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Original Article

A Study on The Relationship of Somatotype and Anthropometric Variables with Blood Pressure levels among Urban Adolescents in Howrah District, West Bengal, India

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Abstract

Introduction: Somatotype is depiction of human body build as manifested in configuration of human external morphology and the body shape and body composition can be depicted as it highlights the different components of the body constitution. Findings f rom some investigations have thrown light on the fact specific somatotype are associated with specific lif e style diseases. **Objective:** Keeping above contentions in mind, the present study was carried out among urban Bengali adolescents of West Bengal, India with the following objectives 1. Study the relationship of age and sex variation in somatotype with blood pressure. 2. Assessment of the relationship between the somatotype with hyper and hypotension of the subjects. 3. To ascertain the association of anthropometric variables and somatotype. **Methods:** The cross-sectional investigation was undertaken to evaluate association of somatotype and anthropometric variables and blood pressure of adolescent boys and girls aged 10 to 17 years. Relationship of somatotype and anthropometric indicators with physiological marker like blood pressure in adolescent boys and girls was investigated. In order to investigate such association, study participants were chosen f rom two schools of Howrah Municipal Corporation, the district city of Howrah, West Bengal. Descriptive analysis and partial correlation, regression and regression analysis (logistic) were considered for inferential statistics. **Results:** The mean values of endomorphy, mesomorphy and ectomorphyare found to be higher in boys than girls. Results of partial correlation coefficient of somatotype components with SBP and DBP in boys and girls revealed that both endomorphy and mesomorphy show significant (p<0.01) and positive correlation with both SBP and DBP. Regression analysis using somatotype components showed that all somatotype components are significant (p<0.01) predictors of both SBP and DBP. **Conclusion:** All anthropometric variables had statistically significant positive association with both SBP and DBP irrespective of sex. Somatotypes were also significantly correlated with blood pressure in both sexes.

Keywords: *Somatotype; Anthropometric Variables; Blood Pressure Variables; Adolescents*

Introduction

Leko Bankole (2017) defined Somatotype as "the present morphological configuration of the human body build" and it is the most apt representation for the human body shape and composition throwing a detailed insight into the various components of the body constitution (Leko Bankole *et.al.,* 2017).

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In 2012, Rahmawati *et.al* reported that anthropometric measurements and somatotypic components are very important in the assessment of overall growth and development and may exhibit variation in children and adolescents. It is also revealed that individuals with high endomorphic sc ores are more susceptible to hypertension in later adulthood.

It has been reported in some research f indings that somatotype profiles of adolescents during growth and development period for cardiovascular risk factors, diabetes and hypertension, and older f rail adults still need to be assessed (Yang *et.al.,* 2020; Price *et.al.,*2022; Sachdev *et.al.,* 2021; Makgae *et.al.,* 2017; Malina et.al., 1997; Baltadjiev, 2012; Baltadjiev and Vladeva,2014). In 2000, William *et al* found that in persons suffering f rom coronary heart disease, the endomorphic component was significantly correlated to increased circumference of the waist circumference and increased ratio of waist: hip.

Burgos et.al in 2013 reported f rom his study on children aged 7-18 years that a significant relationship exists between blood pressure and ectomorphic somatotype component. In 2004 Herrera et.al also found a negative association between ectomorphic components and blood pressure.

Review of Literature

World Perspective

Study in Tianjin children revealed that both BMI and WC were superior to WSR and WHR (waist hip ratio) in predicting increased blood pressure among subjects comprising of children and adolescents (Lu *et al.,* 2018). In a study among Brazilian adolescents Madruga *et al.* (2016) demonstrated that adolescents with higher WSR were 2.4 times more susceptible to hypertension than those with lower WSR. Guilherme *et al.* (2015) indicated that WC was a f itter predictor for arterial hypertension than BMI in adolescents. The prevalence of elevated blood pressure increased with the ascending trend of WC, WSR, and BMI (Yi *et al.,* 2015). Ellisras longitudinal growth and health study in rural South African children demonstrated that not only BMI, ectomorphy components was also significantly associated with blood pressures (Makgae *et al.,* 2007). Another study in school children of Nigeria demonstrated that endomorphy correlated positively with SBP while ectomorphy correlated negatively with SBP (Leko Bankole *et al.,* 2017). Overweight/obese students were 2.7 times more likely to have elevated blood pressure than normal weight students in Nassau (Conliffe *et al.,* 2015). The f indings are in accordant with the results of Kalichman *et al.* (2004), which also displayed similar positive association of blood pressure with endomorphy and mesomorphy and negative association with ectomorphy. Leko Bankole *et al.* (2017) in a study among school children of Nigeria also demonstrated positive association of mesomorphy and endomorphy with SBP and negative association of ectomorphy with SBP. However, in that study (Leko Bankole *et al.,* 2017) endomorphywas negatively correlated, while ectomorphy was positively correlated with DBP. A trend of higher blood pressure in endomorphic boys was also observed by Badenhorst *et al.* (2003) among South African children.

