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**Original Research Article**

# Evaluation of blood pressure in school children aged 12-16 years

**Balakrishnan Nadesan, Mani Madhavan Sachithananthamoorthi*, Sivaraman Thirumalaikumarasamy, Ezhilarasu Ramalingam**

Department of Pediatrics, Institute of Child Health and Hospital for Children, Madras Medical College, Chennai, Tamil Nadu, India

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***Correspondence:**
Dr. Mani Madhavan Sachithananthamoorthi,
E-mail: drmani76@gmail.com



## ABSTRACT

**Background:** Hypertension is considered as a major health issue in developed as well as developing countries and its possible origin during childhood prompts pediatricians to routinely include measurement of blood pressure (BP) as an integral part of pediatric physical examination. The objectives of the study were to evaluate the normal range of blood pressure in adolescent school going students of 12-16 years, prevalence of hypertension and relationship of BP with variables like age, body mass index (BMI), socioeconomic status and family history of hypertension.
**Methods:** A cross sectional study was undertaken for a period of one year in adolescent school children in age groups between 12-16 years. Detailed clinical examination was done in 1060 adolescent school children and BP was recorded in right upper limb and correlation of BP with BMI, family history of hypertension and diabetes were studied.
**Results:** Mean systolic and diastolic pressure showed linear relationship with age. There was a highly statistically significant difference between mean systolic and diastolic blood pressure between lower and middle socio-economic class. Prevalence of obesity in our study was 1.13%, overweight was 7.83%. Prevalence of hypertension in obese children was 33.33% and in overweight children 18.07%. Family history of hypertension and diabetes carry a significant correlation with elevated systolic and diastolic blood pressure in adolescents.
**Conclusions:** This study revealed that socio economic factors play a significant role in determining the blood pressure of the individual. Children of middle class have significantly elevated mean systolic pressure and mean diastolic pressure than low socio-economic groups.

**Keywords:** Adolescent school children, Blood pressure, Body mass index, Socio economic status

## INTRODUCTION

Recent emphasis on hypertension and its possible origin during childhood has served as an impetus for paediatricians to routinely include measurement of blood pressure (BP) as an integral part of paediatric physical examination.[1] BP is a reflection of cardiac output, peripheral vascular resistance, blood volume, arterial elasticity, and other hemodynamic variables.[2] Readings considered to be abnormal therefore have wide-spread implications and determine the basis for further investigation of a number of systems which influence the level of BP.[2] Thus the accuracy of BP measurement has assumed a portion of primary importance since an error in the other direction may lead to neglect of an important underlying problem.[3] The measurement of BP is an estimate rather than a precise determination since a number of physiologic variations, some of which cannot be controlled are operative.[4] Systolic arterial pressure varies diurnally with an early morning low point and an early evening high point. With complete bed rest, as in sound sleep the systolic pressure decreases. After food intake, a minor transient increase occurs, strong sensory stimuli arise from things such as a distended bladder or physical activity are known to result in elevation of BP. Fear, apprehension, agitation and other emotional factors tend to raise the arterial pressure. Exposure to cold may cause a decrease BP whereas exposure to heat may result in an increase.[5]

Finally, periodic physiologic undulations, Traube Hering waves possibly related to variation in vasomotor activity and respiratory movements.[5] Heart rate and stroke volume may account for fluctuations which can reach a magnitude as high as 40 mm Hg in some individuals. But the knowledge of the physiologic variable directs the attention and eliminate extrinsic errors and need for more than one single measurement.

BP is often a neglected procedure in school going children as compared to adults in whom it forms a routine procedure. But the prevalence of hypertension in adolescent school children reported in various literatures has encouraged us to find out the same in our population. Available data in the Indian standards are minimal and we are forced to compare our own values with the western standards. May such studies will go a long way in setting normal standards for Indian children.

