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"AGE AND HEIGHT SPECIFIC NORMATIVE REFERENCE LIMITS OF BLOOD PRESSURE IN SCHOOL GOING CHILDREN IN INDIAN POPULATION"

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Abstract:

Introduction: Early detection of Hypertension requires normative reference limits of blood pressure for children. Present study was planned to determine age & height specific normative reference limits of blood pressure, since nationally representative reference data of blood pressure for Indian children is not available.

Methods: An observational descriptive cross-sectional study was conducted in randomly selected 2138 healthy school children of age 7 to 14 years from government and private schools. Anthropometric measurements were done using standard protocol. After 10mins of rest to child, blood pressure readings were obtained by the investigator of the project by a validated automated devise as per the international guide lines laid down by the Task force.

Results: 50th to 95th percentile values of systolic blood pressure (SBP) & diastolic blood pressure (DBP) with respect to age and height was derived in both sexes using polynomial regression model. It was found that percentile values of both SBP & DBP increases significantly with age and height percentile in both sexes. On comparing the cut off values of our population with the existing international values provided by the Task force report, it was found that our local values were on lower side.

Conclusion: Findings of the present study indicates that there is a need to develop local reference data of BP for Indian population.

Key Words: Blood Pressure, Percentiles, Reference Limits, Indian children

INTRODUCTION:

Hypertension at early period of life is nowadays a major public health problem leading to screening of BP in children for early detection of hypertension and prevention of adult cardiovascular complications[1,2,3] Though screening for high BP in children and adolescent has been recommended since the publication of task force report in 1977, but because of the belief that childhood hypertension is rare and uncommon phenomenon, little attention was given to BP measurement in routine pediatric clinical examination[4] Earlier reports on Blood pressure tracking studies revealed that BP estimates in early age predicts blood pressure in the adult life and there is correlation between blood pressure levels of childhood and adulthood[5] These studies further suggest that hypertension in adulthood often has its origin in childhood[1] and therefore childhood blood pressure is best predictor of hypertension in adult life[6].

Taking these into consideration the fourth report of Task force on National high blood pressure programme (NHBPEP) in 2004, provided the normative reference limits of the blood pressure.[7]

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Since the existing reference values of blood pressure in children were derived from US population, the applicability of these values to other population became limited in terms of environmental & genetic cultural, social class & race, nutrition & diet and ethnic factors along with growth and maturation of the child [8,9,10] However height was observed to be the most important determinant of BP in terms of dynamicity of growth in children, thus, prompting the development of own cutoff limits of BP in some countries[11,12]. Therefore in the light of the aforesaid review which indicates a geographic variation in reference norms of childhood BP, there is a need to develop normative reference limits of BP for Indian children.

MATERIAL AND METHODS:

A cross sectional observational study was carried out in randomly selected private and government schools of Indore district of Madhya Pradesh. The study sample consisted 2158 (1038 boys & 1120 girls) healthy children of age 7 to 14 years.

Informed written consent was obtained following norms applicable to minors prior to the aforesaid screening and recording of all subsequent parameters. Initially medical screening was done in the children and healthy ones with no known or observed disorders related to cardiovascular system were included in the study.

Age was taken from school record and rounded to the completed years. Anthropometric measurements where taken by the investigator. Weight and height of the child was recorded in with a portable weighing machine and stadiometer to the nearest one kilogram and one centimeter respectively using standardized protocol[13].

Body Mass Index (BMI) of the child was calculated and those children having BMI>95th percentile for their age and sex were considered obese and were eliminated from the study[14]. In addition, anxious and stressed children were also excluded from the study (total exclusions = 322).

Before blood pressure measurement, children were called in the examination room and the procedure was explained to them giving sufficient time to allay anxiety and fear. After five minutes of rest, blood pressure was recorded using standard protocol[7] by the investigator without wearing white coat to avoid white coat hypertension[15]. All the recordings were made between 9:30AM to 11:30AM to avoid diurnal variations in blood pressure [16].

