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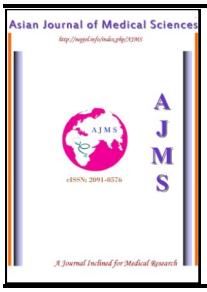

Normal Blood Pressure and Different Factors Affecting it among Healthy School-Children

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Abstract

Objective: To find out the normal range of blood pressure among school-children (aged 5-15 years) and the relationship of blood pressure with variables such as age and weight.

Material & Methods: This is a school-based prospective cross-sectional study. Healthy school-children aged 5-15 years from primary and secondary schools in Kolkata were selected for the study. The individuals with any acute or chronic illnesses or the intersexes were excluded. Their age, weight, blood pressure and socioeconomic status were determined.

Results: Blood pressure (both systolic and diastolic) showed almost upward linear relationship with age and weight in both boys and girls in the age group of 5-15 years. At 15 years, girls achieved higher blood pressure than boys did. The present study also showed that girls recorded higher blood pressure than boys in the weight range of 41-45 kg (For all "*r*" values, $p < 0.05$).

Conclusion: Blood pressure in children rises with age as well as with weight. Girls achieve higher blood pressure than boys do at the age of 15 years.

Key Words: *School-children; Blood pressure; Diastolic blood pressure; Systolic blood pressure; Age; Weight; Socioeconomic status*

1. Introduction

Hypertension is a very common problem in adults and is an important risk factor for ischemic heart disease, cerebrovascular accident and renal failure. Normal blood pressure range and cut-off values for adults are well standardized. Hypertension in adults has its origin in childhood and effective control of high blood pressure can control these complications.[1] There are few studies to delineate the normal distribution of blood pressure in children in India. The first age related norms were developed by a Task Force of National Heart Lung and Blood Institution in 1977 and have been revised to account for differences based on sex and height, most recently in 1996.[2] To find out the normal range of blood pressure among school-children (aged 5-15 years) and different factors affecting it, we carried out this study in and around Kolkata school-children.

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2. Material and Methods

2.1. Subject

This study was carried out among school-children of different standards in the age group of 5-15 years in and around Kolkata between October 2009 and March 2010. Initially 10250 school-children were registered for the study. One hundred eighty nine students were excluded from the study due to illnesses and/or refusal to participate in the study. Total 9961 children were recruited of which 6360 were boys and 3301 were girls. Institutional Ethical Committee clearance from our institution and permission from the school authorities of the schools involved in the study were obtained.

2.2. Determination the main characteristics of subjects

The whole process was explained to all students in each class in each school. Their name, age, sex, weight, height, and socioeconomic status were recorded. Standard techniques were used to measure weight and height. The helpings of parents and teachers were

sought for calculating the right age and socioeconomic status of the children where needed. Only the healthy children in the age group of 5-15 years were included in the study.

2.3. Measuring the blood pressure

Students were called in separate room/ or hall and allowed to wait for 30 minutes to relieve their restlessness and anxiety. Each child was then called one by one and blood pressure was measured in the sitting posture in the right upper arm using standard blood pressure measuring cuffs of different sizes for different age groups. Three readings were recorded at the gap of five minutes and mean of the three readings was the measured blood pressure value for both systolic and diastolic blood pressure.

As recommended by the American Heart Association, systolic and diastolic blood pressures (SBP and DBP) were taken to correspond to the appearance and muffling of Korrotkov sounds (phase I and phase IV respectively). This method provides reliable readings within 4 mmHg of intra-arterial values.[3] Muffling gives slightly higher and complete disappearance gives slightly lower than the actual diastolic pressure. Former is the preferred method.[4] Same and standard mercury type of blood pressure instrument was used throughout the study period and was checked periodically for any loss of mercury height, any leak in the tubing or the control valves. Blood pressure cuff with width of 7 and 9 cms were used depending on which cuff approximated 2/3rd of the upper arm length of the child. Length of the bladder was at least 12 cms.[5,6]

Thorough history including family history of hypertension, myocardial infarction, obesity and cerebrovascular accident were recorded. Clinical examination was done in detail. Modified Kuppuswamy's scale of socioeconomic status was used to assess the socioeconomic status of the students in the study group.[7]

2.4. Statistical analysis

Standard statistical package (SPSS Version 10) was used. Results were expressed as mean with standard deviation with range as required. Correlation coefficients of the data were recorded and corresponding "*p*" values were calculated ('*p*' for the '*r*'). *P* <0.05 was considered significant.