A cross sectional study was undertaken for a period of one year in adolescent school children in age groups between 12-16 years. Detailed clinical examination was done in 1060 adolescent school children and BP was recorded in right upper limb and correlation of BP with BMI, family history of hypertension and diabetes were studied.

The objectives of the study were to evaluate the normal range of BP in adolescent school going children of age 12-16 years, cut off point for hypertension, prevalence of hypertension in school children and relationship of BP with variables like age, body mass index (BMI), socioeconomic status and family history of hypertension and diabetes.

## METHODS

Adolescent school children between the ages 12-16 years of both sexes and belonging to middle and lower socio-economic groups were included for the study. The socioeconomic status was assigned on the basis of socioeconomic status scale by Kuppuswami.[6] Children with BP >95$^{th}$ percentiles were referred to Govt. Royapettah Hospital for follow up. Age was taken in completed years and was recorded from school registers. Height was measured by using a vertical scale to the nearest 0.5 cms. Weight was measured using a standard weighing scale to the nearest 0.5 kg. The international cut off points for body mass index were used for classifying children as overweight and obese.[7] BMI- in 85$^{th}$-95$^{th}$ percentile is called overweight and >95$^{th}$ percentile is obese <5$^{th}$ percentile is underweight.[7]

A sample size of 1060 school children from different schools stratified for age and sex were selected. The schools were selected randomly and the study was carried out after taking permissions and consents from the authorities. All children included were subjected to through clinical examination and children found to have cardiac and renal diseases were excluded from the study.

The procedure was informed to all children and measures have been taken to reduce the anxiety. Their co-operation was sought specifically for information regarding hypertension, diabetes in any immediate member of the family.

One very important aspect is to familiarise the child in advance in order to reduce the anxiety associated with the measurement procedure and to avoid excitement associated with anticipation. In our study cordial atmosphere was created to do an unhurried and relaxed examination which was achieved by talking to the child and recording BP as the last part of the examination procedure. The child was also made to witness similar pressure recording in other children and this helped in a large way to allay their apprehension. Prior to recording the child was asked to void urine. Repeated measurements were obtained. These measures helped to obtain basal pressures.

The basal pressure is important because the basal pressure in adolescents seems to be a better predictor of essential hypertension in adulthood than casual BP.

### *Recording of BP*

Mercury sphygmomanometer in conjunction with a good stethoscope was used to measure BP for all ages. The cuff sizes of 7 cm and 12 cm were used and care was taken to select appropriate sized cuffs which cover about 2/3$^{rd}$ of the upper arm. All observations were made in the right arm with the child properly seated. In all the cases, brachial artery was routinely felt and then the right upper limb was used for recording BP as it is the direct continuation of ascending aorta. These group of children were very co-operative and technically also feasible to hear the korotkoff sounds well with child sitting in a proper chair and sphygmomanometer at child's heart level. BP was recorded in the right upper limb. The cuff was firmly placed over the brachial artery and inflated to 30 mm above the systolic BP recorded by palpatory method, then the cuff is deflated by 2-4 mm of Hg per second. The appearance of 1$^{st}$ korotkoff sound and muffling of korotkoff sounds were taken as systolic and diastolic pressure respectively. Three readings were taken at an interval of 5 minutes each and average of the 3-reading taken as systolic and diastolic BP respectively.

### *Statistical analysis*

Descriptive (mean and standard deviation) statistics was used to analyse the data. One way analysis of variance (ANOVA) was computed to test any significant difference in BMI and BP measurement of groups. Chisquare test, 't' test, and Pearson's correlation coefficient were used for significant difference in BP, BMI, Family History of Hypertension and Diabetes.

## RESULTS

A sample size of 1060 Adolescent school children (12-16 years) of both sexes from different schools and belonging to middle and lower socio-economic groups were selected for the study.

The distribution of school going students according to their age and sex along with their systolic and diastolic BP are presented in Table 1.

Highest number of cases studied was in age group of 15 yrs. In other groups on an average 150 cases were studied.

