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Original Research Article

Study of blood pressure profile and correlation of hypertension with age, sex, anthropometric measurements (weight, height, body mass index), socio economic status and hereditary factors in school going children

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ABSTRACT

Background: Pre hypertension in childhood is a precursor of hypertension in adulthood. Weight, height and body mass index (BMI) can be taken as surrogate marker of prevalence of hypertension and hence measurement of these parameters can help in early detection of children at risk of hypertension. The present study was done to determine the correlation of hypertension with age, gender, anthropometric measurements, socioeconomic status, and hereditary factors and to estimate the prevalence of hypertension and pre hypertension.
Methods: It is an observational study involving 1009 healthy urban school children of 5 to 15 years of age. Height and weight were taken according to standard techniques (Jelliffee 1966). In order to exclude age as a confounding factor; BMI was plotted on percentile charts.
Results: There was a linear increase of mean blood pressure with increasing age, height and weight. The mean systolic and diastolic blood pressures of children with BMI 85th to 95th percentile (overweight group) and with BMI ≥95th percentile (obese group) were higher than the lower BMI groups. The children belonging to high socio economic status (class I) and those with family history of hypertension were having higher mean values of systolic and diastolic blood pressure. Equal number of children belonged to pre hypertension (65) and hypertension (67) category.
Conclusions: The mean systolic and diagnostic blood pressure was equal in both sexes. Children with overweight/obesity, family history of hypertension and class I socioeconomic status had increased mean values of systolic and diastolic blood pressure. Prevalence of high blood pressure was 13.1% (pre hypertension: 6.44% and hypertension: 6.64%).

Keywords: BMI, Hypertension, School children, Systolic blood pressure

INTRODUCTION

Blood pressure measurement in pediatric practice is an important component of clinical examination but it is commonly ignored in routine office practice by many of the busy pediatric practioners as it consumes considerable time and also possibly because of non-availability of blood pressure nomograms for the children in the community. Since available data of blood pressure in Indian children is scanty, cutoff values of 'high blood pressure' for local community are to be determined to the satisfaction of the researchers in the field. Hence, early identification of hypertension cases specifically those falling into pre hypertension category (90-95th percentile of BP for age) are largely missed. Prevailing number of cases that are diagnosed and declared as hypertension are

small in number which indicate the just tip of ice berg as it was documented that almost 75% hypertension cases and 90% of pre-hypertension cases are undiagnosed.[1] Evidence suggests that pre hypertension in childhood is a precursor of hypertension in adulthood and it is associated with cardiovascular morbidity.[2] Children in the upper percentiles of blood pressure are more likely to become hypertensive in adulthood. If the trend towards hypertension can be recognized early in childhood, it may be possible to adopt lifestyle modifications by the individuals early in the life to prevent development of systemic hypertension and its complications in later life.[3] The data on blood pressure profile in Indian school children is inadequate and few available studies also showed varied patterns.[4-9] Evidence suggests that anthropometric measurements such as weight, height and BMI can be taken as surrogate marker of prevalence of hypertension. Hence measurement of these parameters can help in early detection of children at risk of hypertension. Therefore, the present study was taken up to know the distribution pattern of blood pressure in apparently healthy school children, to determine the correlation of hypertension with age, gender, anthropometric measurements, socioeconomic status, hereditary factors and to estimate the prevalence of hypertension and Pre hypertension in school going children.

