the other hand, diastolic BP (DBP) is important in monitoring BP in younger individuals.<sup>[17]</sup> Earlier studies done among children and adolescents have shown high burden of hypertension in younger age groups as well.<sup>[11,18]</sup> 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.<sup>[7]</sup> 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 10–17 years. The study also examines the relationship between BMI and BP.

## MATERIALS AND METHODS

A cross-sectional study was carried out among 240 boys belonging to Dangi community of Udaipur, Rajasthan. The sample size was calculated based on the prevalence of hypertension in children of Western India as 6.48%.<sup>[19]</sup> The following formula given by Daniel, 1999, was used to calculate sample size.<sup>[20]</sup>

$$n = Z^2 P(1-P)/d^2 \quad (1)$$

Where,  $n$  = sample size,  $Z$  = Z statistic for a level of confidence (for the level of confidence of 95%, which is conventional, Z value is 1.96),  $P$  = expected prevalence or proportion (in proportion of one; if 6.48%,  $P = 0.06$ ), and  $d$  = precision (in proportion of one; if 5%,  $d = 0.05$ ).

$n = (1.96)^2 \times 0.06 (1-0.06)/(0.05)^2 = 87$  (After substituting all the values).

To get more accurate and significant results, a sample size, that is,  $n = 240$  was considered in the present study. An informed consent was obtained from the parents or the guardians of the participants. Children who were apparently

healthy belonging to the age group of 10–17 years were included in the study. Children with any chronic or acute illness and those who were on long-term medications were excluded from the study.

General information such as educational level, occupation and income of the parents, family size, and dietary preference was collected using an interview schedule. Height was measured in centimeters (cm) using an anthropometric rod (Galaxy, India) and body weight was measured in kilograms (kg) using weighing scale (Krupps, India). Both of these measurements were taken according to standardized protocols established by the International Society for the Advancement of Kinanthropometry.<sup>[21]</sup> BMI was calculated as weight in kg divided by height in square meters ( $m^2$ ). The reference data used to identify the cutoff points were taken from the Centers for Disease Control and Prevention (CDC) 2000 dataset for BMI as per the guidelines of the Fourth Report on the Diagnosis, Evaluation, and Treatment of High BP in Children and Adolescents.<sup>[3,22]</sup> Children who had BMI for age percentile  $<5^{th}$  were regarded as underweight,  $5^{th}$ – $<85^{th}$  percentile as of normal healthy weight,  $85^{th}$ – $<95^{th}$  as of overweight, and  $\geq 95^{th}$  percentile as obese.<sup>[22]</sup>

BP was measured in a sitting posture with the hands resting on the examining table with the cubital fossa supported at the level of the heart after providing a rest of 5–10 min.<sup>[3]</sup> For each participant, it was measured thrice at an interval of 5 min each and mean of these three readings was used for statistical analysis. It was assured that each participant has not taken coffee, tea, water, or any kind of food item in last half an hour before measuring BP. Omron HEM-7080 digital BP monitor validated by Association for the Advancement of Medical Instrumentation and British Hypertension Society after calibration was used to measure BP using an appropriate size cuff.<sup>[23]</sup> This study was approved by the Ethical Committee of the Department of Anthropology, University of Delhi, Delhi, India (Ref. No./2016/15).

## Classification of BP

Polynomial regression models were considered to estimate BP percentiles for arbitrary sex, age, and height as per guidelines given by the Fourth Report on the Diagnosis, Evaluation, and Treatment of High BP in Children and Adolescents (2004).<sup>[3]</sup> The model used was a fourth degree polynomial model to predict adjusted BP as a function of age and height Z-score. First, observed height was converted into height Z-score using CDC growth charts.<sup>[22]</sup> After obtaining height Z-score values, regression coefficients were obtained using regression equations. These obtained coefficients values were then used in the formulae provided by the guidelines to calculate expected SBP or DBP.<sup>[3]</sup> From expected SBP or DBP, SBP or DBP Z-scores were calculated. These obtained SBP or DBP Z-scores were then converted to corresponding SBP or

DBP percentiles. Further, individuals were classified into the following categories:

1. Normal (SBP and DBP < 90<sup>th</sup> percentile),
2. Pre hypertension (SBP or DBP  $\geq$  90<sup>th</sup> percentile to <95<sup>th</sup> percentile),
3. Hypertension ( $\geq$ 95<sup>th</sup> percentile)

### Statistical analysis

All the statistical analyses were carried out using MS-Excel 2010 and Statistical Package for the Social Sciences software version 20. Kolmogorov–Smirnov normality test was performed for all the variables and they were found to be normally distributed. Basic descriptive statistics (mean and standard deviation) were calculated for weight, height, BMI, SBP and DBP for all age groups. Odds ratios (ORs) with 95% confidence intervals (CI) were calculated.  $P < 0.05$  was considered to be statistically significant.

## RESULTS

The distribution of somatometric variables (weight, height, and BMI) showed a steady increase with age from 10 years onward to 17 years [Table 1]. The distribution of individuals into different categories of BMI revealed that 46% of the children had normal weight, 49% were underweight, 3% were overweight, and 2% were obese [Figure 1].

The age-wise mean SBP, DBP, and percentile values were calculated from 50<sup>th</sup> percentile to 95<sup>th</sup> percentile [Table 2]. The mean values of SBP and DBP showed an overall increasing trend across age groups. Regression coefficients using polynomial regression models were obtained [Table 3].

The overall prevalence of hypertension (BP  $\geq$ 95<sup>th</sup> percentile) was found to be 16.2% among the studied population. It was found that 13 (5.4%) children had systolic hypertension, 14 (5.8%) diastolic hypertension, and 12 (5%) both systolic and diastolic hypertension [Table 4].

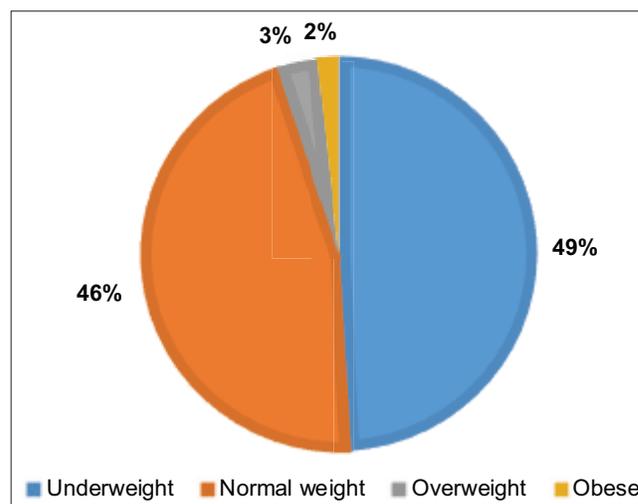
The distribution of individuals with different types of hypertension (systolic, diastolic, and both systolic and

diastolic) was seen with respect to their BMI statuses [Table 5]. It was found that BMI was a significant determinant of hypertension. OR analysis revealed that children who were overweight/obese were more likely to have hypertension, whether systolic hypertension (OR - 2.39; CI - 0.43–13.0), diastolic hypertension (OR - 1.54; CI - 0.16–14.0), or both systolic and diastolic hypertension (OR - 1.34; CI - 0.14–12.1); however, the finding was not statistically significant ( $P > 0.05$ ).

Moreover, it was found that among the children with normal weight, 8.2% had systolic hypertension, followed by both systolic and diastolic hypertension (7.2%), and diastolic hypertension (6.4%). Similarly, in case of overweight or obese children, 16.7% had systolic hypertension, followed by diastolic hypertension (8.3%), and both systolic and diastolic hypertension (8.3%) [Table 5].

