VOLUME - 12, ISSUE - 03, MARCH - 2023 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper

Physiology

PREVALENCE OF HYPERTENSION AND ASSOCIATED RISK PREDICTORS AMONG SCHOOL GOING ADOLESCENTS LIVING IN WEST BENGAL, INDIA

Sanchita Rakshit* JRF, Post Graduate Department of Physiology, Hooghly Mohsin College, Chinsurah, Hooghly, West Bengal, India. *Corresponding Author

Dr. Purushottam Pramanik Principal & Professor, Hooghly Mohsin College, Chinsurah, Hooghly, West Bengal, India.

ABSTRACT

Background: Hypertension or high blood pressure (HBP) is a most common non-communicable disease. Childhood HBP is a major public health problem worldwide as it tracks to adulthood. HBP was associated with obesity. **Objective:** This study was undertaken to investigate the prevalence of high blood pressure in Indian adolescents and its association with various anthropometric obesity indices. **Methods:** The study was conducted among school students aged 11-17 years. Blood pressure was measured using digital oscillometric blood pressure monitor. Anthropometric parameters like height, weight, Neck circumference, Waist circumference and Hip circumference were assessed using standard methods. BMI, Neck height ratio and waist height ratio were calculated. Blood pressure status was evaluated on the basis of American Academy of Pediatrics guideline. SBP and/or DBP > 95th percentile in children below 13 years and 130/80 or above in adolescent 13 years or older was considered as high blood pressure. The association between BP and anthropometric parameters were examined. **Results:** A total 1272 students of class V-XII were participated in this study out of which 56.3% were female and 43.7% were male. 26.8% boys and 13.1% girls were under HBP category. Significant positive correlation was observed between BP and body fat indices. Overweight and obesity were significantly associated with risk of hypertension among boys and girls. Central obesity and upper body obesity were also associated with high blood pressure. **Conclusion:** Prevalence of high blood pressure in adolescent is alarming. Hypertension was significantly associated with general obesity, abdominal obesity and upper body obesity. Thus screening of risk of high BP should be carried out in adolescents and initiate intervention to control the consequences of it.

KEYWORDS : Adolescent, hypertension, BMI, obesity, neck circumference, hip circumference, waist circumference

INTRODUCTION

High blood pressure (HBP) or hypertension is a commonest non communicable disease. It is a silent threat to the health of people all over the world. In children and adolescent HBP is an emerging public health issue. There is strong evidence of tracking of high BP from childhood to adulthood[1, 2].Thus early detection and intervention for HBP among children and adolescents are gaining importance in recent years.

Recently it is seen that there is an increase the prevalence of high blood pressure in children and adolescent due to obesity, intake of more calorie and salt, reduced physical activity, high stress and family history[3].It places the affected individuals at an increased risk of cardiovascular accident, ischemic heart disease and renal failure[4]. The development of hypertension in younger age causes greater reduction of life expectancy if HBP is left untreated[5]. It has also been noted that even asymptomatic adolescents with blood pressure elevation can have target organ damage including left ventricular hypertrophy and pathological vascular changes[6,7].

Obesity is an important risk factor for cardio metabolic diseases including hypertension[8]. Prevalence of elevated blood pressure is higher in overweight and obese children in compare to non-overweight and non-obese children [9, 10]. Worldwide 43 million children are either overweight or obese out of which 35 million are in developing countries [11]. According to WHO 70 million children will be overweight and obese by 2025[12]. In India prevalence of childhood and adolescent obesity varies from 3% to 29%[13].Epidemiological studies suggested that overweight predicts future development of HBP and there is linear relationship between BP and BMI[8]. George et al. 2016[14] suggested the relationship between HBP and body fat. Measurement of body fat using anthropometric indicators had proven to be an effective approach in predicting HBP particularly in large population and community-based studies[15].There are several anthropometric indicators for body fat including BMI, WC, HC and NC. The present study was undertaken to evaluate the prevalence of hypertension and its association with anthropometric body fat indices among school going adolescent of West Bengal.

