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Research Article

EPIDEMIOLOGY OF BLOOD PRESSURE IN RELATION TO CERTAIN QUANTITATIVE TRAITS AMONG URBAN PUNJABI ADOLESCENTS

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ABSTRACT

The objective of the present work was to study the blood pressure with respect to some anthropometric characteristics in adolescent's age groups. The study comprised 1225 subjects (634 males and 591 females) aged 10-18 years. The range of average blood pressure (systolic/diastolic) was 116.33-134.52/ 78.23-92.62 mmHg in males and 117.71-128.75/ 77.97-88.85 mm Hg in females of 10 to 18 years of age respectively. It was observed that 11 and 12 years of age groups were more susceptible for pre-hypertension (4.49% and 4.24% respectively). Whereas, 10 years and 14 years age groups were more susceptible for hypertension (6.12% and 4.40% respectively). According to multivariate regression analysis, systolic and diastolic blood pressure was significantly associated with weight, BMI and waist circumference. The results of the present analysis support the hypothesis that BMI is a significant predictor of blood pressure in adolescent age groups.

Keywords: Adolescent, Blood pressure, Anthropometric characteristics and Punjab

INTRODUCTION

Cardiovascular diseases (CVD) have become a ubiquitous cause of morbidity and a leading contributor to mortality in whole world and especially in developing countries. Although the present high burden of CVD deaths is in itself an adequate reason for attention, a greater cause for concern is the early age of CVD deaths in the developing countries like India. According to World Health Report [1], CVD will be the largest cause of death and disability by 2020 in India and also India becomes the capital of heart diseases in near future because it is estimated that 2.6 million Indians are predicted to be died due to coronary heart disease which is almost 54% of CVD related deaths in the world. Extensive literature exists, which documented that the blood pressure is a strong risk factor for cardiovascular diseases. The increasing prevalence of hypertension is a worldwide trend and is becoming a significant public health problem.[2-10] Cardiovascular diseases in adults have been related to the prevalence of risk factors in childhood [2] hence there is definite need to monitor the prevalence of risk factors in the adolescent age group and plan intervention measures for the same. It has been suggested that high diastolic blood pressure is a strong predictor of heart attack and stroke in young age and in people of any age with essential hypertension. Furthermore, high blood pressure in pediatric population's progress to hypertension in adults, especially among children and adolescents with a tendency to develop excess weight during the growth phase. [11] Blood pressure from unknown causes creates a major concern and health burden in all ages in the present day. There is abundant epidemiological evidence that environmental cofactors and anthropometric variables are directly and consistently associated with cardiovascular morbidity, mortality and levels of cardiovascular risk factors in the developing countries like India.[12-20]

The vast majority of the studies reported significant relationship between blood pressure and anthropometric measurements. [21-25] Different anthropometric measurements like height, weight, BMI, waist and hip circumferences, waist to hip ratio, waist to height ratio, conicity index and thickness of different skinfolds were overwhelmingly used in present day as a risk factor for cardiovascular diseases. [26-30] BMI and WHR are widely used as a reflection of accumulation of abdominal and visceral fat because role of visceral fat to increase blood pressure and obesity is well documented. [31-32] However different anthropometric measurements such as BMI, WHR and thickness of skinfolds have showed different types of association with SBP and DBP. Despite of different associations, it is suggested that a consistent and substantial relationship between SBP and DBP with anthropometric measurements have been observed in every population. Therefore, cardiovascular diseases in adolescents are also associated with various risk factors, including hypertension, dyslipidemia and elevated insulin levels. [2,3,33-35] Genetic studies of blood pressure have suggested varying degrees of genetic and common environmental influences. The most common findings from different studies have suggested the significant effects of various anthropometric variables and cholesterol, obesity, nutrition, alcohol intake, smoking, oral contraceptive usage and stress on blood pressure phenotypes. [36-44] In India, the burden of cardiovascular diseases has increased many folds in recent times due to increase of westernized diets, life styles and increasing mean age of population. The risk factors for CVDs seem to cut across all demographic regions in India

There are very few systematic and population based studies related to blood pressure and anthropometric measurements available in adolescent population. However, it is reported that development of cardiovascular diseases has their origin in adolescence time. [10] Therefore it is clear that many traditional risk factors such as higher blood pressure, obesity and related metabolic determinants are significantly prevalent among adolescent age group. It is assumed that high risk adolescents are likely to become high risk adults. [45] The objectives of the study are to analyze the trends of blood pressure variations with respect to anthropometric variables in different adolescent age group and to clarify that which of the anthropometric indices is best predictor for cardiovascular risk factors and also to determine the magnitude of association varies with the gender in adolescent population in Punjab.