Indian Perspective

In a number of community-based studies it has been proved that there exists a positive association between metric measurements and blood pressure in studied population (Durrani and Waseem, 2011; Ghosh and Bandyopadhyay, 2013; Ahmed *et al.,* 2016; Kumar *et al.,* 2017). However, the staunchest risk factor for primary hypertension in pre-adolescents, irrespective of place of residence, was elevated BMI (Mohan *et al.,* 2004; Kajale *et al.,* 2014; Verma and Sinha, 2014; Madruga *et al.,* 2016). But a f luctuating BMI has stronger inf luence than the absolute level of BMI in inf luencing pediatric blood pressure as showed by a previous cohort study in 12129 children (Raj *et al.* 2010). In a study among urban Indian school children the adjusted risk ratios of high SBP with WSR, BMI and WC were 2.48, 2.59 and 2.38, respectively. Similar results were seen with high DBP also (Mishra *et al.,* 2015).

The aim of the present study was to determine about the association between somatotype and blood pressure among the 10-17 years of adolescents.

Objective

In view of the above context, the present study among urban Bengali adolescents of West Bengal, India was carried out to find out

1. the age and sex variation in somatotypic components and blood pressure.
2. the relationship between somatotypic components and blood pressure.
3. the association between anthropometric variables and somatotypic components.

Methodology

The cross-sectional investigation was attempted to evaluate the association of somatotype and anthropometric variables and blood pressures among adolescents aged 10 to17 years. Relationship between somatotype and anthropometric parameters with blood pressure in adolescents were investigated. In order to examine such relationships, subjects were chosen from two schools of Howrah Municipal Corporation, the industrial district city of Howrah, West Bengal.

A sample size of 1072 (555 boys and 517 girls) adolescents reportedly in good health and without any chronic disease and abnormality since birth, were included in the present investigation. The participating students were aged between 10 and 17 years. Wilful consent was obtained from each of the project volunteer along with their parents' and permission was taken from the school administration before the study commenced.

Anthropometric measurements were taken on each participant, following Tg *et al.* (1988) and Carter and Heath (1990). All participants were classified using the Heath–Carter anthropometric somatotype method (Carter and Heath 1990) owing to the applicability irrespective of variation in humans irrespective of age, sex or differences attributed to climate, diet, genetics, race, health or physical activity (Carter and Heath, 1990; Katzmarzyk *et al.,* 1998; Makgae *et al.,* 2007). Resting SBP and DBP were measured following standard techniques (National High Blood Pressure Education Program Working Group on high blood pressure in children and adolescents, 2004). An appropriate calf with sphygmomanometer and a stethoscope were adopted to measure the blood pressure by auscultation method. The first perception of sound was taken as the level of SBP and the DBP was taken as the level at which the sounds disappeared.

All anthropometric and physiological variables were checked for normality and the variables not in normal distributions were log-transformed. Descriptive analysis of anthropometric variables, somatotypic units and blood pressure were calculated by mean and standard deviation (SD). PCA, adjusted for age and HT were utilized to examine the relationship among somatotype components with blood pressures, respectively. Regression analysis was utilized to examine somatotype components as predictor of blood pressure variables. Logistic regression analysis was performed for somatotype components as predictor of hypertension. The data were rechecked for any inadvertent error. The necessary statistical considerations were done with the help of IBM SPSS 22.0. The resultant statistical value considered to be significant ($p \leq 0.05$).

Results

Table-1 &2 shows age specific mean and SD of anthropometric characteristics of boys and girls.

Mean and SD of somatotype components of the studied population are presented in Table-3. It shows that the mean values of the three types of somatotype are found to be higher in boys than girls.