MATERIALS & METHODS:

Subject:

The present study was conducted among adolescent school students having standard class V to class XII aged 11-17 years from five schools in West Bengal, India during their school hours. The prior written permission of school authority was taken. Written consent from the parents of students experimented in the study was obtained. 1272 students were included in this study. Every students in this study was given a predesigned questionnaire to obtain the information regarding age, last blood pressure readings, diabetes, kidney disease, congenital heart defect, myocardial infarction and/or stroke.

Measurement of Blood Pressure:

Blood pressure was measured using digital oscillometric blood pressure monitor. Before recording the blood pressure students were allowed to wait for 10 minutes in a sitting positions to relieve their restlessness and anxiety[16]. Each student was then called one by one and pressure was measured in the sitting posture in the right upper arm. The cuff size was based on circumference of the upper arm of participants[17].Two readings were taken at 2 minute intervals and their mean was taken as subject's blood pressure. In the case when the differences of two readings were above 5mmHg a third reading was taken. The final reading would be the based on the average of all readings taken. Normotensive, elevated blood pressure and hypertension was defined on the basis of American Academy of Paediatrics Guideline-2017[18]. In adolescent aged 11-12 years SBP and/or DBP $\geq$ 90th percentile but < 95th percentile or 120/80 (whichever is lower) is considered as elevated blood pressure and SBP and/or DBP $\geq$ 95th percentile plus 12 mm Hg or 130/80 (whichever is lower) as hypertension. In adolescent 13 years and older SBP and/or DBP 120/<80 to 129/<80 1s considered as elevated blood pressure and 130/80 or above as hypertension.

Anthropometric Measurements:

Prior to the weight and height measurement subjects were asked to remove their shoes and heavy clothing. Body weight was measured using bathroom scale accurate to 0.5kg. The scale was kept on a flat surface and adjusted with '0' mark. Now the subject was requested to step on it in bare feet. Weight was recorded to the nearest 0.5kg. For the measurement of height subjects were asked to stand still and quiet and erect position, hanging their arms freely and keeping their head aligned in the Frankfort plane. The measurements were recorded to the nearest 0.1 cm for each subject using anthropometric rod[19]. Body mass index (BMI) was calculated from the height and weight using following equation: BMI (kg/m^2) = weight (kg) / height^2 (m). BMI was calculated from the height and weight using following equation: BMI (kg/m^2) = weight (kg) / height^2 (m). Age and sex-specific BMI percentiles criteria of each students were determined. Nutritional status of the students was categorized based on percentile value of BMI: < 5th percentile as underweight, > 5th percentile but < 85th percentile as normal, ≥ 85th percentile but <95th percentile as overweight and ≥ 95th percentile as obese[20]. Neck circumference (NC) was measured just below the laryngeal prominence (Adam's apple) using calibrated plastic tape[7]. Waist circumferences (WC) was measured mid-way between iliac crest and lowermost margin of the ribs in quiet breathing using plastic tape[7]. Hip circumference (HC) was measured using plastic tape at horizontal level of greater trochanters with the leg close together. Waist- height- ratio (W: Ht) was calculated by dividing waist circumference with height. Waist to hip ratio (WC: HC) was calculated by dividing WC with HC and Neck height ratio (NC: Ht) by dividing NC with height.

Statistical analysis: Results are described as mean values ± standard deviations (SD). Pearson's correlation coefficient was used to determine the gender specific relationship between blood pressure and various anthropometric indices. Numerical data from boys and girls were compared using independent samples of t-test. The association between BP with anthropometric variables and age were analyzed using chi square test. The prevalence of elevated blood pressure, Overweight and obesity was presented as frequency and percentage. Statistical significance was determine at p value <0.05.

RESULTS:

Gender wise anthropometric characteristic of study population are presented in table-1and table-2. 1272 adolescent having age limit 11-17 year were participated in this study. Out of all 556 were boys and 716 were girls. Among different age group majority were in the age group of 13 years for boys and 16 years for girls. Age and gender wise mean values and standard deviation of all tested parameters also represented in table-1.