MATERIALS AND METHODS

For data collection, independent random samples were drawn using two stage sampling. Firstly, identified the modernized town/localities and schools in urban areas of Punjab. In the second stage, sample stratified by gender and age groups likely 10 to 18 years were taken. Consent to conduct the school survey for anthropometric and physiometric measurements of the students were obtained from parents through school authorities. Signed consent was taken from the children after demonstrating and explaining the procedure.

Sampling

Data collection were carried out by face to face interviews at the schools. In addition to anthropometric and physiometric measurements, the other information like demographic features, socio-economic status, food habits, life style behavior, time spent on TV watching, reading and exercise, smoking habits, alcohol intake and family history about hypertension were collected through well

designed questionnaire. Simple random sampling was done and only healthy individuals were recruited in the study. A total 1225 healthy adolescent children aged 10 to 18 years were ascertained, which includes 634 boys and 591 girls.

Blood Pressure Measurements

Children from the representative sample were called for screening according to their classes and were given rest for five minutes. The procedures were explained briefly and demonstrated to them. Those children who would be cooperative and relaxed undergo blood pressure measurement. An adequate time was given to others to come to terms with the procedure. The blood pressure was measured with standardized mercury sphygmomanometer and a stethoscope by following the recommendations of American Heart Association. [46] Blood Pressure was measured in sitting posture with the hands resting on examining table with the cubital fossa supported at the level of the heart. Chairs of adequate height were used for various groups. The stethoscope was placed over the brachial artery pulse, proximal and medial to the cubital fossa and below the bottom edge of the cuff (i.e. about 2 cms above the cubital fossa). The blood pressure measurement was done on the right arm of subject. On the basis of circumference of the participant's arm, a regular adult or small or medium cuff was chosen. The cuff was placed on the participant's right arm, which is at the heart level and inflated until the cuff pressure was 20mm Hg above the level of which the radial pulse disappeared. The systolic blood pressure is defined as the appearance of the first sound (Korotkoff phase I) and diastolic blood pressure is defined as the disappearance of sound (Korotkoff phase V). The average of the 3 blood pressure measurements was used as the estimate of SBP and DBP in the present analysis. Mean arterial blood pressure (MBP) is defined as the average pressure level during the cardiac cycle and MBP was simply estimated as DBP+(SBP-DBP)/3. To calculate the pulse rate, the radial artery at the wrist is most commonly used to feel the pulse. It was count over one minute and pulse pressure was calculated through SBP and DBP using the formula: pulse pressure=SBP-DBP.

Anthropometric Measurements

The anthropometric measurements were taken from each individual including height, weight, sitting height, waist and hip circumferences, three skinfolds (biceps, triceps and sub-scapular). All measurements were taken with standard anthropometric technique. [47-48] BMI was calculated as weight in Kilograms divided by height in meters squared. WHR was calculated as waist circumference divided by hip circumference.

Statistical Analysis

Appropriate analysis was done through statistical package for social studies (SPSS 17.0) version using different statistical parameters.