3. Results

Total 9661 children of different schools and different grades were studied of which 6360(65.83%) were boys and 3301(34.17%) were girls [Table 1].

Table-1: Sex distribution of children in different age groups

Age	Male	%	Female	%
5	585	9.19%	333	10.08%
6	525	8.25	280	8.48%
7	635	1.57%	254	7.69%
8	615	9.66%	216	6.54%
9	570	8.96%	218	6.60%
10	500	7.86%	280	8.48%
11	700	11%	285	8.63%
12	600	9.43%	260	7.87%
13	580	9.11%	325	9.84%
14	625	9.82%	400	12.11%
15	425	6.68%	450	1.36%
Total	6360	65.83%	3301	34.17%

Table-2: Systolic and diastolic blood pressure in girls with mean, standard deviation and range

Age	Sys-tolic M	Sys-tolic SD	Systolic +/- 2SD	Dia-stolic M	Dia-stolic SD	Diastolic +/- 2SD
5	96.62	9.9	116.42-76.82	61	9.25	79.5-42.5
6	96.00	8.8	112-78.8	61.6	9.75	81.1-42.1
7	96.42	9.6	115.62-77.22	62.4	8.25	78.9-45.9
8	98.2	9.7	117.6-78.8	62.8	9.15	81.1-44.5
9	98.6	9.1	116.8-80.4	63.8	7.1	78-49.6
10	100.4	8.5	117.4-83.4	66.2	6.6	79.4-53.0
11	105.00	8.6	122.2-87.8	68.2	7.1	82.4-54
12	106.00	8.8	127.8-88.8	71.3	7.2	85.5-57.1
13	110.2	8.1	126.4-94	72	7.4	86.8-57.2
14	116.6	10.2	137-96.2	75	6.8	88.6-61.4
15	120.86	9.4	139.66-102.6	77	6.9	90.8-63.2

Mean SBP at 5 years was 96.62 mm Hg for girls and 98.2 mm Hg for boys while the corresponding values at 15 years were 120.86 mm Hg for girls and 118 mm Hg for boys [Table 2 & 3]. Boys started with higher mean systolic pressure (MSP) and mean diastolic pressure (MDP), girls crossed them at the age of 11 years. Ultimate MSP and MDP at 15 were higher in girls [Table 4]. Rate of rise of MSP between boys and girls showed that there was persistent rise of blood pressure from year to year except for 5-6 years range. During 10-15 years period, total rise of MSP in girls (20.46 mmHg) was higher than that of boys (15.58 mm Hg). In both sexes, the peak rise of MSP was at the 13-14 years-age period. MDP like MSP also started at a higher value in boys at 5 years than girls but ultimate value at 15 years were higher in girls than in boys. There was steady rise of MDP with age in both sexes except in boys between 6-7 years range. Maximum rise of MDP in boys was in the age range of 12-13 years while the same was in 13-14 in girls [Table 5].

Table-3: Systolic and diastolic blood pressure in boys with mean, standard deviation and range

Age	Systolic M	Sys-tolic SD	Systolic +/- 2SD	Dia-stolic M	Dia-stolic SD	Diastolic +/- 2SD
5	98.2	9.2	116.6-79.8	63	6.1	75.2-50.8
6	97.5	8.6	114.7-80.3	62	6.3	74.6-49.4
7	97.8	8.9	115.3-80	61.62	7.1	76.7-47.42
8	98.1	8.1	114.3-81.9	62.5	8.2	78.9-46.1
9	101.89	8.9	119.69-83.62	65	9.2	83.8-46.6
10	102.42	9.1	120.62-84.22	66.9	7.2	80.9-52.5
11	102.52	9.4	121.32-83.72	68	8.6	85.2-50.8
12	106.42	9.9	126.02-86.62	72.01	8.8	89.6-54.8
13	107.22	10.2	127.22-86.82	75.22	7.2	89.62-60.82
14	116	9.9	135.8-96.2	75.42	7.2	89.82-61.02
15	118	9.8	137.6-98.4	76.62	8.6	93.82-59.42