Table-1: Characteristics of adolescent male

Age (year)	Height (cm)	Weight (kg)	BMI (kg/m2)	NC (cm)	WC (cm)	HC (cm)	NC: Ht	WC: Ht
11	145.8 (6.66)	38.8 (11.24)	18.2 (4.32)	29.1 (2.64)	68.4 (11.45)	76.1 (9.75)	0.199 (0.016)	0.468 (0.068)
12	152.3 (7.81)	41.9 (10.57)	17.9 (3.54)	29.6 (2,72)	69.9 (9.98)	77.9 (8.22)	0.194 (0.018)	0.459 (0.059)
13	157.1 (8.83)	49.1 (13.31)	19.7 (4.50)	30.0 (2.95)	71.2 (12.21)	79.5 (9.79)	0.191 (0.016)	0.453 (0.073)
14	162.5 (8.16)	52.3 (12.07)	19.7 (3.88)	32.22 (2.85)	72.9 (11.17)	84.0 (14.58)	0.198 (0.017)	0.449 (0.069)
15	167.5 (6.26)	57.8 (13.78)	20.5 (4.22)	33.0 (2.33)	75.2 (11.93)	88.7 (8.92)	0.198 (0.013)	0.449 (0.064)
16	170.0 (6.11)	58.7 (12.00)	20.3 (3.73)	33.1 (2.44)	76.6 (10.68)	89.1 (8.14)	0.195 (0.015)	0.439 (0.060)
17	171.8 (6.84)	64.7 (14.83)	21.9 (4.88)	34.4 (2.39)	77.8 (11.82)	91.8 (8.75)	0.200 (0.015)	0.453 (0.071)

*Data represent as mean. Figures in the parentheses are standard deviations

Table-2: Characteristics of adolescent female

Age (year)	Height (cm)	Weight (kg)	BMI (kg/m2)	NC (cm)	WC (cm)	HC (cm)	NC: Ht	WC: Ht
11	145.7 (7.55)	35.5 (9.29)	16.6 (3.58)	27.6 (2.92)	58.2 (7.29)	68.7 (12.60)	0.190 (0.023)	0.399 (0.042)
12	150.4 (6.03)	40.3 (10.18)	17.7 (3.96)	27.8 (2.04)	62.5 (8.05)	76.6 (9.35)	0.185 (0.013)	0.416 (0.050)
13	153.7 (5.32)	44.5 (12.86)	18.7 (4.63)	28.5 (2.40)	62.1 (9.74)	78.6 (12.02)	0.186 (0.014)	0.404 (0.057)
14	155.5 (5.91)	48.3 (10.69)	19.9 (3.85)	29.2 (2.26)	64.8 (8.62)	78.0 (10.69)	0.188 (0.014)	0.417 (0.052)
15	156.4 (6.23)	47.9 (11.60)	19.5 (4.30)	29.9 (2.80)	66.4 (8.60)	78.9 (11.07)	0.191 (0.016)	0.425 (0.053)
16	156.9 (5.44)	52.8 (12.64)	21.4 (4.69)	31.1 (3.09)	73.8 (11.75)	84.5 (15.44)	0.198 (0.020)	0.470 (0.073)
17	157.7 (5.59)	54.0 (13.35)	21.7 (5.10)	30.7 (3.12)	74.5 (12.64)	85.7 (14.09)	0.195 (0.020)	0.473 (0.080)

*Data represent as mean. Figures in the parentheses are standard deviations

The comparative analysis of study parameters of boys and girls represent in table-3. All the study parameters viz height, weight, NC, HC, and WC increase with advancing age among male and female adolescents. All the study parameters differ significantly between male and female adolescents.

Table-3: Comparison of age and anthropometric parameters between boys and girls

Parameters	Boys		Girls		p
	Mean	SD	Mean	SD	
Age (year)	13.8	1.99	14.6	1.86	< 0.0005
Height (Cm)	160.1	11.57	154.7	7.67	< 0.0005
Weight (kg)	51.2	15.28	48.0	13.11	< 0.0005
BMI (kg/m2)	19.7	4.39	20.5	6.36	< 0.01
NC (cm)	31.4	3.28	29.6	2.91	< 0.0005
WC (cm)	72.5	11.76	67.8	11.52	< 0.0005
HC (cm)	83.2	11.41	80.6	12.05	< 0.0005
NC: Ht	0.196	0.016	0.192	0.022	< 0.0005
WC: Ht	0.453	0.067	0.438	0.073	< 0.0005

Age and gender wise mean of SBP and DBP was given in table-4. In male there was no significant difference of SBP and DBP among 11 and 12 year of age. Both type of BP increase gradually with advancing age for male and female but comparatively slow rate in female. SBP of male adolescent was significantly higher than female counter part in all age group. Like SBP similar pattern was obtained for DBP except of age group 13 year.