RESULTS

In the present study, sampling has been done from the schools of urban areas of Punjab. A total of 1225 subjects have been sampled for various anthropometric and physiometric measurements, age ranged from 10 to 18 years old. In the total sample size there are 634 boys (51.76%) and 591 girls (48.24%) which are further classified according to age and sex as shown in table 1. The means and standard deviations for measured anthropometric and physiometric phenotypes of the samples studied among Punjabi male and female adolescent children aged 10 to 18 years are illustrated in tables 2 and 3 respectively. In general, girls have higher mean values of hip circumferences, bicep skinfold and diastolic blood pressure among all the age groups (10 to 18 years). Furthermore, the mean values of WHR, systolic blood pressure and pulse pressure except 11 years age group have found significantly higher among male children within all age groups. Mean values for height, weight, sitting height, waist and hip circumferences, biceps, triceps and subscapular skinfolds increased with age in both sexes except 15 years age in male and 17 year age in females where means of all these characters dropped slightly. There are some characteristics like height, weight, BMI, sitting height and mean MBP which have higher mean values among females than in males in younger age groups (10 to12 or 13years), but in elder age groups (13 or 14 to 18 years) males have higher mean values than females for same characteristics. The mean values of SBP and DBP in male and female children consistently increasing with age after 13 years in boys and 15 years in girls. Mean values of SBP and BMI were significantly higher (with 1 or 2 exceptions) in males ($p \leq 0.001$) than in females and mean value of DBP is higher (except 10 year age) in females than in males (Tables 2 and 3). The age adjusted correlation coefficients between SBP, DBP and MBP with anthropometric indicators are presented in table 4. Almost all the variables except WHR were significantly related to SBP, DBP and MBP among both sexes. The magnitude of correlations between anthropometric variables and SBP were generally stronger for male group as compared to female group. Pulse rate was not associated with SBP among males. In males, the weight has shown strongest association with SBP and DBP (r=0.51 for SBP; r=0.44 for DBP) which is followed by pulse pressure and BMI for SBP (r=0.48 and 0.42 respectively) and hip circumference and BMI for DBP (r=0.37 and 0.36 respectively). In females, the pulse pressure and waist circumference for SBP (r=0.57 and 0.35 respectively) and BMI and waist circumference for DBP (r= 0.38 and 0.37 respectively) have shown strongest association.

In linear regression model, the intercept, the standardized regression coefficients with associated standard error (SE), percent of variance accounted by regression and level of significance of variance for SBP and DBP have been presented in table 5 and 6 among both Punjabi adolescent male and female children. Regression coefficients for all the selected variables (age, height, weight, BMI, sitting height, waist and hip circumferences, biceps, triceps and subscapular skinfolds and pulse pressure) except WHR and pulse rate for SBP and DBP have been found significant ($p<0.001$) among both sexes. Maximum percent of variance (R^2) in studied variables among males have been found for weight (25.8% for SBP and 19.4% for DBP) and has been followed by BMI (17.5% for SBP and 12.8% for DBP), waist circumference (16.9% for SBP) and hip circumference (13.5% for DBP). The maximum percent of variance (R^2) have been found among females in waist circumference (11.7% for SBP and DBP) and has been followed by weight and BMI (11.5% for SBP and DBP respectively).

The results of multivariate analysis for SBP and DBP conducted on selected variables such as age, height, weight, BMI, sitting height, waist and hip circumferences, WHR, biceps, triceps and subscapular skinfolds, pulse rate and pulse pressure have shown in table 7. Height, weight and BMI are significantly associated with SBP and DBP in both sexes. Beyond common variables triceps skinfold and pulse pressure in males and pulse rate in females are significantly associated with SBP and DBP. In addition to that biceps skinfold has shown association with SBP and age has relation with DBP in case of females. In overall multivariate analysis, it was observed height, weight and BMI were strong predictor for SBP and DBP among both sexes. Whereas, pulse rate was observed as a strong predictor for SBP and DBP among females. Age has also significant impact on DBP in females. Prevalence of hypertension in total sample in both sexes has been shown in table 8. Among pooled data, a total of 172 (14.04%), 418 (34.12%) and 635 (51.84%) were found to be pre-hypertensive, hypertensive and normo-tensive respectively. Among the age distribution, it was observed that 11+ and 12+ year age group for pre-hypertension and 10+, 13+ and 14+ years age group for hypertension were more susceptible.

The pronounced influences of the BMI, waist circumference, WHR, biceps and triceps skinfolds on blood pressure (SBP and DBP) were observed by using stepwise regression model. The results have depicted in table 9. All the models (every model has different combination of various anthropometric variables) have shown strong relation with the SBP and DBP among both sexes. The model 1 (BMI) accounted for 17.6% and 12.9% for males and 11.7% and 14.6% for females of total variation in SBP and DBP respectively. However, for final model (model5: BMI, waist circumference, WHR, biceps and triceps skinfold) these values increased to 21.3%, 16.1% for males and 14.2%, 16.7% for females of total variation in SBP and DBP respectively. F ratios for all models have been found significant ($p < 0.001$) for SBP and DBP. However, from the magnitude of F ratio

it could be seen that model 1 (BMI) provided a better insight into the importance of predictors in these models and have more impact as compared to other models.