METHODS

The present study was conducted in the Department of Pediatrics, Gandhi Medical College, Secunderabad, Telangana, India. It is a prospective observational study involving 1009 apparently healthy children 5 to 15 years age attending various urban schools at Hyderabad city. Children suffering with acute illness, anemia, cardiac, renal or other systemic disorders and those having history of chronic illness were excluded from the study. As part of the study, school authorities were detailed about the importance and objectives of the study. The information was collected by questionnaire-cum-interview methods from children/parents and schedule was design and pre-tested. A copy of the questionnaire was given to all the subjects in the study group with a request to fill it up by their parents and collected the data regarding their socioeconomic status, food habits, present and past medical history, family history of hypertension etc. Height and weight were taken according to standard techniques (Jelliffee 1966) using the same equipment for all the subjects to ensure uniformity and accuracy. BMI for boys and girls was calculated by using formula BMI = weight (kg)/height^2 (meters) according to WHO. Blood pressure measurements were recorded with a standard mercury sphygmomanometer using appropriate sized cuff with the subjects in sitting posture. Blood pressure was recorded three times for each child and the mean was taken as the representative value. In children in whom higher blood pressure was observed, measurement was repeated after taking rest for one hour to alleviate possible anxiety and fear. Systolic and diastolic values of blood pressure were correlated with various factors like age, sex, height, weight, BMI, family history of hypertension and socio-economic status. For statistical analysis IBM SPSS software for windows, Version 16 was used. Chi square test was done for statistical significance. In all instances, a P value of <0.05 was considered statistically significant. Data analysis was done using ANOVA. Charts were prepared from Microsoft Excel 2007 Version.

RESULTS

Out of 1009 children in the study, 549 (54%) were boys and 460 (46%) were girls. Except in 5 years, 7 years and 9 years age group the distribution of males and females were almost equal in each age group (Figure1). The mean systolic blood pressure in boys at 5years is 88.3 mm of Hg and at 15 years is 110 mm of Hg. In this study there is linear increase of mean blood pressure with increasing age. The mean systolic blood pressure in girls at 5 years is 85.0 mm of Hg and at 15 years, 104.3 mm of Hg. There is linear increase of blood pressure with age except at 9 and 10 years. The mean diastolic blood pressure in boys at 5 years is 57.6 mm of Hg and at 15 years 69.9 mm of Hg. There is increase in diastolic BP from 5 to 7 years and again at 14 to 15 years but not much increase from 7-13 years. The mean diastolic blood pressure in girls at 5 years is 56.4 mm of Hg and at 15 years 66.3 mm of Hg. There is a linear increase in diastolic BP with age except at 7 and 8 years where it is disproportionately higher. There is no significant difference of blood pressure (systolic as well as diastolic) between males and females in most of the age groups except at the age of 9 years. Based on the height, the subjects were divided into 8 groups with 10 cm intervals independent of age and weight. It is observed that as the height of the group increased, there is a linear increase of mean systolic and diastolic blood pressures of the group with a steep rise in >170 cm height group. According to weight, students were arranged into 6 groups with a difference of 10 kg between each group, independent of age and height. It is observed that with increase of weight, there is a linear increase of mean systolic and diastolic blood pressures in both boys and girls. In order to exclude age as a confounding factor, BMI was plotted on percentile charts to correlate the percentiles with blood pressure.37 BMI between 85th -95th percentiles was taken as overweight and more than 95th percentile taken as obesity. Based on BMI of subjects, students were categorized into four groups (those with BMI < 5th percentile, between 5th and <85 percentile, 85th and <95 percentile and those $\geq$ 95 percentile). The mean SBP and DBP of the overweight group (BMI 85th to 95th percentile) and obese group (BMI $\geq$95th percentile) was higher than other BMI groups.37 Out of the 1009 children, 73 children had family history of hypertension. The individuals with family history of hypertension has a mean SBP and DBP of 103.3 and 66.0 mm of Hg respectively, which is higher than those without family history. Using modified Kuppuswamy's socio economic scale students were

grouped into five classes (I, II, III, IV, V).It was observed that the mean SBP and DBP in high socio economic status (class I) were 101.6 and 64.9 mm of Hg as compared to SBP of 94.3 mm of Hg and DBP of 59.7 mm of Hg in low socio economic group (class V).Blood pressure values equal to and above 90th percentile was considered as pre hypertensive and values ≥95th percentile was taken as hypertensive. Out of 1009 subjects, 67(6.64%) were falling under hypertension category and 65 (6.44%) were falling under pre hypertension category. Out of total 549 boys, 32 (5.8%) were pre hypertensive and 38 (6.9%) were having hypertension. Out 460 girls, 33 (7.2%) were pre hypertensive and 29 (6.3%) were having hypertension. It was observed that both boys and girls contributed almost equally to total number of pre hypertension cases. In boys higher prevalence was seen in age groups of 6years and 10 years, where as in girls higher prevalence was seen in the age groups of 5, 6 and 10 years. Hypertension was seen predominantly in males (male versus female 38:29). Age wise prevalence of hypertension is high in 9, 13, 14, 15 years age group. Higher percentage in 9 years age group can be attributed to low numbers in the age group and higher values in 13, 14, and 15 can be attributed to hormonal changes that occur at that age.