The systolic as well as diastolic BP was increasing with age. The distribution of the systolic and diastolic BP by percentiles in various age groups is also presented in Table 1.

The values are increasing with age in both the cases of both sexes at 95th percentile.

**Table 1: Systolic and diastolic BP according to their age and sex.**

| Age (in yrs) | Sex | systolic BP | | | Diastolic BP | | |
|---|---|---|---|---|---|---|---|
| | M/F (No.) | Mean±SD | $5^{th}$ | $95^{th}$ | Mean±SD | $5^{th}$ | $95^{th}$ |
| 12 | M (48) | 112.58±9.91 | 97.8 | 125.2 | 74.25±5.11 | 67 | 78.2 |
| | F (67) | 107.61±10.45 | 94.0 | 120.8 | 69.85±8.64 | 64.0 | 76.2 |
| 13 | M (67) | 113.58±9.73 | 100 | 126.4 | 73.46±6.44 | 68.2 | 79.6 |
| | F (123) | 109.06±11.11 | 92.4 | 124.0 | 72.23±7.76 | 66.0 | 78.4 |
| 14 | M (128) | 113.48±9.78 | 97.8 | 128.2 | 74.84±5.72 | 70.6 | 80.4 |
| | F (156) | 112.29±11.38 | 94.0 | 124.6 | 73.96±7.33 | 64.3 | 79.6 |
| 15 | M (164) | 114.04±11.38 | 96.0 | 129.0 | 74.49±6.14 | 71.2 | 81.3 |
| | F (149) | 111.91±11.99 | 90 | 128.0 | 74.03±7.49 | 65.6 | 80.0 |
| 16 | M (103) | 115.17±11.64 | 96 | 130.0 | 75.05±6.16 | 72.6 | 83.8 |
| | F (55) | 114.07±12.52 | 90 | 129.0 | 76.51±6.31 | 70.2 | 82.8 |

**Table 2: Mean BMI and BP.**

| Age group | Weight (Kg) | Height (cms) | BMI | Mean Sys. BP±SD | Mean Dia BP±SD |
|---|---|---|---|---|---|
| 12 | 38.41 | 145.84 | 18.23 | 109.69±10.48 | 71.69±7.66 |
| 13 | 40.22 | 147.66 | 19.27 | 110.65±10.84 | 72.66±7.32 |
| 14 | 42.78 | 150.85 | 19.50 | 112.83±10.69 | 74.36±6.66 |
| 15 | 47.99 | 156.32 | 19.80 | 113.02±11.70 | 74.27±6.86 |
| 16 | 49.63 | 157.10 | 20.28 | 114.78±11.92 | 75.56±6.23 |

Mean BMI with systolic and diastolic BP in studied age range are presented in Table 2. The study result revealed the age was proportional to BMI and BP. Highest score of mean BMI and BP (both systolic and diastolic) was found at 16 years.

Total samples were distributed with both the sexes in various age groups and their mean weight, height and BP were studied which is shown in Table 3.

Mean BP scores and number of cases of hypertension of both sexes were studied according to various categories of BMI and is presented in Table 4.

Highest percentage (33.33%) of hypertension was found in obese category in which maximum cases were females (50% obese females).

The distribution of students of both sexes according to type of hypertension in various age groups is shown in Table 6.

Highest number of cases studied in age of 15 years. The number of cases of hypertension was depended on the cases studied. However, highest number of hypertension cases was found in 15 years.