Table-4: Age and gender wise distribution of SBP and DBP

Age (year)	SBP			DBP		
	Male	Female	p	Male	Female	p
11	105.2 (12.71)	101.9 (12.00)	< 0.0005	71.9 (8.43)	70.6 (9.17)	<0.005
12	105.9 (12.63)	102.5 (9.17)	< 0.0005	71.6 (10.27)	68.0 (5.90)	< 0.0005
13	108.2 (14.13)	105.4 (13.80)	< 0.0005	69.9 (9.27)	69.2 (11.38)	>0.05
14	115.3 (12.51)	103.7 (11.03)	< 0.0005	74.1 (8.95)	68.1 (8.07)	< 0.0005
15	117.4 (13.90)	103.1 (16.72)	< 0.0005	72.9 (8.17)	69.1 (10.71)	< 0.0005
16	118.8 (12.17)	105.9 (14.74)	< 0.0005	75.3 (11.09)	71.2 (8.09)	< 0.0005
17	124.0 (15.90)	107.8 (12.65)	< 0.0005	76.4 (9.83)	72.0 (8.56)	< 0.0005

11-17	112.5 (16.62)	104.7 (13.28)	< 0.0005	72.7 (9.71)	69.9 (9.05)	< 0.0005

The correlations between obesity indicators and systolic and diastolic blood pressure are shown in table-5. Highly significant correlations are noted between systolic and diastolic blood pressure and all obesity indices viz. BMI (General obesity marker) NC and Neck circumference: height ratio (upper body fat markers) WC, HC and WC: Ht (abdominal obesity markers) except waist to hip ratio. Waist to hip ratio shows insignificant correlation with SBP and DBP of both males and females.

Table-5: Correlation between blood pressure and anthropometric obesity indices

Parameters	Male				Female			
	SBP		DBP		SBP		DBP	
	r	p	r	p	r	p	r	p
NC	0.457	< 0.001	0.281	< 0.001	0.340	< 0.001	0.280	< 0.001
WC	0.358	< 0.001	0.281	< 0.001	0.346	< 0.001	0.286	< 0.001
HC	0.430	< 0.001	0.297	< 0.001	0.340	< 0.001	0.271	< 0.001
BMI	0.393	< 0.001	0.320	< 0.001	0.258	< 0.001	0.202	< 0.001
NC/Ht	0.156	< 0.001	0.186	< 0.001	0.244	< 0.001	0.230	< 0.001
WC/Ht	0.180	< 0.001	0.211	< 0.001	0.322	< 0.001	0.283	<0.001
WC/HC	(-) 0.005	>0.1	(-) 0.014	>0.1	(-) 0.010	>0.1	(-) 0.007	>0.1

The overall prevalence of HBP was 26.8% for male and 13.1% for female adolescent. In male highest prevalence of HBP was 42.0% and 18.5% among female having age group 17 year and 13 year respectively. In female prevalence for 13 years (18.5%) and 17 year (18.3%) was very close (table-6).

Table-6: Age and gender wise prevalence of elevated and high blood pressure among Bengali adolescent

Age (year)	Male			Female			Total (Male + female)	
	n	EBP	HBP	n	EBP	HBP	EBP	HBP
11	82	2	14 (17.1)	62	10	6 (9.7)	12 (8.3)	20 (13.9)
12	86	4	17 (19.8)	66	10	6 (9.1)	14 (9.2)	23 (15.1)
13	113	8	20 (17.7)	54	3	10 (18.5)	11 (6.6)	30 (18.0)
14	71	9	22 (31.0)	143	4	14 (9.8)	13 (14.0)	36 (38.7)
15	65	12	21 (32.3)	102	6	14 (13.7)	18 (10.8)	35 (21.0)
16	56	9	20 (35.7)	169	6	22 (13.0)	15 (6.7)	42 (18.7)
17	83	12	35 (42.2)	120	9	22 (18.3)	21 (10.3)	57 (28.1)
Total	556	56 (10.1)	149 (26.8)	716	48 (6.7)	94 (13.1)	104 (8.2)	243 (19.1)

It is seen from table-7 that prevalence of HBP was more among all type of obese group in respect to non-obese counterpart. Overweight and obesity were significantly associated with risk of hypertension. Central obesity (indicated by age and sex specific > 85th percentile of WC, HC and WC: Ht) and upper body obesity (indicated by age and sex specific > 85th percentile of NC and NC: Ht) were also associated with HBP.