Table 1: Systolic blood pressure (SBP) percentiles/mean for boys and girls.

Systolic blood pressure percentiles										
Age (years)	Boys					Girls				
	Mean±Sd	50th	90th	95th	99th	Mean±Sd	50th	90th	95th	99th
5	88.3±7.2	90	98.8	100	105.12	85.0±6.6	85	90	97.6	99.58
6	91.2±7.4	90	100	106	111.4	90.5±9.1	90	100	110.8	116.08
7	93.3±7.9	90	101.2	108.8	113.6	93.7±7.8	92	100.6	107.3	114.12
8	94.5±6.4	92	102	103.1	108.26	96.1±8.4	95	106.4	110	111.42
9	98.5±7.4	97	110	112	112	92.6±6.0	90	98.8	103.5	108.7
10	94.1±5.5	92	102	103.5	105.48	94.8±5.2	94	102	102	103.46
11	98.7±11.2	96	112	120	132.4	97.8±8.0	98	110	110.7	115.62
12	97.7±7.5	98	107.6	111.8	117	101.3±12.1	100	114.4	130	138.6
13	100.3±7.2	100	110	112.9	115.92	101.8±9.6	100	113.8	120	124.3
14	104.9±9.3	106	120	121	122.02	106.5±12.0	104	120	123	144.6
15	110.0±9.9	110	120	130	131	104.3±11.1	104	113.6	130	130

- A linear increase in Systolic blood pressure with increasing age was found in both sexes and this was statistically significant with p <0.001
- No significant difference of Systolic blood pressure between Males and Females in most of the age groups.

Table 2: diastolic blood pressure (DBP) percentiles/mean for boys and girls.

Systolic blood pressure percentiles										
Age (years)	Boys					Girls				
	Mean	50th	90th	95th	99th	Mean	50th	90th	95th	99th
5	57.6±8.1	60	64.8	66.4	73.12	56.4±7.1	60	60	61.9	63.58
6	59.3±9.7	60	70	73	77.4	60.5±7.5	60	68	71.6	78.08
7	64.6±6.2	66	70	70	77.44	64.8±6.5	66	70	70	75.3
8	63.3±4.3	63	68	68	69.42	65.2±5.1	64	70.2	74.2	76
9	64.3±7.1	64	72	75	77.5	60.6±5.6	60	66.8	68.7	69.74
10	63.5±5.9	62	70	71.4	77.92	62.5±5.3	64	68.6	71.3	72
11	63.8±8.2	64	74.8	78.4	82.4	62.9±6.0	62	70	72	76.6
12	62.8±6.5	64	70	70	74.34	64.8±7.2	64	72	80	84.3
13	62.9±6.2	62	70	72	74.94	65.1±8.3	66	73.8	80	80
14	65.8±6.1	68	70.2	72	76.04	67.7±8.3	68	80	82.4	90
15	69.9±7.2	70	80	80	90	66.3±9.3	66	78	80	90

- A linear increase in diastolic blood pressure with increasing age was found in both sexes and this was statistically significant with p <0.001
- No significant difference of diastolic blood pressure between males and females in most of the age groups.

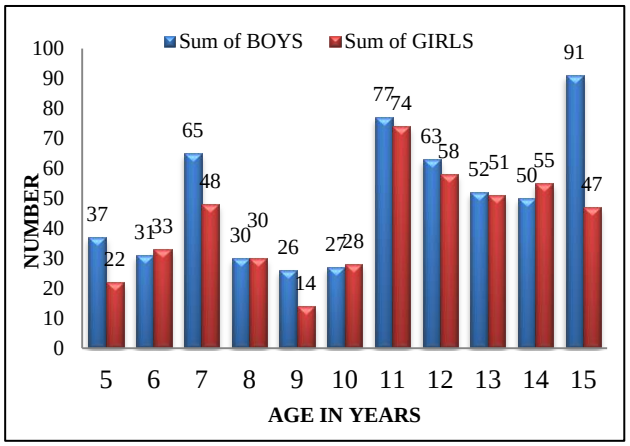

Figure 1: Distribution of subjects according to age and sex.