Validated Automated Oscillometric device (Nissei WS-1) with standard cuff was used for BP recording as recommended by various childhood epidemiological studies including the Task Force[7,17,18]. The device measure BP automatically and the software of the device calculates SBP and DBP as a function of mean arterial pressure and the results were displayed on digital display.

Use of automatic oscillometric device eliminates the need to detect korotkoff sounds which are difficult to hear in children particularly in noisy environment, also removes controversy of choosing between phases K-IV and K-V for DBP[19]. In addition it also removes the chances of observer bias and terminal digit preference[20] and seems to get better cooperation from children[21].

The accuracy of the recording device was checked prior to the study in a pilot study.

STATISTICAL ANALYSIS:

All the analysis was done on SPSS-11.0 Statistical software.

Age specific height percentiles of 1803 school children were calculated and it was converted into Z height scores. Regression of blood pressure on height was done in each age group in both the sexes. 50^{th}, 90^{th}, 95^{th} and 99^{th} percentiles of SBP and DBP at different ages and height percentile were derived using regression equations[7].

RESULTS:

Analysis of the data of 1836 (Boys 893, Girls 943) healthy school children was done, after eliminating obese children (n=322) in order to get normal reference population to derive blood pressure reference limits and to avoid influence of excess weight on blood pressure distribution.

Table (1) represents the descriptive data of the school children in which maximum children were in the age group 12 years (n= 369) with minimum number of children in the age group 10 years (n= 129). The mean height of boys rose from 124 ± 6.11 at 7 years to 160 ± 7.84 at 88 14 years. Similarly in girls it rose from 119.14 ± 7.26 at 7 years to 155.33 ± 7.51 at 14 years of age. Mean Body Mass Index (BMI) in boys is 13.2 ± 1.59 at 7 years while at 14 years it is 15.5 ± 2.2. Similarly in girls the values of BMI are 12.63 ± 1.33 at 7 years to 14.97 at 14 years.

The mean value of SBP and DBP in boys at 7 years is 99.4 ± 7.46 and 64.7 ± 6.33 whereas at 14 years the corresponding values are 112 ± 7.69 and 64.7 ± 6.92 mm Hg. Similarly these values in girls at 7 years were 94.68 ± 8.57 & 61.87 ± 7.82 mm Hg. whereas at 14 years the values were 112 ± 8.03 and 69 ± 6.46 mm Hg. respectively and 61.85 mm Hg. In the age group 7 years whereas at 14 years the values are 112.27 mm Hg. and 69.01 mm Hg, respectively.

Height percentile values were calculated from 5^{th} to 95^{th} percentile for each age group in both sexes are shown in Table (2)

Regression coefficient from Polynomial regression model were derived in the reference sample to calculate 50^{th} to 99^{th} percentile values of SBP and DBP according to age height in both saxes. The age and Z-height scores and some of their powers where strong predictors of SBP and DBP for both boys and girls the findings were presented in the Table (3). The intercept (α) for SBP was 107.09 mmHg in boys and 106.02 mmHg in girls the corresponding values for DBP was 66.24mmHg and 67.44mmHg respectively.

The regression coefficient for various powers of age (β_1, β_2, β_3 and β_4) in case of SBP for boys were -0.71, -0.28, -0.01 and -0.0161 respectively. The corresponding values in girls were -0.66, -0.54, -0.15 and -0.0569. Similarly the values (β_1, β_2, β_3 and β_4) of DBP for boys were 0.14, -0.18, -0.038, and -0.0143 respectively. The corresponding values for girls were -1.53, -0.39, -0.23 and -0.054 respectively. The regression coefficients for varies powers of Z height score (γ_1, γ_2, γ_3, and γ_4) for SBP in boys were 7.84, -0.05, 0.290 and -0.0122 respectively. The corresponding values for girls were 7.22, -0.61, -0.37 and 0.0216 respectively. The values (γ_1, γ_2, γ_3, and γ_4) for DBP in boys were 1.60, -0.45, -0.092 and 0.0016 respectively. The corresponding values for girls were 1.42, -0.91, -0.134 and 0.010.

