RESEARCH PAPER

Blood Pressure-to-Height Ratio as a Screening Tool for Hypertension in Children

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Objective: To test whether blood pressure-to-height ratio (BPHR) can be used to screen for hypertension in children.

Methods: Data regarding blood pressure and other variables was recorded for 2702 school children between the ages of 10-16 years as a part of a nutritional survey.

Results: The optimal thresholds for defining hypertension in boys were 0.76 for systolic BPHR and 0.50 for diastolic BPHR; the respective threshold in girls were 0.80 and 0.52.

Conclusion: BPHR can be used as an effective screening test for diagnosing both hypertension and prehypertension in children aged 10-16 years.

Keywords: *Adolescent, Diagnosis, Prehypertension, Schoolchildren*.

Hypertension has a prevalence of less than 1% in children but is seen in 30% children with BMI more than the 95th centile [1,2]. Hypertension in children can cause increased carotid medial and intimal thickness as well as left ventricular hypertrophy [3-5]. Blood pressure-to-height ratio (BPHR) has been proposed as a useful screening test for estimation of high blood pressure in children [6-11]. The aim of this study was to confirm whether BPHR can be used as a screening test for diagnosing hypertension in Indian children.

Methods

The study was conducted using data collected during a nutritional survey on schoolchildren aged 10-16 years in Kashmir. Thirty percent of the districts were randomly selected for the study; 2 tehsils were randomly selected from each district, out of which 25% of schools were randomly selected. Consent for this study was taken from the school heads as well as from the parents.

Children with known medical conditions or drug use causing dyslipidemia, diabetes or hypertension (*e.g.* chronic renal diseases, steroid use, chronic pancreatic disease) were excluded from the study.

Weight was measured in the upright position to the nearest 0.1 kg using a calibrated electronic balance. Height was measured without shoes to the nearest 0.1 cm using a calibrated portable stadiometer. Blood pressure was measured in the right arm, with the individual in a sitting position and at rest for at least 5 min, using standardized mercury sphygmomanometers and appropriate-sized cuff. Following indexes were computed by using the equations: SBPHR = SBP (mmHg)/height (cm) and DBPHR = DBP (mmHg)/ height (cm).

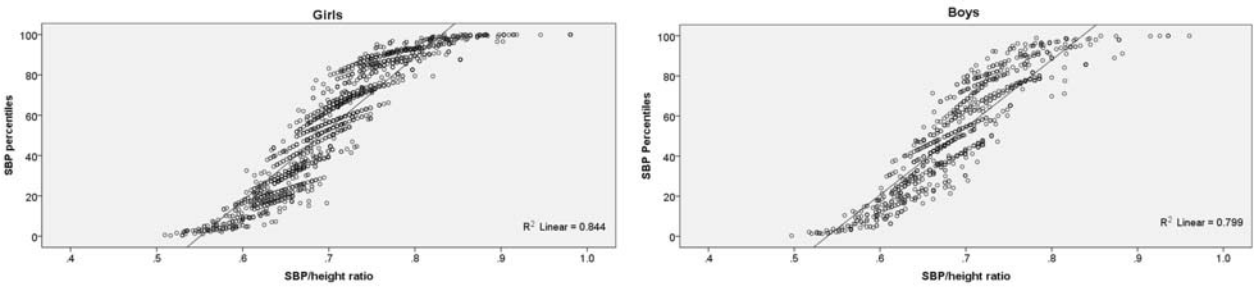
Hypertension was defined as SBP/DBP ≥95th percentile. Prehypertension was defined as SBP/DBP ≥90th but ≤95th percentile or SBP/DBP ≥120/80 mm Hg [12,13].

Statistical analysis: Data were analyzed using SPSS version 19.0. Receiver-operating characteristic (ROC) curve analyses were performed to calculate sensitivity and specificity of SBP/height and DBP/height ratios [14]. Correlation analysis was performed between SBP percentile and SBP-height ratio and for DBP percentiles and DBP-height ratio.

Results

There were 2702 (247 boys) children with 7.9% boys and 9.9% girls having hypertension. Prehypertension was present in 18.3% boys and 17.8% of girls. SBP-height ratio correlated strongly with SBP percentiles both in boys (r^2=0.799, P<0.001) and girls (r^2=0.844, P<0.001) (***Fig.* 1**). Similar results were obtained with DBP-height ratios and DBP percentiles.