Table 1: Distribution of subjects according to age and gender for 1225 adolescent children in Punjab

Age in years	Males		Females		Total	
	N	%age	N	%age	N	%age
10+	59	4.82	54	4.41	113	9.22
11+	82	6.69	70	5.71	152	12.41
12+	94	7.67	69	5.63	163	13.31
13+	91	7.43	80	6.53	171	13.96
14+	86	7.02	75	6.12	161	13.14
15+	74	6.04	68	5.55	142	11.59
16+	56	4.57	62	5.06	118	9.63
17+	50	4.08	61	4.98	111	9.06
18+	42	3.43	52	4.24	94	7.67
TOTAL	634	51.76	591	48.24	1225	100

Table 2: Mean and Standard Deviations of measured phenotypes among urban Punjabi male adolescents aged 10-18 years

Age (years)Variables	10-10.9 (N=41)		11-11.9 (N=40)		12-12.9 (N=39)		13-13.9 N=38)		14-14.9 (N=42)		15-15.9 (N=52)		16-16.9 (N=40)		17-17.9 (N=41)		18-18.9 (N=28)	
	Mea	S.D	Mea	S.D	Mea	S.D	Mea	S.D	Mea	S.D	Mea	S.D	Mea	S.D	Mea	S.D	Mea	S.D
Height (cm)	135.83	5.91	138.32	8.82	143.70	7.70	150.85	7.41	160.01	9.67	164.91	7.78	169.34	7.73	173.14	6.41	174.93	6.59
Weight (kg)	28.95	6.09	30.68	7.03	34.44	7.13	40.53	9.03	48.37	11.44	49.09	10.40	51.12	8.31	55.16	10.49	62.51	14.23
BMI (kg/m^2)	15.58	2.47	15.89	2.26	16.51	2.36	17.70	3.15	18.76	3.53	17.95	3.05	17.80	2.48	18.33	2.92	20.37	4.17
Sitting Height (cm)	70.86	3.83	71.07	4.55	72.86	3.84	75.51	4.09	80.20	4.37	81.87	4.79	83.21	4.20	84.74	3.94	86.54	3.90
Waist circum. (cm)	56.41	6.00	55.59	6.08	58.47	6.83	65.15	8.71	68.62	9.52	65.46	9.29	66.21	6.25	68.90	5.69	72.48	7.99
Hip circumference(cm)	65.75	5.65	67.82	6.73	70.27	7.32	76.42	8.24	82.28	9.35	81.97	6.62	83.39	6.22	84.92	7.22	87.76	8.72
WHR	0.86	0.06	0.82	0.06	0.83	0.07	0.85	0.07	0.83	0.06	0.80	0.08	0.80	0.06	0.82	0.09	0.83	0.05
Biceps Skinfold(mm)	5.70	3.30	5.45	3.21	6.18	4.15	7.38	3.64	8.37	4.54	6.33	4.06	5.58	2.11	6.84	4.17	7.92	5.77
Triceps Skinfold(mm)	8.54	4.40	8.81	5.66	9.12	6.37	11.32	5.44	12.41	6.40	9.24	5.57	8.09	4.40	9.44	5.89	11.93	7.27
SubscapularSkinfold(mm)	8.02	3.75	8.85	4.68	10.06	6.46	11.76	5.38	13.08	6.77	10.09	4.97	10.32	3.86	13.14	6.04	15.38	8.37
SBP (mm of Hg)	119.41	14.33	116.35	11.71	116.33	12.25	119.51	11.74	122.00	14.34	124.46	12.94	125.36	10.26	132.20	13.60	134.52	11.52
DBP (mm of Hg)	82.12	11.15	78.23	10.04	78.24	12.63	78.79	9.02	82.09	12.84	85.20	11.24	86.96	10.08	90.80	10.27	92.62	13.08
MBP (mm of Hg)	94.72	11.83	90.94	9.82	90.94	12.00	92.36	9.35	95.36	12.75	98.38	11.00	99.70	9.33	104.60	10.45	106.59	12.09
Pulse rate	77.19	7.57	77.16	6.96	76.89	7.42	76.22	6.45	77.14	6.49	76.95	5.90	76.50	6.64	77.74	6.58	77.02	6.34
Pulse Pressure	37.29	7.90	38.12	8.65	38.03	7.63	40.71	7.55	39.91	8.28	39.53	9.07	38.21	8.11	41.40	10.10	41.90	7.40