Table-4 demonstrate the mean and SD of SBP and DBP of the studied population. It reveals that the mean values of SBP and DBP are found to be higher in boys than girls.

Results of partial correlation coefficient (adjusted for age and HT) of somatotype components with SBP and DBP in boys are presented in Table-5. The results reveal that both endomorphy and mesomorphy show significant ($p<0.01$) and positive correlation with both types of blood pressure. Contrary to that, ectomorphy does not show any significant ($p<0.01$) correlation with both systolic and diastolic blood pressure.

Results of partial correlation coefficient (adjusted for age and HT) of somatotype components with SBP and DBP in girls are presented in Table-6. The results also show that both endomorphy and mesomorphy show significant (p<0.01) positive correlation with both systolic and diastolic blood pressure. But, ectomorphy has significant (p<0.01), but negative correlation with both SBP and DBP.

Results of regression analysis using somatotype components as predictors of adjusted (age and HT) SBP and DBP in boys are presented in Table-7. It seems that all somatotype components are significant (p<0.01) predictors of both SBP and DBP. It also appears that ectomorphy explain 16.6% of variance of SBP, follows by mesomorphy (16.2% of variance) and endomorphy (12.5% of variance). On the other hand, mesomorphy explain 9.9% of variance of DBP, follows by ectomorphy (9.8% of variance) and endomorphy (7.3% of variance).

Table 1: Age Specific Mean and Standard Deviation of Anthropometric Characteristics of Boys

Age (Year)		**BMI (kg/m^2)**	**WHR**	**WSR**	**CI**
10	Mean	18.72	0.90	0.50	1.24
	SD	3.71	0.03	0.05	0.04
11	Mean	20.47	0.90	0.51	1.25
	SD	4.69	0.03	0.06	0.04
12	Mean	20.62	0.89	0.51	1.25
	SD	4.53	0.05	0.07	0.05
13	Mean	20.53	0.88	0.49	1.23
	SD	4.11	0.05	0.06	0.06
14	Mean	21.41	0.87	0.48	1.22
	SD	3.43	0.04	0.056	0.05
15	Mean	21.61	0.87	0.48	1.23
	SD	3.96	0.04	0.06	0.05
16	Mean	21.69	0.86	0.48	1.22
	SD	4.06	0.04	0.05	0.05
17	Mean	21.97	0.86	0.48	1.22
	SD	4.76	0.04	0.06	0.05

SD= standard deviation; BMI=body mass index; WHR=waist hip ratio; WSR=waist stature ratio; CI=conicity index

Results of regression analysis using somatotype components as predictors of adjusted (age and HT) SBP and DBP in girls are presented in Table-8. It seems that all somatotype components are significant (p<0.01) predictors of both SBP and DBP. It also appears that ectomorphy explains 20% of variance of SBP, follows by mesomorphy (18.6% of variance) and endomorphy (17.1% of variance). On the other hand, endomorphy explains 13% of variance of DBP, follows by ectomorphy (12.0% of variance) and mesomorphy (11.0% of variance).

The results of logistic regression analysis using somatotype components for hypertension in boys are shown in Table-9. It appears that all somatotype components are statistically significant (p<0.01) predictors of hypertension. The OR associated with one unit increase in endomorphy is 1.82 (95% confidence interval,1.23-2.70). The OR for one unit increase in mesomorphy is 1.63 (95% confidence interval,1.37-1.95), follows by ectomorphy (OR=0.64; 95% confidence interval, 0.52-0.79).

The results of logistic regression analysis using somatotype components for hypertension in boys are shown in Table-10. It appears that all somatotype components are statistically significant (p<0.01) predictor of hypertension. The OR associated with an unit increase in endomorphy is 4.30 (95% confidence interval, 2.41-7.64). The value for an unit increase in mesomorphy is 1.59 (95% confidence interval,1.33-1.89), follows by ectomorphy (OR=0.48; 95% confidence interval, 0.35-0.64).