Table-4: Comparison of MSP and MDP between two sexes in different age groups

Age	MSP Boys	MSP Girls	MDP Boys	MDP Girls
5	98.2	96.62	63	61
6	97.5	96.00	62	61.6
7	97.8	96.42	61.62	62.4
8	98.1	98.2	62.5	62.8
9	101.89	98.6	65	63.8
10	102.42	100.4	66.9	66.2
11	102.52	105.00	68	68.2
12	106.42	106.00	72.01	71.3
13	107.22	110.2	75.22	72
14	116	116.6	75.42	75
15	118	120.86	76.62	77

Table-5: Rate of rise of MSP and MDP in boys and girls in different age groups (in mm Hg)

Age Groups (Years)	Rate Of Rise MSP (Boys)	Rate Of Rise MSP (Girls)	Rate Of Rise MDP (Boys)	Rate Of Rise MDP (Girls)
5-6	-0.7	-0.62	1	0.60
6-7	0.3	0.42	-0.38	0.80
7-8	0.3	1.82	0.88	0.40
8-9	3.79	0.40	2.50	1.00
9-10	0.53	1.80	1.90	2.4
10-11	0.10	4.60	1.10	2
11-12	3.90	1.00	2.01	3.1
12-13	0.80	4.20	3.21	0.70
13-14	8.78	6.40	0.20	3
14-15	2.00	4.26	1.20	2

MSP= mean systolic pressure, MDP= mean diastolic pressure

Table-6: MSP and MDP in boys and girls in different weight groups (in kg)

Weight Range (Kg)	MSP (mm Hg) Boys	MSP (mm Hg) Girls	MDP(mm Hg) Boys	MDP (mm Hg) Girls
15-20	96.4	96	61	62
21-25	103	102	64	66
26-30	105	104	66	68
31-35	114	112	74	76
36-40	115.6	116	76	82
41-45	116	117.4	84	86

Children were divided into several groups of 5 kg starting from 15 kg to 45 kg and MSP and MDP were recorded in these weight groups. It was seen that advancement of weight and blood pressure followed a linear relationship [Table 6]. Out of total 9661 children evaluated, only 222 children had blood pressure > + 2 standard deviation (SD) for their respective age and sex. There was family h/o obesity in 32, hypertension in 52 and cerebrovascular accident in 18 cases. 19 children themselves were obese. Majority of children with high BP (> +2SD) belonged to class II or class III groups after scoring using modified Kuppuswamy's scale.

Statistical analysis revealed that correlation coefficient of systolic blood pressure with age was 0.78 and 0.93 for boys and girls, respectively. Corresponding values for diastolic blood pressure were 0.85 for boys and 0.71 for girls. For all "r" values, *p* was <0.05 and in some cases, it was p <0.001. Therefore, the results were statistically significant. Similarly for different weight groups, "*p*" value was <0.05.

4. Discussion

In the present study MSP increased from 98.2 mmHg in boys and 96.62 mmHg in girls at 5 years of age to 118 in boys and 120.86 mmHg in girls at 15 years of age. The rate of change of MSP in both sexes was persistently upward except during 5-6 years period when there was actually fall of MSP in both boys (0.7 mmHg) and girls (0.62 mmHg). In both sexes, maximum rise was at 13-14 years of age. Total rise of blood pressure during 10-15 years of age was 20.86 mm Hg for girls and 15.58 mmHg for boys enabling the girls to achieve higher blood pressure than boys at 15 years of age. Like MSP, MDP also had a higher start in boys than girls did at 5 years of age but at 15 year-girls overtook the boys. Maximum rise of MDP in boys and girls was at 12-13 and 13-14 years respectively.

Increments of SBP and DBP along with age had been reported in different cross-sectional studies.[8-15] Similar findings had also been reported among Indian children.[16, 17]

Data analyzing the various works demonstrated that MSP and MDP in boys at 5 years of age were 94 mmHg and 55 mmHg[18], 101 mmHg and 60 mmHg[19], 102 and 62 mmHg[20], 97.97 and 62.96 mmHg[1], 105.62 mmHg and 67.1 mmHg[21]. Corresponding data from various workers for girls at 5 years of age were 121 mmHg and 61 mmHg[5], 102 mmHg and 60 mmHg[7], 100 mmHg and 61 mmHg[20]. MSP in girls at 5 years in this study was 96.62 mm Hg which was less while MDP was either same or less in comparison.