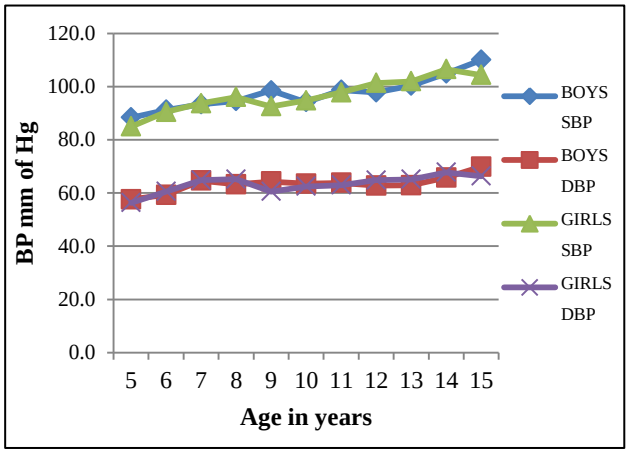

Figure 2: Comparison of mean systolic and diastolic blood pressure in different age groups.

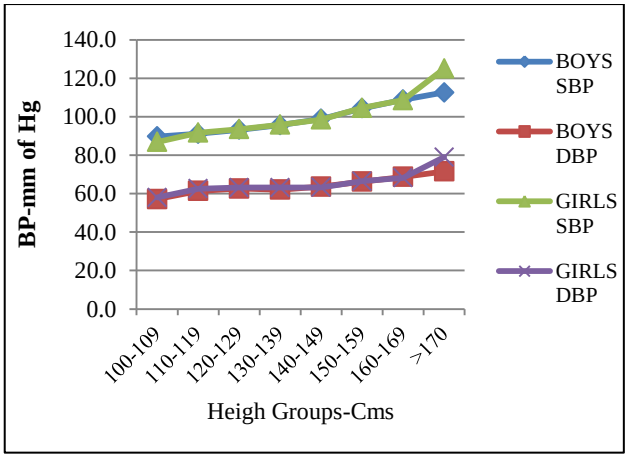

Figure 3: Distribution of blood pressure according to height.

- A linear increase in systolic and diastolic blood pressure with increasing height
- The increase was statistically significant with p<0.001.

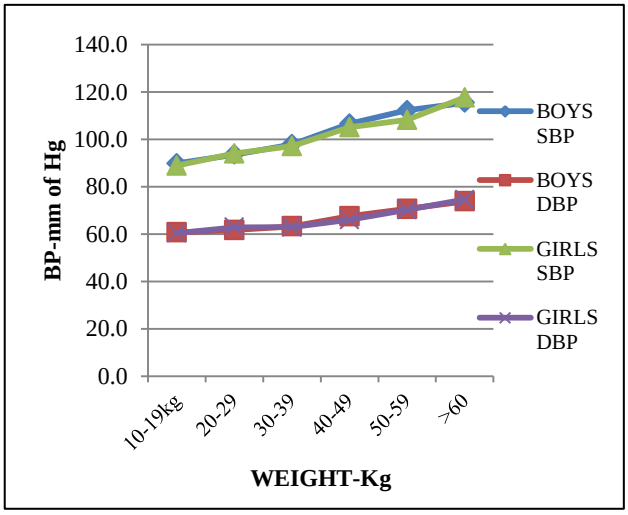

Figure 4: Distribution of blood pressure according to weight.

Table 3: Distribution of blood pressure according to weight.