Table 3: Mean and Standard Deviations of measured phenotypes among urban Punjabi female adolescents aged 10-18 years

Age(yrs) Variables	10-10.9 (N=41)		11-11.9 (N=40)		12-12.9 (N=39)		13-13.9 (N=38)		14-14.9 (N=42)		15-15.9 (N=52)		16-16.9 (N=40)		17-17.9 (N=41)		18-18.9 (N=28)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D	Mean	S.D.	Mean	S.D.	Mean	S.D	Mean	S.D.	Mean	S.D.
Height (cm)	137.85	4.92	141.17	7.84	147.26	7.27	152.66	6.96	155.31	6.74	159.02	5.86	159.83	5.52	159.56	5.30	160.47	5.31
Weight (kg)	30.64	4.50	31.21	5.57	36.19	7.67	39.93	8.42	43.07	7.40	44.60	6.66	48.91	9.65	48.10	9.15	48.86	7.91
BMI (kg/m^2)	16.14	1.98	15.59	1.87	16.55	2.44	17.07	3.03	17.82	2.68	17.59	2.28	19.12	3.54	19.58	6.33	18.95	2.79
Sitting Height (cm)	71.39	2.34	71.39	3.97	74.93	4.34	76.88	4.42	78.01	6.19	80.78	4.15	81.84	3.97	81.26	2.80	81.40	7.28
Waist circumference(c	57.00	6.25	56.56	4.01	58.61	7.84	61.24	7.48	63.41	6.04	63.65	6.26	66.47	9.40	65.07	7.49	64.83	5.71
Hip circumference(c	68.78	6.89	68.71	6.33	74.69	7.99	77.91	7.62	82.05	7.57	83.38	6.86	85.66	8.89	85.28	8.71	83.38	7.98
WHR	0.83	0.06	0.83	0.06	0.79	0.10	0.79	0.07	0.77	0.05	0.76	0.06	0.77	0.06	0.76	0.05	0.78	0.07

Biceps Skinfold(mm)	5.83	3.24	5.46	2.53	6.36	3.16	6.22	2.22	8.38	3.43	8.73	3.91	9.94	4.33	9.73	4.46	8.53	3.24
Triceps Skinfold(mm)	8.46	4.28	8.36	3.80	9.01	3.98	9.08	3.06	11.97	4.00	11.60	4.26	13.65	5.00	13.84	6.21	13.47	5.22
Subscapular Skinfold(mm)	10.10	4.45	9.49	8.03	9.99	3.70	9.96	3.79	12.82	4.93	12.44	4.32	14.92	4.28	15.10	6.71	14.20	4.88
SBP (mm of Hg)	118.33	14.63	117.71	13.72	118.26	13.36	119.44	14.56	121.73	13.69	119.41	9.91	126.21	15.59	127.38	16.09	128.75	11.33
DBP (mm of Hg)	80.19	10.90	79.71	9.40	77.97	12.99	80.00	10.79	83.15	11.27	83.38	10.74	85.48	11.97	86.64	13.13	88.85	10.78
MBP (mm of Hg)	92.90	11.78	92.38	10.06	91.35	12.34	93.87	13.33	96.01	11.41	95.59	9.38	98.42	11.64	100.22	13.60	102.21	10.53
Pulse rate	77.72	6.74	76.51	7.01	78.04	6.55	77.34	7.71	76.63	6.63	75.47	6.69	75.61	7.39	75.80	8.13	76.23	7.43
Pulse Pressure	38.15	7.29	38.00	9.57	40.29	9.07	39.56	8.83	38.57	8.70	36.62	9.87	40.73	9.91	40.74	8.56	39.90	6.45

Table 4: Age Adjusted correlation coefficient between systolic, diastolic and mean arterial blood pressure and selected anthropometric and physiometric indicators in male and female adolescents aged 10 to 18 years