**Table 3: Mean scores weight, height and blood pressures.**

| Age in yrs | Sex M/F/Total (No.) | Weight Mean±SD | Height Mean±SD | Systolic Mean±SD | Diastolic Mean±SD |
|---|---|---|---|---|---|
| 12 | M | 35.56±4.584 | 140.75±7.46 | 112.58±9.91 | 74.25±5.11 |
| | F | 39.74±8.025 | 149.49±6.93 | 107.61±10.45 | 69.85±8.64 |
| | Total | 38.41±6.595 | 145.84±8.34 | 109.69±10.48 | 71.69±7.66 |
| 13 | M | 39.00±4.376 | 143.19±7.12 | 113.58±9.73 | 73.46±6.44 |
| | F | 40.89±7.483 | 150.09±6.63 | 109.06±11.11 | 72.23±7.76 |
| | Total | 40.22±6.607 | 147.66±7.55 | 110.69±10.84 | 2.66±7.32 |
| 14 | M | 41.71±52.86 | 148.29±7.27 | 113.48±9.78 | 74.84±5.72 |
| | F | 43.66±7.696 | 152.96±5.52 | 112.29±11.38 | 73.96±7.33 |
| | Total | 42.78±6.777 | 150.85±6.77 | 112.83±10.69 | 74.36±6.66 |
| 15 | M | 51.83±7.997 | 158.01±8.55 | 114.04±11.38 | 74.49±6.14 |
| | F | 43.77±8.333 | 154.45±6.74 | 111.91±11.99 | 74.03±7.59 |
| | Total | 47.99±9.089 | 156.32±7.93 | 113.02±11.70 | 74.27±6.86 |
| 16 | M | 51.41±7.902 | 157.94±7.47 | 115.17±11.64 | 75.05±6.16 |
| | F | 46.29±8.591 | 155.53±4.82 | 114.07±12.525 | 76.51±6.31 |
| | Total | 49.63±8.481 | 157.10±6.31 | 114.78±11.92 | 75.56±65.34 |

**Table 4: Mean scores of BP and hypertension of male and female children based on BMI.**

| | BMI Category | Male | | | | Female | | | | Total | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. of Males | BP mean ±SD | HT | % | No. of Female | BP mean ± SD | HT | % | No. of Children | BP mean±SD | HT | % |
| SBP | Normal | 410 | 113.61 ±10.14 | 33 | 8.00 | 424 | 111.28 ±11.21 | 31 | 7.31 | 834 | 112.43 ±10.75 | 64 | 7.67 |
| DBP | | 410 | 74.43 ± 5.95 | | | 410 | 73.56 ±7.59 | | | 834 | 73.99 ±6.84 | | |
| SBP | Over weight | 53 | 117.66 ±12.99 | 10 | 18.86 | 30 | 116.73 ±12.22 | 5 | 16.66 | 83 | 117.33 ±12.65 | 15 | 18.07 |
| DBP | | 53 | 75.17 ±6.46 | | | 30 | 75.93 ±6.95 | | | 83 | 75.45 ±6.61 | | |
| SBP | Obese | 6 | 118.33 ±13.48 | 1 | 16.66 | 6 | 123 ±13.00 | 3 | 50.00 | 12 | 120.67 ±13.25 | 4 | 33.33 |
| DBP | | 6 | 76.33 ±5.16 | | | 6 | 80.67 ± 6.53 | | | 12 | 78.50 ±6.79 | | |
| SBP | Under weight | 41 | 112.05 ±11.83 | 5 | 12.19 | 90 | 107.42 ±12.04 | 4 | 4.4% | 131 | 108.87 ±12.12 | 9 | 6.87 |
| DBP | | 41 | 74.88 ±6.01 | | | 90 | 71.00 ±8.16 | | | 131 | 72.21 ±7.74 | | |

**Table 5: Relationship between BMI and BP.**

| | Systolic BP | | Diastolic BP | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| 12 | 0.322* | 0.363** | 0.203 | 0.185 |
| 13 | 0.299 | 0.066 | -0.051 | 0.056 |
| 14 | 0.055 | -0.249** | -0.159 | 0.242 |
| 15 | 0.066 | 0.330** | -0.002 | 0.299** |
| 16 | -0.040 | 0.468** | -0.23 | 0.488** |

*Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level.