Table 2: Age Specific Mean and Standard Deviation of Anthropometric Characteristics of Girls

Age (Year)		BMI (kg/m^2)	WHR	WSR	CI
10	Mean	18.14	0.86	0.47	1.19
	SD	4.24	0.04	0.06	0.05
11	Mean	18.65	0.84	0.45	1.15
	SD	3.74	0.03	0.05	0.04
12	Mean	19.75	0.83	0.45	1.13
	SD	4.38	0.03	0.06	0.04
13	Mean	20.92	0.84	0.46	1.15
	SD	4.42	0.04	0.05	0.05
14	Mean	22.24	0.84	0.47	1.14
	SD	4.77	0.04	0.06	0.05
15	Mean	22.61	0.86	0.50	1.21
	SD	4.22	0.05	0.06	0.08
16	Mean	22.53	0.86	0.51	1.23
	SD	4.23	0.04	0.06	0.07
17	Mean	22.75	0.85	0.51	1.22
	SD	3.68	0.04	0.05	0.07

SD= standard deviation; BMI=body mass index; WHR=waist hip ratio; WSR=waist stature ratio; CI=conicity index

Table 3: Mean and Standard Deviation of Somatotype Components of the Studied Population

Variables	Boys		Girls	
	Mean	SD	Mean	SD
Endomorphy	6.02	0.97	5.87	0.93
Mesomorphy	3.75	1.70	3.53	1.77
Ectomorphy	2.55	1.75	2.35	1.72

SD= standard deviation

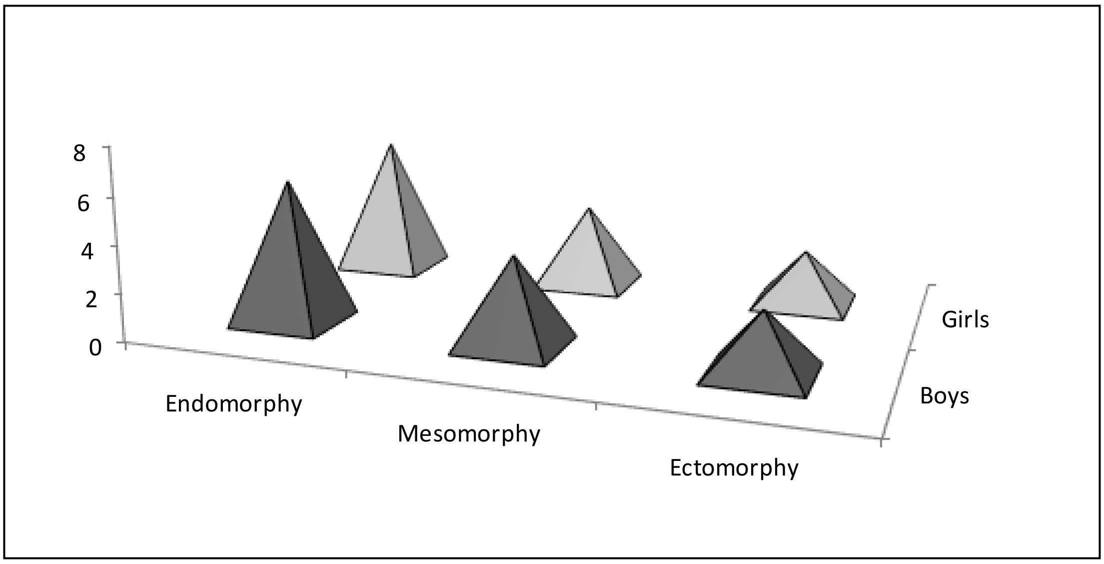

Figure 1: Somatotype Components of the Studied Group

Table 4: Mean and Standard Deviation of Systolic and Diastolic Blood Pressure of the Studied Population

Variables	Boys		Girls	
	Mean	**SD**	**Mean**	**SD**
SBP(mmHg)	109.10	12.63	101.11	10.68
DBP(mmHg)	65.37	8.34	62.14	8.30

SD= standard deviation; SBP=systolic blood pressure; DBP=diastolic blood pressure