Variables	SBP		DBP		MBP	
	Males(n=634)	Females(n=591)	Males(n=634)	Females(n=591)	Males(n=634)	Females(n=591)
Height	0.40**	0.19**	0.35**	0.18**	0.38**	0.19**
Weight	0.51**	0.34**	0.44**	0.36**	0.49**	0.38**
BMI	0.42**	0.34**	0.36**	0.38**	0.40**	0.39**
Sitting Height	0.41**	0.19**	0.36**	0.18**	040**	0.20**
Waist Circumference	0.41**	0.35**	0.35**	0.37**	0.39**	0.38**
Hip Circumference	0.41**	0.30**	0.37**	0.34**	0.41**	0.34**
WHR	0.06	0.05	0.02	0.03	0.04	0.04
Biceps skinfold	0.22**	0.32**	0.19**	0.33**	0.21**	0.34**
Triceps skinfold	0.19**	0.29**	0.16**	0.31**	0.18**	0.32**
Subscapular skinfold	0.30**	0.24**	0.26**	0.27**	0.29**	0.27**
Pulse Rate	0.07	0.08*	0.08*	0.09*	0.08*	0.09*
Pulse Pressure	0.48**	0.57**	0.14**	0.06	0.09*	0.19**

*** Correlation is significant at the 0.01 level (2-tailed)**

**** Correlation is significant at the 0.001 level (2-tailed)**

Table 5: Standardized regression coefficient and standard error (SE) with 't' value and percent of variance (R^2) for SBP with selected anthropometric and physiometeric variables in Linear regression model among Punjabi adolescent male and female

Variables	Males (n=634)					Females (n=591)				
	Intercept	Coefficient ± SE	t	P	R^2	Intercept	Coefficient ± SE	t	P	R^2
Age	92.63	2.17 ± 0.22	10.03	<0.001	0.136	102.91	1.35 ± 0.23	5.94	<0.001	0.055
Height	67.89	0.35 ± 0.03	10.80	<0.001	0.154	81.39	0.26 ± 0.06	4.57	<0.001	0.033
Weight	100.26	0.51 ± 0.03	14.86	<0.001	0.258	101.96	0.48 ± 0.05	8.81	<0.001	0.115
BMI	90.61	1.80 ± 0.16	11.62	<0.001	0.175	93.81	1.60 ± 0.18	8.82	<0.001	0.115
Sitting Height	57.67	0.83 ± 0.07	11.41	<0.001	0.169	91.14	0.40 ± 0.08	4.81	<0.001	0.036
Waist Circumference	84.24	0.59 ± 0.05	11.41	<0.001	0.169	81.85	0.64 ± 0.07	8.91	<0.001	0.117
Hip Circumference	80.22	0.54 ± 0.05	11.41	<0.001	0.169	87.44	0.43 ± 0.06	7.60	<0.001	0.088
WHR	112.06	12.06 ± 7.92	1.52	0.128	0.002	114.30	9.31 ± 8.43	1.10	0.270	0.000
Biceps skinfold	117.08	0.75 ± 0.13	5.62	<0.001	0.046	112.31	1.22 ± 0.15	8.21	<0.001	0.101
Triceps skinfold	117.77	0.43 ± 0.09	4.77	<0.001	0.033	112.53	0.83 ± 0.12	7.25	<0.001	0.080
Subscapular skinfold	114.55	0.68 ± 0.09	7.90	<0.001	0.088	114.17	0.62 ± 0.10	6.11	<0.001	0.058
Pulse Rate	111.32	0.14 ± 0.08	1.73	0.085	0.003	109.61	0.16 ± 0.08	1.92	0.055	0.005
Pulse Pressure	90.84	0.79 ± 0.06	13.87	<0.001	0.232	85.71	0.92 ± 0.06	16.73	<0.001	0.321

Table 6: Standardized regression coefficient and standard error (SE) with 't' value and percent of variance (R^2) for DBP with selected anthropometric and physiometeric variables in Linear regression model among Punjabi adolescent male and female