ROC analysis showed a very steep progression of sensitivity and specificity above cutoff values. The



(a) *(b)*

FIG. 1 *Correlation of systolic blood pressure (SBP)/height ratio with SBP percentile in (a) girls and (b) boys.*

optimal SBPHR cut-offs for diagnosing systolic hypertension were ≥0.76 in boys and ≥0.80 in girls; the cut-offs of DBPHR for diastolic hypertension were ≥0.50 for boys and ≥0.52 for girls. The ROC values for the accuracy of both SBPHR and DBPHR in diagnosing hypertension in both sexes ranged from 0.82-0.87 and 0.89-0.94, respectively (***Table* I**). The optimal cut-offs of SBPHR for diagnosing systolic prehypertension were ≥ 0.75 in boys and ≥0.76 in girls; the values of DBPHR for diastolic prehypertension were ≥0.47 for boys and ≥0.48 for girls (***Table* I**).

There was a negative correlation between SBPHR and age (r = -0.188), weight (r = -0.081) and a positive correlation with BMI (r = +0.143). Similarly a negative correlation was seen between DBPHR and age (r = -0.158), weight (r = -0.074) and a positive correlation with BMI (r = +0.131).

DISCUSSION

Our study showed that BPHR is an accurate method of screening for hypertension and prehypertension in children aged 10-16 years.

BPHR is strongly and positively associated with systolic and diastolic blood pressure, but is not dependent on height or age, as shown in our study. The inverse correlation between SBPHR, DBPHR and height implies that the overall effect of height on both these indices is nil and neither tall subjects are misclassified as hypertensives nor short subjects are misclassified as normotensives. Similarly the inverse correlation between SBPHR and DBPHR with age and weight imply that both these factors have no effect on these indices. The high Negative predictive value of 99.6 and 100 of cut-offs in our study shows that children with hypertension and prehypertension are unlikely to be missed by these cut offs. However, the Positive predictive value (PPV) are low (29-85) suggesting that some children with normal BP may be classified as prehypertensives or hypertensives, suggesting that BPHR is just a screening method and cannot replace existing nomograms for diagnosing or classifying severity of hypertension. PPV is directly proportional to the prevalence of disease. As prevalence of hypertension is low in children, therefore PPV remained low in our study as in other studies [8-11].

Similar to our findings, Galescu, *et al*. [9] reported BPHR cutoff of 0.75/0.46 and 0.75/0.48 for diagnosing systolic and diastolic pre hypertension in US boys and girls, respectively. There were very few patients with blood pressure more than 95th centile to get optimal thresholds for hypertension. Ejike, *et al*. [8] found a BPHR cutoff of 0.75/0.51 and 0.77/0.50 for diagnosing hypertension in Nigerian boys and girls, respectively, with sensitivity and specificity ranging from 0.98-1.00. The slight differences in cut-offs as compared to our study could be because of genetic or racial factors.

TABLE I OPTIMAL THRESHOLDS OF SYSTOLIC AND DIASTOLIC BLOOD PRESSURE-TO-HEIGHT RATIO (BPHR) AND PRE-HYPERTENSION IN CHILDREN AGED 10-16 YEARS

	Hypertension						*Prehypertension*					
Gender Specific Value	*Threshold*	*Sensitivity*	*Specificity*	*PPV*	*NPV*	*AUC*	*Threshold*	*Sensitivity*	*Specificity*	*PPV*	*NPV*	*AUC*
SBPHR(Boys)	0.76	100	88.3	28.4	100	0.84	0.75	92.1	84.4	19.8	99.6	0.92
SBPHR(Girls)	0.80	94	95.7	60.6	99.6	0.84	0.76	96.6	83.9	30.2	99.7	0.90
DBPHR(Boys)	0.50	91.2	0.7	38.5	9.4	0 .92	0.47	82.3	71.9	40.9	94.5	0.94
DBPHR(Girls)	0.52	99.2	93.9	54.6	99.9	0 .90	0.48	96.6	85.2	59.1	99.1	0.91

WHAT THIS STUDY ADDS?

- The study provides thresholds of systolic and diastolic blood pressure-to-height ratio for screening of hypertension and pre-hypertension in Indian children aged 10-16 years.

The strength of our study is that it is the first study in the Indian subcontinent independent of the economic condition of the parents and both the rural and urban areas were equally selected to rule out screening bias. The limitations of our study are that it only included children in the age group of 10-16 years and more studies enrolling children in all age groups are needed to corroborate the results.

In conclusion, our study demonstrated a strong correlation between BPHR with blood pressure centiles in both boys and girls This suggests that BPHR can be used as an effective screening test for diagnosing hypertension and prehypertension in the study population. As India is a large country with diverse ethnicities, more studies from different parts of the country are needed to corroborate the results before recommendations for widespread use of this modality can be reliably made.

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