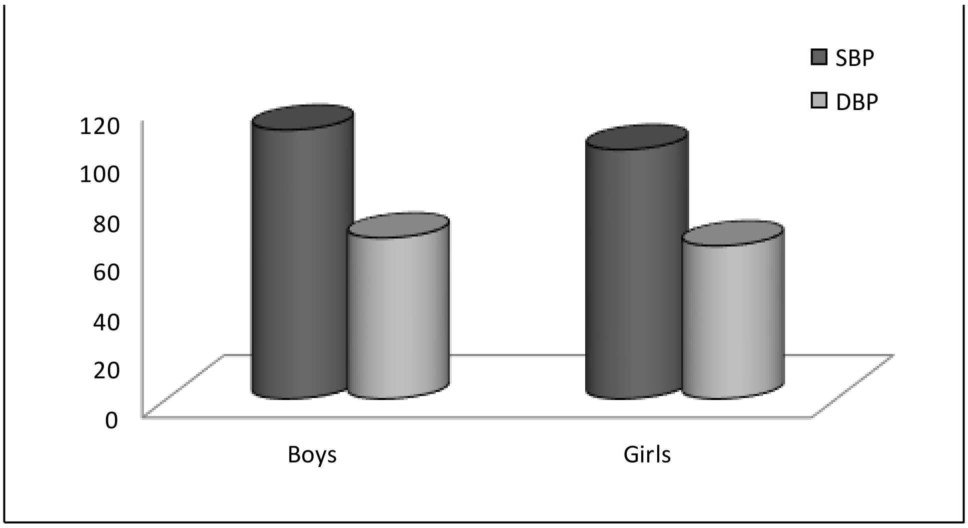

Figure 2: Systolic and Diastolic Blood Pressure of the Studied Group

Table 5: Results of Partial Correlation Coefficient of Somatotype Components with Systolic and Diastolic Blood Pressure in Boys

	SBP(mmHg)		DBP(mmHg)	
Variables*	**r**	***p***	**R**	***p***
Endomorphy	0.353	<0.01	0.271	<0.01
Mesomorphy	0.402	<0.01	0.315	<0.01
Ectomorphy	-0.407	<0.01	-0.313	<0.01

**Adjusted for age and height; SBP=systolic blood pressure; DBP=diastolic blood pressure*

Table 6: Results of Partial Correlation Coefficient of Somatotype Components with Systolic and Diastolic Blood Pressure in Girls

	SBP(mmHg)		DBP(mmHg)	
Variables*	**r**	***p***	**R**	***p***
Endomorphy	0.414	<0.01	0.361	<0.01
Mesomorphy	0.431	<0.01	0.331	<0.01
Ectomorphy	-0.447	<0.01	-0.347	<0.01

**Adjusted for age and height; SBP=systolic blood pressure; DBP=diastolic blood pressure*

Table 7: Results of Regression Analysis Using Somatotype Components as Predictors of Systolic and Diastolic Blood Pressure in Boys

Variables*	SBP(mmHg)				DBP(mmHg)			
	r^2	β	T	*p*	r^2	β	t	*p*
Endomorphy	0.125	0.30	8.85	<0.01	0.073	0.26	6.60	<0.01
Mesomorphy	0.162	0.35	10.30	<0.01	0.099	0.30	7.78	<0.01
Ectomorphy	0.166	-0.35	-10.46	<0.01	0.098	-0.30	-7.72	<0.01

**Adjusted for age and height; SBP=systolic blood pressure; DBP=diastolic blood pressure*

Table 8: Results of Regression Analysis Using Somatotype Components as Predictors of Systolic and Diastolic Blood Pressure in Girls

Variables*	SBP(mmHg)				DBP(mmHg)			
	r^2	β	T	*p*	r^2	β	t	*p*
Endomorphy	0.171	0.40	10.28	<0.01	0.130	0.35	8.75	<0.01
Mesomorphy	0.186	0.41	10.81	<0.01	0.110	0.32	7.93	<0.01
Ectomorphy	0.200	-0.44	-11.33	<0.01	0.120	-0.34	-8.38	<0.01

**Adjusted for age and height; SBP=systolic blood pressure; DBP=diastolic blood pressure*

Table 9: Results of Logistic Regression Analysis Using Somatotype Components as Predictors of Hypertension in Boys

Variables*	β	p	OR	95% CI	
				Lower	Upper
Endomorphy	0.60	<0.01	1.82	1.23	2.70
Mesomorphy	0.49	<0.01	1.63	1.37	1.95
Ectomorphy	-0.45	<0.01	0.64	0.52	0.79

**Adjusted for age and height; OR=odds ratio; CI=confidence interval*

Table 10: Results of Logistic Regression Analysis Using Somatotype Components as Predictors of Hypertension in Girls

Variables*	β	*P*	OR	95% CI	
				Lower	Upper
Endomorphy	1.46	<0.01	4.30	2.41	7.64
Mesomorphy	0.46	<0.01	1.59	1.33	1.89
Ectomorphy	-0.74	<0.01	0.48	0.35	0.64