The association between BMI, NC, NC: Ht, WC, HC, WC: Ht with HBP was found to be statistically highly significant among male adolescents. Like male similar result was obtained for female except that there is no significant association between HBP and NC: Ht.

Table-7: Association between anthropometric obesity markers and high blood pressure

Obesity indices	Gender	Grade of obesity	Non-HBP	HBP	Chi square
BMI	Male	Underweight to Normal	360	106 (22.7)	22.09 (df-1; p<0.001)
		Overweight to obesity	48	42 (46.7)	
	Female	Underweight to Normal	537	60 (10.1)	23.17 (df-1; p<0.001)
		Overweight to obesity	85	34 (28.6)	
NC	Male	< 85th percentile	349	105 (23.1)	17.00 (df-1; p<0.001)
		> 85th percentile	58	44 (43.1)	
	Female	< 85th percentile	544	63 (10.4)	20.50 (df-1; p<0.001)
		> 85th percentile	78	31 (28.4)	
NC: Ht	Male	< 85th percentile	368	117 (24.1)	13.85 (df-1; p<0.001)
		> 85th percentile	39	32 (45.1)	
	Female	< 85th percentile	595	85 (12.5)	3.63 (df-1; p > 0.05)
		> 85th percentile	27	9 (25.0)	
WC	Male	< 85th percentile	363	105 (22.4)	26.70 (df-1; p<0.001)
		> 85th percentile	44	44 (50.0)	
	Female	< 85th percentile	540	68 (11.2)	10.37 (df-1; p<0.01)
		> 85th percentile	82	26 (24.1)	
HC	Male	< 85th percentile	349	107 (23.5)	13.83 (df-1; p<0.001)
		> 85th percentile	59	42 (41.6)	
	Female	< 85th percentile	531	70 (11.6)	5.59 (df-1; p<0.02)
		> 85th percentile	91	24 (20.9)	
WC: Ht	Male	< 85th percentile	362	116 (24.3)	11.12 (df-1; p<0.001)
		> 85th percentile	45	33 (42.3)	
	Female	< 85th percentile	543	69 (11.3)	9.86 (df-1; p<0.01)
		> 85th percentile	79	25 (24.0)	

DISCUSSION:

In this study prevalence of EBP and HBP was 10.1% and 26.8% for male and 6.8% and 13.1% for female. Overall prevalence of EBP and HBP was 8.2% and 19.1% respectively. The prevalence of HBP in most studies in India were variable and ranging from 2.2% to 25.1%[21,22]. In a large cross sectional study in central India on children between 5-15 years of age was found prevalence of HBP 6.8% among boys and 7.0% among girls[23]. Prevalence of HBP was 4.5% among school going adolescents of North India[24] and 6.48% in Western India[25]. Ujunwa et al.[26] reported that the prevalence of HBP and EBP was 5.4% and 17.3% respectively. Another study conducted by Fan et al[27] showed that prevalence of HBP and EBP was 10.6% and 6.0% respectively. There is significant heterogeneity of prevalence of HBP in different studies partly due to the age group studied, use of different cutoffs for diagnosing HBP and difference in the BP measurement procedure.

Elevation of BP in childhood frequently progresses to adult hypertension[28,29] resulting in increased risk of cardiovascular accident. Thus early detection of HBP and associated risk factors is essential to prevent long term adverse effect in adulthood. It is well established that obesity is an important

risk factor for hypertension and anthropometric indicators had proven to be an effective approach in predicting HBP[15].

BMI, indicator of general obesity is restricted in screening regional body fat distribution. WC is superior to BMI in identifying central adiposity reflecting higher cardiovascular risk. NC has been suggested as an index of upper body fat distribution [30]and as a surrogate marker of central obesity in children and adults[31, 32]. NC, indices of upper body subcutaneous fat[33] is now considered as an alternative screening tool for hypertension[34].