Weight (kgs)	Boys			Girls		
	No.	SBP Mean±sd	DBP Mean±sd	No.	SBP Mean±sd	DBP Mean±sd
10-19	68	89.9±7.2	60.7±6.9	72	88.9±8.1	60.4±7.2
20-29	172	93.6±6.8	61.7±7.3	98	94.0±7.4	62.8±6.5
30-39	140	97.9±7.6	63.2±6.8	131	97.1±7.1	62.9±6.1
40-49	101	106.6±7.3	67.5±6.2	110	105.1±11.0	66.0±8.1
50-59	57	112.2±10.9	70.6±7.4	42	108.1±10.9	70.2±8.1
>60	11	115.5±9.1	73.8±4.5	7	117.7±10.7	74.6±4.0

As the weight increased, there is a linear increase in mean systolic and diastolic blood pressure in both boys and girls. This difference was statistically significant with p <0.001.

Linear increase of systolic and diastolic blood pressure is seen in both boys and girls with increasing weight.

Table 4: Distribution of blood pressure according to body mass index (BMI).

BMI	Boys			Girls		
	No.	SBP	DBP	No.	SBP	DBP
		Mean±sd	Mean±sd		Mean±sd	Mean±sd
<5	144	95.8±8.9	63.2±6.4	86	94.0±9.0	62.0±5.5
5- <85	369	99.6±10.6	64.4±7.6	331	98.8±10.7	64.2±7.8
85- <95	22	102.9±13.9	65.2±11.4	35	104.5±14.2	67.7±9.7
>/=95	14	103.9±15.2	67.4±12.9	8	102.3±7.5	66.0±4.7

The mean systolic and diastolic blood pressure of overweight (BMI 85th - 95th percentile) and obese group (BMI ≥95th percentile) was higher than the groups with lower BMI with p<0.001.

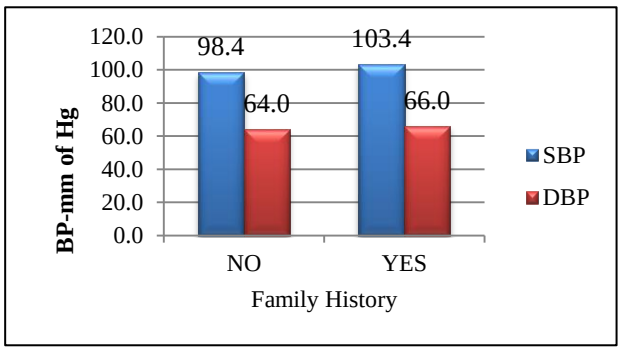

Figure 5: Distribution of blood pressure according to family history.

Out of the 1009 children, seventy three had family history of hypertension. They had higher systolic (103.3mm) and diastolic blood pressure (66.0 mm of Hg) than those without family history with p value <0.001.

Table 5: Distribution of blood pressure according to socio economic status (SES).

Socio economic status (class)	No.	SBP	DBP
		Mean±sd	Mean±sd
I	76	101.7±10.2	65.0±7.4
II	704	99.0±11.0	64.4±7.8
III	200	96.8±10.1	63.3±7.4
IV	23	97.8±12.4	63.2±7.3
V	6	94.3±6.5	59.7±5.3

There is increase in SBP and DBP with higher socio economic status and this increase is statistically significant with p <0.001.

Table 6: Prevalence of pre hypertension and hypertension.

Age/years	Boys (70)		Girls (62)	
	Pre hypertension (=/>90th percentile)	Hypertension (=/>95th percentile)	Pre hypertension (=/>90th percentile)	Hypertension (=/>95th percentile)
5	2	3	4	1
6	3	2	4	2
7	5	4	2	3
8	2	1	0	3
9	1	3	1	1
10	3	1	4	2
11	3	6	6	3
12	4	3	2	3
13	3	4	1	3
14	2	4	7	4
15	4	7	2	4
Total	**32**	**38**	**33**	**29**

- Sixty five (6.44%) children found to be Pre hypertensive and 67 (6.64%) found to be Hypertensive
- Out of 65 students found to be Pre hypertensive 32 were boys and 33 were girls
- Out of 67 students found to be hypertensive 38 were boys and 29 were girls.