OBSERVATIONS & RESULTS:

Table-1 Descriptive data of the school children .

Age (Yrs)	Number of Cases (n)		Weight		Height		Body mass Index (BMI)		Systolic Blood Pressure (SBP)		Diastolic Blood Pressure (DBP)	
			Mean ± S.D.		Mean ± S.D.		Mean ± S.D.		Mean ± S.D.		Mean ± S.D.	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
7	131	107	21.7	18.02	124	119.14	13.2	12.63	99.4	94.68	64.7	61.85
			(±3.99)	(±3.22)	(±6.11)	(± 7.26)	(±1.59)	(±1.33)	(±7.46)	(±8.57)	(±6.37)	(±7.82)
8	81	79	23.6	21.19	128	125.59	14.1	14.37	100	101.47	64.3	67.42
			(±6.14)	(±3.79)	(±6.71)	(±7.24)	(±2.06)	(±1.82)	(±9.74)	(±9.08)	(±6.92)	(±6.41)
9	101	101	25.2	25.73	132	133.42	15.2	14.83	102	103.07	64.9	68.29
			(±5.71)	(±7.35)	(±7.2)	(±8.80)	(±1.71)	(±1.94)	(±9.53)	(±9.20)	(±6.43)	(±6.49)
10	54	75	29.5	27.39	139	138.24	15.4	15.88	106	103.47	66.5	66.24
			(±6.7)	(±5.84)	(±7.12)	(±8.25)	(±2.03)	(±1.81)	(±9.55)	(±8.41)	(±6.95)	(±6.58)
11	83	110	31.5	34	142	143.95	15.2	15.85	107	106.85	65.6	66.32
			(±8.02)	(±9.42)	(±7.31)	(±7.98)	(±2.08)	(±2.14)	(±9.73)	(±8.36)	(±6.63)	(±6.40)
12	190	179	33.9	37.88	147	147.7	14.4	13.9	107	110.06	65.4	67.59
			(±8.99)	(±8.65)	(±8.36)	(±10.17)	(±1.87)	(±1.76)	(±9.45)	(±8.52)	(±6.27)	(±7.53)
13	156	149	37.2	41.09	152	152.34	14.9	14.39	109	111.43	65.2	68.05
			(±8.62)	(±10.17)	(±7.91)	(±8.55)	(±1.85)	(±1.79)	(±8.92)	(±8.45)	(±6.76)	(±6.61)
14	97	143	40.4	44.53	160	155.33	15.5	14.97	112	112.27	64.7	69.01
			(±6.39)	(±10.57)	(±7.84)	(±7.51)	(±2.21)	(±1.76)	(±7.69)	(±8.03)	(±6.92)	(±6.46)

Table-2: Height Percentiles for Boys & Girls.

Age	Height Percentiles-Boys (in cms).							Height Percentiles-Girls (in cms).						
	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
7	113	116	120	124	128	131	133	107	110	114	118	124	129	132
8	117	120	124	128	133	134	136	113	116	120	126	130	136	138
9	120	123	127	132	136	141	146	121	123	126	132	140	147	150
10	125	130	134	139	144	148	151	127	128	132	138	142	148	152
11	130	133	137	142	148	152	154	129	133	140	145	148	153	155
12	134	136	141	147	152	157	162	132	139	144	149	153	157	160
13	139	142	146	152	157	162	164	134	142	149	153	159	163	165
14	146	152	156	162	166	169	173	143	146	151	156	160	164	169

Table-3 Regression Coefficients from Blood Pressure Regression Models.