## DISCUSSION

The results of the study revealed that the majority of the population that is 49.16% falls under the underweight category. The prevalence of overweight/obese individuals is 5%. However, in the studied population, the overall prevalence of hypertension is found to be 16.2% (5.4% systolic hypertension, 5.8% diastolic hypertension, and 5% both systolic and diastolic). The prevalence of hypertension in our study is similar to that reported previously by Thangjam *et al.* in 2017. It showed 15.3% high prevalence of hypertension among the school going children aged 5–15 years of Manipur.<sup>[18]</sup> Similar to this, another study from Imphal showed 15.7% prevalence of hypertension among students of higher secondary.<sup>[24]</sup> In contrast to this, many other studies done in different regions showed the prevalence of hypertension in the school going children to be in the range of 3–10%.<sup>[11,19,25-28]</sup> One of the study showed that the



**Figure 1:** Distribution of body mass index categories among the studied population.

Age (years)	n	Weight (kg) Mean $\pm$ SD	Height (cm) Mean $\pm$ SD	BMI (kg/m <sup>2</sup> ) Mean $\pm$ SD
10+	30	27.87 $\pm$ 6.27	136.40 $\pm$ 6.90	14.82 $\pm$ 2.53
11+	30	35.17 $\pm$ 8.78	146.23 $\pm$ 8.13	16.34 $\pm$ 3.36
12+	30	35.63 $\pm$ 8.14	148.03 $\pm$ 6.49	16.10 $\pm$ 2.60
13+	30	38.50 $\pm$ 7.24	153.57 $\pm$ 8.50	16.22 $\pm$ 2.30
14+	30	41.33 $\pm$ 8.02	158.10 $\pm$ 7.32	16.45 $\pm$ 2.43
15+	30	44.83 $\pm$ 9.88	161.83 $\pm$ 8.40	16.95 $\pm$ 2.73
16+	30	48.03 $\pm$ 7.98	168.00 $\pm$ 8.14	16.93 $\pm$ 1.99
17+	30	49.47 $\pm$ 6.60	169.30 $\pm$ 5.75	17.22 $\pm$ 1.96

**Table 2:** Age-specific distribution of mean blood pressure, and percentiles of SBP and DBP among boys of Dangi community.

Age (years)	SBP (mmHg) (mean±SD)	SBP, percentile			DBP (mmHg) (mean±SD)	DBP, percentile		
		50 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>		50 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>
10+	101.1±10.7	100	113	127	67.9±9.0	66	83	90
11+	106.1±11.9	103	122	132	70.7±8.4	72	83	86
12+	102.5±9.3	103	115	120	68.6±9.3	67	82	90
13+	108.6±13.0	109	125	135	71.1±10.6	70	81	98
14+	113.3±11.0	114	128	131	73.5±8.0	75	85	89
15+	109.8±13.2	109	131	138	70.7±10.0	70	85	92
16+	117.3±14.3	117	137	142	75.5±9.6	75	88	97
17+	114.5±9.9	113	127	136	71.7±8.4	70	86	87

SBP: Systolic blood pressure, DBP: Diastolic blood pressure

**Table 3:** Regression coefficients from blood pressure regression models.

Variable name	Symbol	Systolic BP (mmHg)	Diastolic BP (mmHg)
Intercept	$\alpha$	113.166	72.895
Age			
Age-14	$\beta_1$	3.788	1.864
(Age-14) <sup>2</sup>	$\beta_2$	-0.365	0.016
(Age-14) <sup>3</sup>	$\beta_3$	-0.156	-0.140
(Age-14) <sup>4</sup>	$\beta_4$	0.002	-0.024
Normalized height*			
Zht	$\gamma_1$	2.093	0.504
Zht <sup>2</sup>	$\gamma_2$	-0.235	-0.197
Zht <sup>3</sup>	$\gamma_3$	0.357	0.242
Zht <sup>4</sup>	$\gamma_4$	0.054	0.037
SD	$\delta$	11.343	9.152

\*Height Z score relative to age and sex calculated by taking corresponding reference data from CDC growth charts. BP: Blood pressure

**Table 4:** Prevalence of hypertension among the studied population.

Hypertension	Number of cases (n)	%
Systolic	13	5.4
Diastolic	14	5.8
Both systolic and diastolic	12	5.0

prevalence of hypertension among South Asian children was substantially greater than 5% predicted prevalence of high BP in children in the United States based on the same criteria despite of their lower BMI values.<sup>[29]</sup> It is interesting to note that hypertension which is generally observed among overweight and obese individuals was also found among normal and underweight individuals of the present study.