In the present study significant positive correlation was noted between all anthropometric obesity indicators and systolic and diastolic blood pressure except waist-hip ratio. It is seen that prevalence of HBP was more among all type of obese group in respect to non-obese counterpart. The association between BMI, NC, NC: Ht, WC, HC, WC: Ht with HBP was found to be statistically highly significant among male adolescents. Like male similar result was obtained for female except that there is no significant association between HBP and NC: Ht. Thus obesity either general, or abdominal or upper body is the risk factor for HBP in adolescence.

A limitation of the study was no availability of biochemical measurements. Secondly we didn't record family history of hypertension which may have some effect on the blood pressure status. However, the community surveys for screening hypertension with noninvasive measurement anthropometric obesity indices are very much useful.

CONCLUSION:

In this study we found unexpectedly large burden of HBP in adolescent male and females living in Hooghly, West Bengal, India. As children with HBP are likely to become adults with HBP, suggesting urgent need of early screening and detection of risk factors. In conclusion it is recommended most of the anthropometric obesity indicators viz BMI, NC, WC, HC, WC;Ht and NC:Ht are useful for prediction of hypertension among adolescents having 11-17 years of age.

REFERENCES:

1. Souza MCBD, Rivera IR, Silva MAMD, Carlos A, Carvalho C. Relationship of obesity with high blood pressure in children and adolescents. Arq Bras Cardiol. 2010; 94 (6): 714-719.
2. Lurbe E, Cifkova R, Cruickshank JK, Dillon MJ, Ferreira I, Invitti C, et.al. Management of high blood pressure in children and adolescents: recommendation of European Society of Hypertension. J.Hypertens. 2009; 27(9): 1719-1742.
3. Pareskar SS, Singh MM, Venkatesh BT. High blood pressure and its association with obesity among preuniversity college students of Udupitaluk .Int J Med Sci Pub Health. 2015; 4 (7): 950-956.
4. World Health Organization. The World Health Report 2002. Geneva, Switzerland:WHO, 2002.
5. Sorof JM, Alexandrov AV, Garami Z. Carotid ultrasonography for detection of vascular abnormalities in hypertensive children. PediatrNephrol. 2003; 18(10): 1020-1024.
6. Chobanian AV, Bakris GL, Black HR, KushmanWC, Green LA, Izzo JL Jr, et.al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC-7 report. JAMA. 2003; 289(19): 2560-2572.
7. Androutsos O, Grammatikaki E, Moschonis G, Roma-giannikou E, Chrousos GP, Manios Y, Kanaka-Gantenbein C. Neck circumference: a useful screening tool of cardiovascular risk in children. Pediatric Obesity. 2012; 7: 187-195.
8. Hall JE. The kidney, hypertension and obesity. Hypertension. 2003; 41: 625-633.
9. Dong J, Guo XL, Lu ZL, et al. Prevalence of overweight and obesityand their association with blood pressure among children and adolescent in Shandong, China. BMC Public Health. 2014; 14:1080.
10. Yang Y, Dong B, Wang S, Dong Y, Zou Z, Fu L, Ma J. Prevalence of high blood pressure subtypes and its association with BMI in Chinese children: a national cross sectional survey. BMC Public Health. 2017; 17:598.
11. Youfa W, Hyunjung L. The global childhood obesity epidemic and the association between socio-economic status and childhood obesity. Int Rev Psychiatry. 2012; 24: 176-188.
12. WHO. Commission on Ending Childhood Obesity (ECHO). Facts and figures on childhood obesity. Geneva, Switzerland World Health Organization; 2014.
13. Kaur S, Kapil U, Sing P. Pattern of chronic diseases amongst adolescent obese children in developing countries. Curr Sci. 2005; 88: 1052-1056.
14. George C, Goedecke JH, Crowther NJ, Jaff NG, Kengne AP, Norris SA, et.al. The role of the body fat and fat distribution in hypertension risk in urban Black South African women. PloS ONE, vol. II no. 5. Article ID e0154894, 2016.