Name of Variable	Symbol	S.B.P. (Male)	S.B.P. (Female)	D.B.P. (Male)	D.B.P. (Female)
Intercept	α	107.0962	106.0322	66.24033	67.44693
Age Age-10	β1	-0.71235	-0.66107	-0.14346	-1.5383
(Age-10)^2	β2	-0.28416	0.546447	-0.18488	0.395413
(Age-10)^3	β3	-0.01341	0.154439	-0.0382	0.232077
(Age-10)^4	β4	0.016142	-0.05696	0.014392	-0.05415
Normalized Height zht^{1*}	γ1	7.845314	7.225654	1.606179	1.420481
zht^2	γ2	-0.05373	-0.61017	-0.4578	-0.91588
zht^3	γ3	-0.29089	-0.37413	-0.0921	-0.13427
zht^4	γ4	-0.01228	0.021625	0.001653	0.010097
Standard deviation	σ	8.20325	8.042135	6.5610624	6.831594

The coefficients were obtained from mixed-effects linear regression models.
* Height Z score

Table – 4 BP Levels for BOYS by Age and Height Percentile

BOYS		SBP mmHg							DBP mmHg						
		Height Percentile							Height Percentile						
Age	BP Percentile	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
7	50th	96	99	103	108	114	118	120	64	65	66	67	68	68	68
	90th	107	109	114	119	124	128	130	72	73	74	76	76	77	77
	95th	110	112	117	122	127	131	133	74	75	77	78	79	79	79
8	50th	96	98	102	108	113	117	119	63	64	65	66	67	67	67
	90th	106	109	113	118	123	128	130	71	72	73	75	76	76	76
	95th	109	112	116	121	126	131	133	74	74	76	77	78	78	78
9	50th	96	98	102	108	113	117	119	63	64	65	66	67	67	67
	90th	106	109	113	118	123	127	129	71	72	73	75	76	76	76
	95th	109	111	116	121	126	130	132	74	74	76	77	78	78	78
10	50th	95	98	102	107	112	116	118	63	64	65	66	67	67	67
	90th	106	108	112	118	123	127	129	71	72	73	75	75	76	76
	95th	109	111	115	121	126	130	132	74	74	76	77	78	78	78
11	50th	94	97	101	106	111	115	117	62	63	65	66	67	67	67
	90th	105	107	111	117	122	126	128	71	72	73	74	75	75	75
	95th	108	110	114	120	125	129	131	73	74	75	77	77	78	78
12	50th	93	95	99	105	110	114	116	62	63	64	65	66	66	66
	90th	103	106	110	110	120	124	127	70	71	72	74	74	75	75
	95th	106	109	113	118	123	127	130	72	73	75	76	77	77	77
13	50th	92	94	98	103	109	113	115	61	62	63	64	65	65	65
	90th	102	104	109	114	119	123	125	69	70	71	73	74	74	74
	95th	105	107	112	117	122	126	128	72	72	74	75	76	76	76
14	50th	91	93	98	103	108	112	114	60	61	63	64	65	65	65
	90th	102	104	108	113	119	123	125	69	70	71	72	73	73	73
	95th	105	107	111	116	122	126	128	71	72	73	75	76	76	76

Data constructed from the sample of non-overweight Boys 9n=893)