Variables	Males (n=634)					Females (n=591)				
	Intercept	Coefficient± SE	t	P	R^2	Intercept	Coefficient ± SE	t	P	R^2
Age	59.30	1.72 ± 0.19	8.89	<0.001	0.110	102.91	1.35 ± 0.23	5.94	<0.001	0.055
Height	40.80	0.27 ± 0.03	9.26	<0.001	0.118	81.39	0.26 ± 0.06	4.57	<0.001	0.033
Weight	66.01	0.39 ± 0.03	12.3	<0.001	0.194	101.96	0.48 ± 0.05	8.81	<0.001	0.115
BMI	58.91	1.36 ± 0.14	9.68	<0.001	0.128	93.81	1.60 ± 0.18	8.82	<0.001	0.115
Sitting Height	32.71	0.64 ± 0.07	9.79	<0.001	0.130	91.14	0.40 ± 0.08	4.81	<0.001	0.036
Waist Circumference	54.42	0.45 ± 0.05	9.39	<0.001	0.121	81.85	0.64 ± 0.07	8.91	<0.001	0.117
Hip Circumference	49.65	0.43 ± 0.04	9.99	<0.001	0.135	87.44	0.43 ± 0.06	7.60	<0.001	0.088
WHR	79.70	3.66 ± 7.01	0.52	0.602	0.000	114.30	9.31 ± 8.43	1.10	0.270	0.000
Biceps skinfold	78.93	0.57 ± 0.12	4.83	<0.001	0.034	112.31	1.22 ± 0.15	8.21	<0.001	0.101
Triceps skinfold	79.54	0.32 ± 0.08	4.00	<0.001	0.023	112.53	0.83 ± 0.12	7.25	<0.001	0.080
Subscapular skinfold	76.96	0.52 ± 0.08	6.79	<0.001	0.066	114.17	0.62 ± 0.10	6.11	<0.001	0.058
Pulse Rate	71.69	0.144 ± 0.07	2.01	<0.045	0.004	109.61	0.16 ± 0.08	1.92	0.055	0.005

Pulse Pressure	90.84	0.21 ± 0.06	3.60	<0.001	0.019	85.71	0.92 ± 0.06	16.73	<0.001	0.321

Table 7: Multivariate analysis of systolic and diastolic blood pressure on age and anthropometric and physiometric variables

Variables	SBP				DBP			
	Males (n=634)		Females (n=591)		Males (n=634)		Females (n=591)	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Age	0.61	0.38	0.75	0.32	0.65	0.35	0.64*	0.26
Height	-0.25*	0.10	-0.33**	0.10	-0.22*	0.09	-0.31**	0.08
Weight	0.56**	0.06	0.57**	0.08	0.42**	0.59	0.55**	0.07
BMI	1.38**	0.25	1.64**	0.22	1.08**	0.23	1.51**	0.18
Sitting Height	0.26	0.18	0.07	0.11	0.23	0.16	0.01	0.09
Waist Circumference	-0.10	0.11	0.29	0.13	-0.18	0.10	0.26	0.11
Hip Circumference	-0.23	0.11	-0.08	0.11	-0.23	0.10	0.04	0.09
WHR	-0.59	7.58	11.60	7.97	-5.88	6.88	6.35	6.45
Biceps skinfold	0.12	0.28	0.62*	0.24	0.13	0.26	0.49	0.20
Triceps skinfold	-0.87**	0.22	0.21	0.21	-0.73**	0.20	0.29	0.17
Subscapular skinfold	0.73	0.20	-0.01	0.16	0.59	0.18	0.02	0.13
Pulse Rate	0.14	0.07	0.22*	0.08	0.15	0.07	0.21**	0.06
Pulse Pressure	0.79**	0.06	0.92**	0.06	-0.21**	0.06	-0.08	0.06

*** Correlation is significant at the 0.01 level (2-tailed)**

**** Correlation is significant at the 0.001 level (2-tailed)**

Table 8: Prevalence of normotensives and pre-hypertensives and hypertensives in various age groups among both sexes

Age Groups	Normotensive		Pre-hypertensive		Hypertensive	
	N	%age	N	%age	N	%age
10+	38	3.102	0	0.000	75	6.122
11+	60	4.898	55	4.490	37	3.020
12+	67	5.469	52	4.245	44	3.592
13+	119	9.714	0	0.000	52	4.245
14+	107	8.735	0	0.000	54	4.408
15+	93	7.592	18	1.469	31	2.531
16+	60	4.898	16	1.306	42	3.429
17+	60	4.898	2	0.163	49	4.000
18+	31	2.531	29	2.367	34	2.776
Total	635	51.837	172	14.041	418	34.122

Table 9: Results of Stepwise Regression analysis of anthropometric predictors on blood pressure among Punjabi adolescent