15. Duren DL, Sherwood RJ, Czerwinski SA, Lee M, Choh AC, Siervogel RM, et.al. Body composition methods: comparisons and interpretation. J Diabetes Sci. Technolog. 2008; 2(6): 1139-1146.
16. Smith L. New AHA. Recommendation for blood pressure measurement. Am J Fam Physician. 2005; 72: 1391-1398).
17. National High Blood Pressure Education Program Working Group. The fourth report on the diagnosis, evaluation and treatment of high blood pressure in children and adolescent. Pediatrics. 2004; 114: 555-576.
18. Flynn JT, Kaelber DC, Baker-Smith CM et.al. Subcommittee on Screening and Management of High Blood Pressure in children. Clinical Practice guideline for screening and management of high blood pressure in children and adolescents. Pediatrics. 2017; 140(3): e20171904. doi: 101542/peds. 20171904.
19. Pramanik P. Prevalence of prehypertension and its association with obesity markers in young Indian adults. Eur. J Biomed Pharmaceutical Sci. 2017; 4(12): 624-629.
20. Center for Disease Control and Prevention and National Center for Health Statistics: 2000 CDC Clinical Growth Charts. Available from https://www.cdc.gov/growthcharts/clinical_charts.htm
21. Gupta A, Sachdeva A, Mahajan N, et al. Prevalence of pediatric metabolic syndrome and associated risk factors among school –age children of 10-16 years living in District Shimla, Himajhal Pradesh, India. Indian J Endocrinol Metab. 2018; 22(3): 373-378.
22. Meena J, Sing M, Agarwal A, Chauhan A, Jaiswal N. Prevalence of hypertension among children and adolescents in India: a systematic review and meta-analysis. Indian J Pediatr. 2021; 88(11): 1107-1114.
23. Patel A, Bharani A, Sharma M, Bhagwat A, Ganguli N, Chouhan DS. Prevalence of hypertension and prehypertension in school children from Central India. Ann PediatrCardiol. 2019; 12(2): 90-96.
24. Kumar P, Kumar D, Ranjan A, Sing CM, Pandey S, Agarwal N. Prevalence of hypertension and its risk factors among school going adolescents of Patna, India. J Clinical diagnostic Res. 2017; 11(1):1
25. Charan J, Buch N, Goyel JP, Kumar N, Parmar I, Shah VB. Prevalence of hypertension in school going children in Surat City, Western india. J Cardiovascular Dis Res. 2011; 2(4): 228-232.
26. Ujunwa FA, Ikefuna AN, Nwokocha AR, Chinawa JM. Hypertension and prehypertension among adolescents in secondary school in Enugu, South-east Nigeria. Italian J Pediatr. 2013; 39(1): 70
27. Fan Z, Liao Z, Zong X, Zhang S. Differences in prevalence of hypertension and prehypertension in children and adolescents in eastern, central and western regions of China from 1991-2011 and the associated risk factors. PloS One. 2019; 14(1):
28. Yang L, Magnussen CG, Yang L, Bovet P, Xi B. Elevated blood pressure in childhood or adolescence and cardiovascular outcomes in adulthood: a systematic review. Hypertension. 2020; 75(4): 948-955.
29. Lai CC, Sun D, Cen R, etai. Impact of long-term burden of excessive adiposity and elevated blood pressure from childhood on adulthood left ventricular remodelling patterns: the Bogalusa Heart Study. J Am CollCardiol. 2014; 64 (15): 1580-1587.
30. Ben-Noun L, Sohar E, Laor A. Neck circumference as a simple screening measure for identifying overweight and obesity patients. Obes Res. 2001; 9(8): 470-477.
31. Hatipoglu N, MaziciogluMM, Kurtoglu S, Kendirci M. Neck circumference: an additional tool of screening overweight and obesity in childhood. Eur J Pediatr. 2010; 169: 733-739.
32. Ben-Noun L, Sohar E, Laor A. Neck circumference as a simple screening measure for identifying overweight and obese patients. Obes Res. 2011; 9: 470-477.
33. Preis SR, Massaro JM, Hoffmann U, D'Agostino RB, Levy D, Robins SJ, et.al. Neck circumference as a novel measure of cardiometabolic risk: the Framingham heart study. J Clin Endocrinol Metab. 2010; 95: 3701-3710.
34. Pramanik P. Identification of risk of cardiovascular diseases in asymptomatic young adults using neck circumference. Int J Pharmacy Biol Sci. 2019; 9(2):1266-1273.