*** 90th percentile is 1.28SD, 95the percentile is 1.645 SD over mean**

Table – 5 BP Levels for GIRLS by Age and Height Percentile

GIRLS		SBP mmHg							DBP mmHg						
		Height Percentile							Height Percentile						
Age	BP Percentile	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
7	50th	92	95	99	104	109	112	113	54	55	57	58	58	58	57
	90th	103	105	109	114	119	122	123	62	64	65	67	67	67	66
	95th	106	108	112	117	122	125	126	65	66	68	69	70	69	68
8	50th	96	98	102	107	112	115	116	62	63	65	66	67	66	65
	90th	106	108	113	118	122	125	126	71	72	74	75	75	75	74
	95th	109	111	116	121	125	128	129	73	74	76	77	78	77	77
9	50th	95	98	102	107	112	115	116	64	65	67	68	69	68	67
	90th	106	108	112	117	122	125	126	73	74	76	77	78	77	76
	95th	109	111	115	120	125	128	129	75	76	78	80	80	80	79
10	50th	94	97	101	106	111	114	115	63	64	66	67	68	67	67
	90th	105	107	111	116	121	124	125	72	73	75	76	77	76	75
	95th	108	110	114	119	124	127	128	74	76	77	79	79	79	78
11	50th	94	97	101	106	111	114	115	61	63	64	66	66	66	65
	90th	105	107	111	116	121	124	125	70	71	73	74	75	74	74
	95th	107	110	114	119	124	127	128	73	74	76	77	77	77	76
12	50th	96	98	102	107	112	115	116	59	61	62	64	64	64	63
	90th	106	108	112	108	122	125	126	68	69	71	73	73	73	72
	95th	109	111	115	120	125	128	129	71	72	74	75	75	75	74
13	50th	97	99	103	109	113	116	117	57	58	60	61	62	61	60
	90th	107	109	114	119	123	126	128	66	67	69	70	70	70	69
	95th	110	112	117	122	126	129	130	68	69	71	72	73	72	72
14	50th	96	98	102	107	112	115	116	52	53	55	56	56	56	55
	90th	106	108	113	118	122	125	126	60	62	63	65	65	65	64
	95th	109	111	116	121	125	128	129	63	64	66	67	68	67	66

*Data constructed from the sample of non-overweight Girls (n=943)

* 90th percentile is 1.28SD, 95the percentile is 1.645 SD over mean

For interpreting the blood pressure of a child first height percentile has to be determined from the Table (2) and then according to his/her height percentile the corresponding BP percentile value can be estimated from the Table (4&5). Blood pressure is taken as normal if it is < 90th percentile, Pre-hypertension is between 90th to 95th percentile and Hypertension if the value > 95th percentile for age and sex as suggested by the Task force.

DISCUSSION:

Since adulthood hypertension is a result of tracking of childhood blood pressure values[22] thus early identification of a hypertensive state in childhood may be beneficial to reduce the burden of adulthood hypertension. Keeping this in mind the present study aimed to formulate age and height specific percentile values of blood pressure for local children.

The data analysis of 1836 healthy school children was done and in order to get normal reference population for deriving normative cut off limits of BP, obese(BMI >95th percentile) and anxious children were excluded from the

study. This was done to get normal reference population for deriving BP distribution and to avoid influence of anxiety and excess weight on Blood pressure distribution, since BP in childhood is strongly correlated with BMI as reported by various studies [23,24].

Predicted percentile values of BP according to the height of the child in each age group and in both sexes were derived using regression model and presented in Table (4&5) as per the standard protocol recommended by the task force. The advantage of using PR is that, although the distribution of height varies greatly with age but the distribution of height Z score does not. This is helpful to estimate BP percentiles as a function of age and across wide range of height Percentiles[25].

percentiles as a function of age and across wide range of height Percentiles[25].

As evident from the table, BP percentile values increased with age in both sexes in a non linear manner. Significant increase of SBP & DBP values were observed with height. A significant increase in BP from 50th to 95th percentile values was observed between the tallest and shortest individuals which indicates that apart from age and sex of the child which are well known determinants of blood pressure levels, height played an important role in determining the BP value of a child as reported in various other studies[25,26]

In the past several attempts were made by various authors [13,23] to derive reference values for Indian children but while formulating the cut-off limits of BP , except for few studies,[14,26,27.] majority of them did not took height of the child into consideration.

In order to get a precise classification of blood pressure according to the stature of the child, and to eliminate chances of misclassifying a very tall child for his age as hypertensive, height of the child should not be ignored while formulating the reference values since BP has been found to be critically dependent on height of children as per the current and earlier studies[2,3,14,26.]