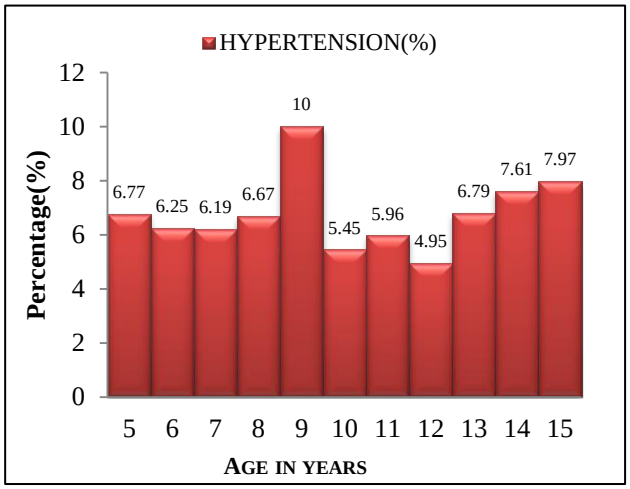

Figure 6: Age wise prevalence of hypertension.

Prevalence of hypertension is high in 9, 13, 14, 15 years.

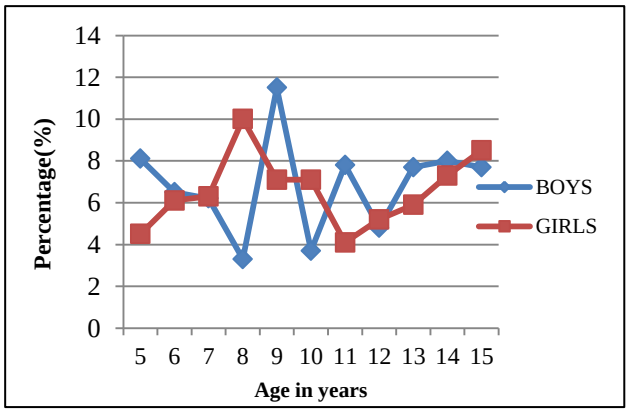

Figure 7: Age and sex wise distribution of hypertension.

DISCUSSION

Correlation of blood pressure with various parameters and interpretation

Age and its relation to blood pressure

Age limit of children in this study is 5-15 years. The study revealed a linear increase of blood pressure with increasing age in both sexes. A spurt in SBP and DBP is noted in both sexes between ages 13-15 years. This may be attributed to hormonal changes that occur in adolescent period. Similar observations were made in the studies done in the past.[6,7,11,19] The increase in systolic and diastolic blood pressure noted in boys at nine years of age and girls at 8 years of age could not be explained.

Height and its relation to blood pressure

In this study, a linear increase in mean SBP and mean DBP also noted with increasing height which is found to be statistically significant P <0.001. Except V.K. Agarwal and et al all other studies showed positive correlation of height with systolic and diastolic blood pressure.[6-8,11,19] In our study, it is observed that there is a spurt in systolic and diastolic blood pressure in children reaching height beyond 150 cm in both boys and girls. Steep increase in systolic and diastolic blood pressure among girls beyond 170 cm of height can be attributed to low number in this group.

Weight and its relation to blood pressure

It is also observed that systolic and diastolic blood pressure increased linearly with weight, and this increase is statistically significant (p<0.001). This finding is consistent with the other studies.[6,7,11,19]

Body mass index and its relation to blood pressure

BMI is used as an indicator of overall adiposity. Over the years, there has been a lack of consensus on the various cut-points or definitions used to classify obesity and overweight in children and adolescents and they are usually defined using age and gender specific normograms of BMI. In order to exclude age as a confounding factor, BMI was plotted on percentile charts.[37] and the children were categorized into four groups (<5 percentile, 5th -<85th, 85th-<95th,>/=95th) to correlate the percentiles with blood pressure. BMI between 85th -95th percentiles was taken as overweight and more than 95th percentile taken as Obesity. Both systolic and diastolic blood pressure were significantly (p<0.001) higher in over weight and obese group when compared to children with normal BMI. This indicates that BMI percentile can be used as predictor of high blood pressure. Similar observations were noted in studies done by Wang et al, Ribeiro et al He Q et al and Sacheil et al.[13,15,18] Among the overweight and obese groups both systolic and diastolic blood pressure was higher in boys who were obese compared to those who are overweight. But similar correlation is not seen in girls and this may be attributed to low number in obese group (>95th percentile) of girls.