Moreover, in the present study, it is found that children who are overweight/obese were nearly 2 times more likely to have hypertension compared to children who are having normal weight or underweight. Studies done in India and

also in various other countries had similar findings to the present study.<sup>[18,30-33]</sup> One of the studies done by Jena *et al.* proposed that greater BMI in adolescence is associated with elevated BP.<sup>[13]</sup> Another study by Sorof and Daniels found that obese children are at a three-fold higher risk for developing hypertension than non-obese children.<sup>[34]</sup> Similarly, Charan *et al.* found a significant rise of hypertension among obese participants whether boys or girls, thus, concluded that obesity plays an important role in development of hypertension during childhood.<sup>[19]</sup> The reason behind this could be supported with the fact that in obesity, abnormal renal tubular dysfunction occurs in which tubular reabsorption of sodium is increased which, in turn, increases the extracellular fluid volume, blood volume, and thus, the BP. Another mechanism responsible for causing high BP in overweight and obese children is the activation of the sympathetic nervous system and renin-angiotensin-aldosterone system.<sup>[35]</sup>

In review of the literature, there have been some studies that have shown that BP in children could be affected by various factors such as cultural, environmental, social, and genetic components, also the levels of BP varies with age, sex, and during growth and development period of an individual.<sup>[36,37]</sup> One of the studies done among adolescents of New Delhi found lifestyle associated risk factors such as low physical activity, alcohol consumption, smoking, and inappropriate dietary practices (such as more fast food consumption and low fruit consumption) to be associated with high prevalence of obesity and hypertension.<sup>[38]</sup>

### Limitations of the study

The present study has some limitations. First, this was a cross-sectional study and only boys were included in the study. A larger group of children comprising both boys and girls is more appropriate for the evaluation of prevalence of hypertension. Second, there is a lack of information on factors such as dietary habits of the children, their physical activity status, genetics, and family history of hypertension, in the present study, which are risk factors associated with

**Table 5:** Distribution of individuals with hypertension with respect to body mass index status.

BMI	Normal blood pressure n (%)	Systolic HTN n (%)	Diastolic HTN n (%)	Both systolic and diastolic HTN n (%)	OR (C.I.), P-value
Normal	86 (78.2)	09 (8.2)	07 (6.4)	08 (7.2)	Referent
Underweight	107 (90.7)	02 (1.7)	06 (5.1)	03 (2.5)	OR1=0.20 (0.03–0.84), 0.03 <sup>†</sup> OR2=0.69 (0.22–2.12), 0.51 OR3=0.30 (0.07–1.17), 0.08 <sup>*</sup>
Overweight/Obese	08 (66.7)	02 (16.7)	01 (8.3)	01 (8.3)	OR1=2.39 (0.43–13.0), 0.31 OR2=1.54 (0.16–14.0), 0.7 OR3=1.34 (0.14–12.1), 0.7

OR and 95% CI were calculated after adjusting for age, HTN: Hypertension, OR: Odds ratios, CI: confidence intervals. <sup>†</sup>Referent versus OR1 – Systolic HTN, OR2 – Diastolic HTN, OR3 – Both systolic and diastolic HTN. \*P-value significant level at  $\leq 0.05$ ; <sup>†</sup>suggestive P-value significant level at  $\leq 0.09$

obesity and high BP. These can be taken up by future research studies. Nevertheless, our study is the first population based study done among children of Dangi community of Western India that has contributed towards the understanding of association between BMI and BP.

### Practical application

Findings of the present study suggest that each and every child whether having normal weight, underweight, overweight or obesity should be screened clinically for his/her BP status. As, any rise in BP during this growing stage can increase the risk of hypertension in their adulthood. Health education in schools should be provided to look seriously into the growing burden of chronic diseases in our society so that preventive measures can be taken up at the grass root level by providing information related to lifestyle modifications.

### CONCLUSION

The findings of the present study indicate that BMI is a crucial factor affecting BP levels. The study highlights the importance of screening children at younger age so that prevention of high BP can be done.

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### Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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### Conflicts of interest

There are no conflicts of interest.

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