Model	Systolic Blood Pressure								Diastolic Blood Pressure							
	Males (n=634)				Females (n=591)				Males (n=634)				Females (n=591)			
	R	R^2	F	P	R	R^2	F	P	R	R^2	F	P	R	R^2	F	P
Model 1	0.420	0.176	134.987	<0.00	0.342	0.117	77.739	<0.00	0.359	0.129	93.692	<0.00	0.382	0.146	100.541	<0.00
Model 2	0.437	0.191	74.513	<0.00	0.364	0.133	44.959	<0.00	0.372	0.139	50.803	<0.00	0.401	0.160	56.085	<0.00
Model 3	0.445	0.198	51.984	<0.00	0.364	0.133	29.927	<0.00	0.384	0.150	36.994	<0.00	0.401	0.161	37.458	<0.00
Model 4	0.451	0.203	40.049	<0.00	0.377	0.142	24.301	<0.00	0.390	0.152	28.221	<0.00	0.401	0.162	29.269	<0.00
Model 5	0.462	0.213	34.038	<0.00	0.377	0.142	19.409	<0.00	0.401	0.161	24.113	<0.00	0.401	0.162	23.397	<0.00

Model 1: BMI.

Model 2: BMI and Waist Circumference.

Model 3: BMI, Waist Circumference and WHR.

Model 4: BMI, Waist Circumference, WHR and Biceps Skinfold.

Model 5: BMI, Waist Circumference, WHR, Biceps Skinfold and Triceps Skinfold.

DISCUSSION

A lot of published literature exists on the relationship between blood pressure and anthropometric variables. Studies have been done among women, [49] children, [50] adolescents, [51] urban subjects [52] and elderly population. [53] Different studies explained different cut offs for hypertension and other cardiovascular disease risk factors, however the present study demonstrated that the significant differences in all characteristics between the sexes of adolescents among urban Punjabi adolescents. The present finding that correlation between height, weight, BMI, sitting height, waist and hip circumferences, biceps, triceps and subscapular skinfolds and pulse pressure and SBP have found significant association among male and female adolescents ($p \leq 0.001$).

Hence, the aim of the present study was to analyze the trends of blood pressure variations and relationship with respect to selected anthropometric characteristics in different adolescent age groups in urban section of population in Punjab. The average ranges of SBP and DBP in 10 to 18 years of adolescents are 116.33-134.52/78.23-92.62 mmHg in boys and 117.71-128.75/ 77.97-88.85 mmHg in girls. These levels of SBP and DBP in the present study were higher as compared to other reported studies in the same age group in different populations. [2, 54-61] As it was expected, among anthropometric characteristics, BMI and waist circumference were most strongly associated with SBP and DBP in both sexes. It was especially pronounced in female which was evidenced in multivariate regression analysis for both SBP and DBP. The interesting finding in the present study was that in males subscapular skinfold was strongly related with blood pressure whereas, in females biceps skinfold was strongly associated with blood pressure. Concerning association between blood pressure and age, it was observed that

age has higher contribution towards blood pressure in males as compared to females (13.6% vs 5.5% in SBP; 11% vs 5.5% in DBP for males vs females respectively). However, many investigators indicated that age was not a significant predictor of blood pressure in adolescent age groups rather than blood pressure was more closely related with body size. [62] The prevalence and severity of pre-hypertension and hypertension are increasing in adolescents. The present study suggested that 11 and 12 year age groups are more susceptible for pre-hypertension and subsequently it is converted to hypertension in 13 and 14 years of age. Therefore, pre-hypertension in childhood should be considered a chronic medical condition and thus, this study may help target prevention towards high risk individuals in this age group. This is also important that connecting adolescent's obesity with metabolic abnormalities and risk of cardiovascular diseases in adulthood. The present findings support the opinion that BMI is an important predictor for tracking blood pressure in adolescents.

Therefore, the present study revealed that almost all studied anthropometric variables were significantly correlated with SBP and DBP among both sexes, but the magnitude of the correlations were stronger in males. It is that weight, BMI, waist and hip circumferences were most important predictors of SBP and DBP among both sexes. The observation has been supported by many previous authors. [63-64]

CONCLUSION

The present study may help target prevention towards high risk individuals in this age group. This is especially important in light of evidence linking adolescent obesity with metabolic abnormalities and risk of cardiovascular diseases in adulthood.

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