Distribution of blood pressure according to socio economic status (Revised kuppuswamy socio economic status scale, 2009)

It is observed that the mean systolic and diastolic blood pressure increased linearly with better socio economic status which could be because of higher mean weight in children with higher socioeconomic status.

Family history and its relation to blood pressure

Evidence exists that hypertension tends to aggregate in families and the cause can be genetic, environmental or both. In our study, 6.24% of children are having family history of hypertension. The study reveals that children of hypertensive parents have higher levels of blood pressure compared to children of normotensive parents. It is observed in both sexes and is statistically significant ($p<0.001$) which is in accordance with findings observed by Mungar et al, Chadha et al and londe.[4,21,34]

Prevalence of pre hypertension and hypertension

In this study, cut off values for prehypertension is taken as > 90th - 94th centile and for hypertension as > 95th percentile according to recommendations of fourth task force report on high blood pressure in children.[2] Most of other studies have considered above 95th percentile as criteria for hypertension. However Gupta et al and Anand and Tandon had considered mean ±2SD for estimation of hypertension. In their studies, prevalence of hypertension was found to be 1.39% and 0.46% respectively.[5,6] In the present study we found a prevalence of high blood pressure among school children as 13.1% among which 6.44% belonged to pre hypertension and 6.64% belonged to hypertension category. Prevalence of pre hypertension is observed to be more in girls (7.1%) than the boys (5.9%) whereas the prevalence of hypertension in boys (6.9%) is almost equal to that in girls (6.3%). The prevalence of hypertension in our study (6.64%) is less compared to that reported by Chadha SL et al who noted a prevalence of 11.9% in their study in urban school children of Delhi in the age of 5-14years.[4] The difference could probably be attributed to varying climatic, genetic, socioeconomic and dietary factors.

Prevalence of hypertension in children in various Indian studies ranged from 0.4% to 11.9%. This diversity in prevalence of hypertension is due to varying age groups taken for the study and different criteria adopted for defining hypertension and basic difference among various racial sub groups, geographic, dietary, and cultural factors.

Table 7: Prevalence of hypertension as reported in various studies.

Study	Year	Age group (years)	Prevalence	Criteria
Hahn et al	1952	14	16.2	130/90mm hg
Londe	1968	4-15	2.3	140/90 mm hg
Dube et al	1975	4-17	3.6	>Mean±2SD
Rames et al	1978	5-18	<1	95th percentile
Loria et al	1986	5-14	2.93	95th percentile
Maguine h et al	1990	School children	5.2	95th percentile
Botash AS et al	1992	School children	9.8	95th percentile
Tendon et al	1996	5-15	0.41	95th percentile
Gupta et al	1990	5-14	1.39	>95th percentile
Chadha et al	1999	5-14	11.9	=/> 95th percentile
Present study	2011	5-15	6.64	=/>95th percentile

Recommendations

Hypertension is not an uncommon problem in children; its morbidity should be prevented by identifying children in pre hypertension stage and adopting life style modification.

Therefore blood pressure measurement should be made mandatory in school health programs and in routine clinical practice. High BMI should be taken as risk factor for hypertension and it should also be taken into consideration for labeling a particular child as hypertensive based on blood pressure nomograms.

The limitations of the study was blood pressure profile of parents was recorded and no uniformity of sample size across different age groups and gender.

CONCLUSION

There was no significant difference of blood pressure (systolic as well as diastolic) between males and females.

With increase of age, weight and height there was a linear increase of mean systolic and diastolic blood pressure.

The mean values of systolic and diagnostic blood Pressure in overweight and obese group is significantly higher with $p<0.01$. For a given age, blood pressure levels were higher in taller and obese children.

Children with family history of hypertension and those belonging to higher socio economic status (class I) had increased systolic and diastolic blood pressure.

Out of 1009 urban school children, 67(6.64%) children were falling under hypertension category and 65 (6.44%) were falling under pre hypertension category.

Higher body weight may be used as a predictor of high blood pressure. Overweight and obesity in children should be considered as pre disease state which may lead to development of hypertension and related cardiovascular complications in later life.

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