It is evident from the Tables (4 & 5) that an increasing trend in SBP and DBP percentile can be seen by age and height for both sexes but with exceptions in certain age groups. Mean blood pressure gradually increase with age, with few exceptions where percentile value is lower in particular age group than the previous age group with corresponding height percentiles.

percentiles. In these situations it is recommended by the task force that higher percentile values are to be used to avoid under reporting of the values of blood pressure

On comparing the mean values of BP in boys and girls it was found that values for females were on higher side Similar were the findings of other studies[25,26]. Some of the studies[14] reported a spurt in the blood pressure levels at the pre-pubertal and pubertal age group particularly in the females. Since in present study we did not get such phenomenon, but our findings are in accordance with findings of studies carried on Indian children[26].

It is difficult to compare the findings of the present study with the findings of various Indian studies and the US task force because of the difference in the demographic profile of the study sample, methodology adopted, age group studied, instrument used etc.

However a different pattern of blood pressure distribution

was found when findings of the present study were compared with the existing international reference of Task force, as explained below.

SBP & DBP cut off limits of the present study were on lower side as compared with the international reference values of Task force. Findings of various studies from India[13,26] Jordan, Pakistan, Iran[23,26,27,28] also noted differences with US norms but their SBP & DBP values were on higher side in comparison to the US data.

The reported variance from US norms in various studies may be due to the differences in the population group studied, large data base (>70,000) used by the task force which was from several states of USA, the methodology adopted, differences in growth pattern of children in USA which was evident from their height percentile values. Apart from these it also reflects that BP cut off limits also depends upon multiple factors, both genetic and environmental but it is often difficult to find which factor is responsible the most.[8,9,10.]

Apart from these it also reflects that BP cut off limits also depends upon multiple factors, both genetic and environmental but it is often difficult to find which factor is responsible the most.[8,9,10.]

Since essential hypertension is a major risk factor for cardio vascular diseases in all age group and both sexes[6,8.] .Various tracking studies in children have identified elevated blood pressure in children is an important precursor of hypertension in adult[4,5,18.] and because of reported variation in blood pressure according to the racial ethnic and socioeconomic differences in the population across the world, separate norms of blood pressure for developing countries like India are required where growth and development of child is affected by malnutrition and infectious diseases affecting the height percentiles. Therefore US height percentile based blood pressure values may not be appropriate to our population because these values were on higher side as is evident from the findings of the present study. If we apply them on our population this may result into under diagnosis of the problem of childhood hypertension which may resulting into increased disease load of adulthood hypertension.

In order to get the local reference values for assessing the BP, more such kind of studies from different parts of the country are required that will determine the influence of diverse socio economic, cultural and nutritional factors on the blood pressure of our population.

In the present study we tried to overcome some of the limitations which were commonly observed in various surveys on school children.

An Oscillometric device was used by us which helped to overcome the controversies in BP recording like selecting between K-IV or K-V stages for DBP, problem of terminal digit preference and inter-observer variations which was reported by various other studies.[4,5,25.]

Further, throughout the study period we tried to measure blood pressure on a fix time of a day and avoided measurements during extreme climatic conditions because BP is affected by many factors and which are difficult to control like time of recording, season, fasting / non fasting state of child, place of recording, type of instrument used etc. In addition in order to get proper characterization of BP the recordings should be done on ≥

≥ 3 different visits. This was not the case in present study as BP was recorded only at a single visit without any follow-up of the subjects. Considering the available resources and time it was difficult to do follow-up of the subjects included in the study , some of the large school surveys in the west and in our country also took readings of BP on a single visit [17,18,29].

To establish reference values of BP beyond local population a large sample size is required from various parts of the country, keeping in view the regional variations. Thus similar studies should be undertaken in other regions to develop normal reference limits for Indian children which would be helpful in routine pediatric examination facilitating the diagnosis of essential hypertension in children.

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