**Table 6: Distribution of students according to type of hypertension in various age groups.**

| | 12 years | | 13 years | | 14 years | | 15 years | | 16 years | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| Normal BP | 40 | 51 | 60 | 104 | 112 | 127 | 139 | 124 | 88 | 50 |
| Systolic HT | 6 | 3 | 5 | 5 | 8 | 10 | 11 | 8 | 6 | 2 |
| Diastolic HT | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 |
| Both | 0 | 2 | 1 | 5 | 2 | 3 | 5 | 3 | 2 | 1 |
| Low BP | 2 | 10 | 1 | 9 | 5 | 16 | 9 | 12 | 7 | 2 |
| Chi square Value | 7.735 N.S. | | 4.782 N.S. | | 5.418 N.S. | | 3.547 N.S. | | 1.094 N.S. | |

Association of BP with family history and socio-economic status was also studied and is summarized in Table 7. The results are significant in both the cases which is a strong evidence of relation of family history with BP. Among the cases of hypertension major cases were from middle socioeconomic status. The comparison of mean score of BMI and blood pressure between lower and middle socioeconomic status cases of students are tabulated in Table 8. The BMI and BP were higher in students belonged to middle socioeconomic status. Mean BP score was significantly higher in this category when compared to lower socioeconomic status.

**Table 7: Association of BP with family history and socio-economic status.**

| B.P. category | Family history | | | | SE status | |
|---|---|---|---|---|---|---|
| | HT | DM | HT+DM | NIL | Low | Middle |
| Normal | 150 | 44 | 14 | 687 | 487 | 408 |
| Systolic hypertension | 19 | 5 | 10 | 30 | 25 | 39 |
| Diastolic hypertension | 2 | 1 | 0 | 1 | 2 | 2 |
| Both | 3 | 3 | 1 | 17 | 15 | 24 |
| Low BP | 9 | 6 | 2 | 56 | 27 | 73 |
| Chi square value | 71.939 P<0.01 | | | | 10.800 P<0.005 | |

**Table 8: Comparison of BMI and blood pressure between the low and middle socio-economic status.**

| | Low SE n=569 | Middle SE n= 491 | 't' Value | 'p' Value |
|---|---|---|---|---|
| | Mean ±SD | Mean ±SD | | |
| Weight | 43.47±8.53 | 45.59±8.80 | 3.779 | <0.01 |
| Height | 152.03±8.21 | 152.58±884 | 3.779 | NS |
| BMI | 19.09±6.77 | 19.64±3.48 | 1.626 | NS |
| Sys. BP | 111.62±10.87 | 113.40±11.66 | 2.565 | <0.01 |
| Diast BP | 73.44±6.86 | 74.46±7.08 | 2.377 | <0.05 |

## DISCUSSION

Hypertension is a major risk factor for cardiovascular and cerebrovascular diseases. The insidious and steady course of hypertension in adults, indicates that it may have its roots in childhood and adolescent age group but probably goes undetected. Aggarwal and coworkers suggested, that BP level correlates better with BMI in children and adolescents than with age.[8]

It is not clear what level of pressure should be considered distinctly abnormal at a given age or size. The prevalence of hypertension in children is reported to range from 1.0 to 16.2%.[9] In the above studies the high incidence of hypertension may be due to inclusion of transient hypertension. Hypertension was defined as blood pressure above the 95$^{th}$ percentile on 3 different occasions. In order to study the variations in blood pressure over various ages it is necessary to study the normal range of blood pressure among children. A considerable work has been done in different parts of India to establish the normal blood pressure variation for different age groups.[8,9]

In the present study, a total of 1060 school students in age groups of 12-16 years were studied and tabulated in Table 1. Highest no of cases was studied in the age group of 15 years, lowest number in age group of 12 years. The mean blood pressure levels of systolic and diastolic pressure of the 1060 children were studied in relation to age in both sexes. Blood pressure levels increases progressively with age.