MSP in boys at 5 years in our study was slightly lower except the results shown by Graham, Hines & Gaje[18] and Gupta & Ahmed.[1] MDP for the same group was higher except the result shown by Agarwal, et al.[21] In addition, Luepker, et al.[22] reported that blood pressure normally increases with growth and development.

It has also been seen that SBP and DBP are higher in boys than girls at all age groups, but the total increment in SBP and DBP from age group 6+ to 14+ is more among girls than boys.[16]

When the results of 15 years age group were studied from various researches, it was seen that MSP and MDP in boys were mmHg 121 and 61 mmHg[18], 125 mmHg and 67 mmHg[19], 113 mmHg and 67 mmHg[25], 117.24 mmHg and 76.95 mmHg[1], 116.51 mmHg and 77.02 mmHg[21]. MSP in different age groups in boys in our study was higher than the finding of some researchers[1,21] and lower than that of others.[18,19,23] However, the differences in our study were not significant.

For MDP in boys, some[21,1,23] workers had shown values which were close to us whereas other researchers[18-20] had results with different values. For girls, MSP and MDP in our study were different from the result of other worker.[19]

Year to year increment of blood pressure of the boys and girls in our study were different from the values of various cross-sectional studies,[24,25] where they had shown an increment of 1.2 to 1.7 mmHg for systolic and 1.0 mmHg for diastolic blood pressure.

Spurt in blood pressure during childhood had been variously reported. We found that girls had maximum rise between 13 and 14 years of age for both systolic and diastolic pressure, but for boys it was between 12 and 13 years of age for systolic and 13 and 14 years of age for diastolic blood pressure. Agarwal, et al.[21] noted a spurt in SP between 4 and 5 years of age and between 12 and 13 years of age for both sexes. Londe[19] noted the spurt in SP between 14 and 15 years of age for both sexes, between 5 and 6 years of age in boys and between 4 and 5 years of age in girls. The others researchers[26, 27] noted only one spurt between 5 and 6 years in both sexes. At age 12+, a spurt of about 6.1 mmHg and 4.9 mmHg in SBP had been observed in boys and girls, respectively. However, there is no such spurt in DBP.[28] Laroia[5] and Gupta & Ahmed[1] also observed a spurt in SBP between 13 and 15 years of age , but the Task Force Committee Report in 1987 found spurt in SBP between 5 and 6 years of age in both sexes.

Many authors noted differences in blood pressure between two sexes. The values of SBP and DBP were slightly lower among girls than boys, but the differences were not found statistically significant in most of the age groups except for the difference between the SBP at age 7+.[16] This is consistent with the findings of other workers.[9,10,20]

The differences in patterns of increase in blood pressure between males and females are probably related to certain biological and psychosocial factors. The appearance of secondary sex characters together with the menarche is associated with a high level of anxiety resulting in higher SBP values in girls. However, there are no appreciable differences in the level of the BP of children, aged 5-14 years, between the two sexes revealed by some authors.[3,16,29]

Londe[19] observed the difference at 11 years (7 mmHg higher in girls) and 15 years (10 mmHg higher in boys). In our study, boys had a higher start but ultimate achievements were higher in girls at 15 years observed similarly by Gupta & Ahmad.[1] Agarwal, et al.[21] also had the same finding except that MDP in girls at 15 years were less than boys.

It was found that increment in height and weight had a significant positive relationship with SBP and DBP.[24] Voors, et al reported that blood pressure was correlated more closely to height and body mass than age.[29] Verma et al have also reported an increase in SBP and DBP with age in Indian children.[30]

In our study, there was almost linear relationship between weight range and blood pressure (both systolic and diastolic) , also recorded by other workers.[21] The present study showed girls recorded higher blood pressure than boys in the weight range of 41-45 kg.

Statistical analysis revealed that association of MSP and MDP in both sexes with age and weight was significant ($p<0.05$).

This study was conducted among a section of urban school-children and other important variables like height, obesity and socioeconomic status were not included in the main objectives of the study. These are important limitations of this study and the present study failed to make a broad-based conclusion.

To make a broad-based opinion regarding normal blood pressure in children and the variables affecting it,

similar study on larger number of children involving both urban and rural schools taking into account height, obesity and socio-economic status along with age and weight should be undertaken.

5. Conclusion

We conclude that blood pressure in children increases as age and weight advance. Though boys start with higher blood pressure at the age of five years, girls achieve higher blood pressure at the age of 15 years.

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