** adjusted for age and height; OR=odds ratio; CI=confidence interval*

Discussion

Somatotype characteristics of the studied population revealed that the mean values of endomorphy, mesomorphy and ectomorphy were more in boys than girls and there was significant ($p<0.05$) age and sex differences in all somatotype components. Similarly, Katzmarzyk *et al.* (1998) also demonstrated significant age and sex variation in somatotype components. Contrary to that, a recent study in school children of Nigeria demonstrated higher mean values of endomorphy and ectomorphy in girls compared to boys (Leko Bankole *et al.,* 2017). Ellisras longitudinal study demonstrated higher endomorphic ratings in girls compared to boys, while mesomorphy rating was higher in boys compared to girls (Makgae *et al.,* 2007).

The present study also demonstrated a strong association of BMI with blood pressures in both boys and girls. In accordance with the present study a number of studies also demonstrated stronger association of BMI with blood pressure (Guimaraes *et al.,* 2008; Hosseini *et al.,* 2010; Moser *et al.,*2013; Kapil *et al.,*2013; Hardy et.al., 2021; Mphekgwana *et.al.,* 2020; Konlan et.al; 2023). Moreover, BMI was also positively associated with body fat (Katzmarzyk *et al.,* 2015), dyslipidemia (Furtado *et al.,* 2018), fasting blood glucose (Mehdad *et al.,* 2012), junk food consumption (Azemati *et al.,* 2018) and screen time (Sourtiji *et al.,*2019), but negatively associated with physical activity (Van Zant and Toney, 2012) and sleeping time (Doherty *et al.,*2015) in children and adolescents.

Results of regression analysis using somatotype components as predictors of adjusted blood pressure in the studied population revealed that all somatotype components are significant ($p<0.01$) predictors of both systolic and diastolic blood pressure. However, ectomorphy and mesomorphy explained highest amount of variance of SBP (16.6%) and DBP (9.9%) in boys and in girls highest amount of variance of SBP (20%) and DBP (13%) was explained by ectomorphy and endomorphy.

Similar inverse association between ectomorphy and both SBP and DBP was also observed in young adults (Herrera *et al.,*2004). Positive correlation between blood pressure and endomorphy, and negative correlation between blood pressure and ectomorphy in adults were also observed by Rahmawati (2012). Koleva *et al.* (2002) demonstrated that adults with higher ratings of endomorphy and mesomorphy and the lower rating of ectomorphy were suffered most f requently f rom arterial hypertension.

Conclusion

The present study was conducted among adolescent boys and girls aged between 10 -17 years f rom two schools of Howrah Municipal Corporation, in the state of West Bengal, India. The studied population comprising of 1072 apparently healthy adolescents including 555 boys and 517 girls were included in the present study. The (Body Mass Index (BMI), Waist Hip Ratio (WHR), Waist Stature Ratio (WSR) and Conicity Index (CI)) indices, ratio etc were derived by using different anthropometric measurements

Somatotype characteristics of the studied population revealed that the mean values of endomorphy, mesomorphy and ectomorphy were more in boys than girls and there was significant (p<0.05) age and sex variations in all somatotype components.

Blood pressure characteristics of the studied group revealed that the mean values of SBP and DBP were more in boys than girls. However, significant (p<0.05) age and sex difference exists only in SBP.

Somatotype components were also significant (p<0.01) predictors of both SBP and DBP. However, ectomorphy and mesomorphy explained highest amount of variance of SBP (16.6%) and DBP (9.9%) in boys, respectively and in girls' highest amount of variance of SBP (20%) and DBP (13%) was explained by ectomorphy and endomorphy, respectively.

All anthropometric variables were significantly and positively correlated with both SBP and DBP without sex bias. Somatotypes were also significantly correlated with blood pressure in both sexes.

However, the main limitation of the present study was the cross-sectional studied population, which allowed determining only the associations of somatotype and anthropometric variables with blood pressure in adolescent. Moreover, the present study was conducted on a relatively small group and was not representative of the pan Indian population. Because of enormous ethnic and cultural heterogeneity in Indian population, it is imperative to conduct comparative study on other ethnic groups to see if the trends observed in the present study also exist among them.

Conflict of Interest

The authors declare that they have no conflict of interests.

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