The gradual increase in mean systolic pressure and mean diastolic pressure of boys and girls with age which is the result of this study is similar with the findings of the Task Force Committee report and other workers.[10] The mean systolic pressures of males for various age groups are higher than females. The difference in mean diastolic pressure between males and females are negligible. In Indian school children, an increase in systolic blood pressure and diastolic blood pressure has also been reported by various authors.[9,11,12]

In the present study, the value of systolic and diastolic BP is slightly lower among girls than boys, but the differences were not found statistically significant in most of the age groups. This is consistent with findings of Chadha et al and Anand et al.[9,12]

The prevalence of hypertension in school children of Chennai is 9.21% in boys and 8.18% in girls. According to Chadha et al the prevalence of hypertension in Delhi school children of age 5-14 years is 11.7%.[9] But Chahar et al and Anand and his coworker Tandon reported a low prevalence of hypertension i.e. 0.41-3.5% among school children.[11,12] The reason for low prevalence of hypertension in these populations according to Chadha et al is mainly the use of arbitrary criterion of hypertension assessment and not the recognized criterion of 95$^{th}$ percentile of blood pressure values.[9]

In the present sample sex differences in the prevalence of hypertension were not statistically significant ($P>0.05$). The finding that there are no appreciable sex differences in the prevalence of hypertension among school children has also been observed by many workers.[9,12]

In present study, the prevalence of overweight was 7.83% and obesity was 1.1% which was comparable with study of Bisavmohan et al with 11.63% of overweight and 2.35% obese in urban areas but our study group comprises of subjects from middle and lower socio economic status.[13] The overall prevalence of hypertension in overweight children is 18.07% (n=15) and in obese children it is 33.33% (n=4). The prevalence of hypertension in children with normal body mass index was 7.67% (n = 64). The mean body mass index of hypertension population was significantly higher than respective normotensive population. The mean systolic and diastolic BP of overweight and obese children is higher than their normotensive counterparts. The correlation of BMI with hypertension shows a statistical significance of ($P <0.001$).

The prevalence of overweight and obesity in children aged between 6 to 17 yrs in all ethnic groups is reported to be between 5-30%. Kapil et al reported prevalence of obesity in adolescent school children of affluent families to 7.4% and overweight 23.1%.[14] High incidence of obesity and overweight reported by Kapil et al is probably due to selection of different populations (affluent family's children).[14]

In our present study reported prevalence is 7.83% of overweight and 1.1% of obese children. The United States National Centre for Health Statistics suggests that nearly 15% of adolescents are overweight or obese.[15] There is evidence that children and adolescents are becoming overweight possibly because of decreased physical activity, sedentary lifestyle, altered eating pattern, and increased fat content of diet. Hypertension in obese children may occur due to increased cardiac output, excessive sodium intake, increased steroid production and alteration in response for various pressor substances.[16]

In present study, the correlation of hypertension in children is strongly associated ($P <0.001$) with family history of hypertension or hypertension with diabetes which has also figured in study done by Gupta.[17] The family history of hypertension does not have a significant association with overweight or obese status of the child. The prevalence of hypertension in middle socio economic status when compared to lower socio economic status show a significant association ($P<0.05$). This indicates a direct relationship of hypertension influenced by obesity, overweight, family H/o hypertension and diabetes and socio economics status.

## CONCLUSION

Blood pressure readings taken in various schools from middle and lower socio-economic groups were tabulated for boys and girls in 12-16 yrs age group. Mean systolic and diastolic pressure showed linear relationship with age. There was no significant difference in mean systolic and diastolic blood pressure between both sexes. The prevalence of underweight children was 12.35% which was high as the population studied comprises of children belonging to middle and lower socio-economic status. The prevalence of hypertension in these children (6.87%) was less than that of children belonging to normal weight group (7.67%).

Family history of hypertension and diabetes carry a significant correlation with elevated systolic and diastolic blood pressure in adolescents. From this study, it is evident that socio economic factors play a significant role in determining the blood pressure of the individual. Children of middle class have significantly elevated mean systolic pressure and mean diastolic pressure than low socio economic groups.

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