Original Article

BMI is a Better Indicator of Cardiac Risk Factors, as against Elevated Blood Pressure in Apparently Healthy Female Adolescents and Young Adult Students: Results From a Cross-Sectional Study in Tripura

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ABSTRACT

Background: Anthropometric measures are used as indicators of elevated blood pressure, but reported to have variable sensitivity among populations. This study was undertaken to identify the better indicator of Cardiac-risk factors by statistical comparison of BMI, Waist circumference, and Waist to Height (WtHr) ratio in apparently healthy adolescents and young adult female students of Tripura. **Materials and Methods:** A cross-sectional study was conducted in a resource limited setup on 210 apparently healthy female adolescents and young adult students in Tripura. Mean (±SD) of all parameters were compared (ANOVA) to recognize significant independent (anthropometric measures) and dependent factors (blood pressure indices and so on). Correlation (r) analysis was used to identify the better (p) indicator of blood pressure indices (dependent variable) and its impact was assessed by Multiple Regression analysis. **Results:** blood pressure indices are comparatively higher in obese and overweight participants with statistically significant (95.5% confidence) mean differences. Significant correlation with dependent factors is observed with BMI followed by WtHr and Waist Circumference. Impact of anthropometric measures with blood pressure Indices is most significant for BMI ($P \leq 0.020$) followed by WtHr ($P \leq 0.500$) and waist circumference ($P \leq 0.520$). **Conclusion:** BMI is a superior indicator of blood pressure indices and can identify participants at risk even in apparently healthy adolescent and young adult females.

Keywords: Adolescent, young adults, female, Tripura, anthropometric measures, BMI, waist circumference, waist to height ratio, blood pressure indices, DBP, SBP, pulse pressure, mean pressure, rate pressure product, heart rate, students,

Introduction

Suboptimal blood pressure (>115 mmHg SBP) is the number one attributable risk for death throughout the world.[1] Guidelines of advisory bodies (National Heart, Lung, and Blood Institute NHLBI, WHO) emphasize to increase awareness, prevention, and control of risk factors[2] because awareness and early diagnosis of the vulnerability of hypertension and prehypertension can substantially reduce the risk .Anthropometric measures can be used as predictor for cardiovascular risk factors[3-5] and essentially aids in prevention and control. However, there seems to have considerable variability

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of sensitivity among the anthropometric measures such as BMI, waist circumference, waist to height ratio and so on to predict cardiovascular risks[5] among populations across geographies, ethnicity, and demography. The debate over a more sensitive anthropometric predictor of cardiovascular risks is amplified on the basis of the reports demonstrating variability in the efficacy of anthropometric parameters in predicting cardiovascular risks. According to several workers in India and abroad BMI alone is less accurate as a predictor and waist circumference and/or waist to height ratio is advocated as more sensitive indicator/s of cardiovascular risks[6-8]. On the contrary, some researchers argue that sensitivity of BMI is better and it sufficiently correlates with cardiovascular risk factors as hypertension.[9,10] Yet another group reports BMI and waist circumference both are equally good predictors of cardiovascular risks.[11,12] In this background, a study to evaluate sensitivity of anthropometric measures on cardiovascular risk factor as high blood pressure seems imperative, more so when similar studies are not reported from this region (Tripura).

In the present work, the focus is on correlation and the degree of association of anthropometric measures with blood pressure indices in apparently healthy female adolescent and young adult students. There was a general perception that women to be less vulnerable to cardiovascular complications but it is acknowledged that women are more prone to several other impediments for their inherent physiology[13-16], which may have a negative synergistic effect if hypertension or prehypertension coexists. Moreover, prognosis of cardiac complications in women may be less satisfactory.[17] Also in menopause the so-called "female advantage" is reversed due to rapid decrease in female steroid hormones, and thus, sex-associated differences must be considered in hypertension management of women.[18-19] So identification of cardiovascular risk factors and its more sensitive anthropometric indicator even in apparently healthy female population is crucial for prevention and control of cardiovascular causalities in the long run. In this respect the present study is significant.

Materials and Methods

A cross-sectional study on anthropometric measures, blood pressure indices, and some hematologic parameters was conducted among the female students (Women's Polytechnic) in Tripura, as a part of the academic dissertation during July 2014 and February 2015. All measurements were taken in duplicate and averaged.

Participants

Total 210 (*n*) female students of Women's polytechnic studying in various disciplines in the age group 16–22 years participated in the study. Written consent of the participants and guardians were taken based on recommendation of World Medical Association Declaration of Helsinki Sixth revision guidelines.[20] None of the participants were habitual users of Tobacco in any form. Any participant with immediate family history of sever cardiac anomalies were excluded from the study. All the included participants were on regular normal diet .All these factors including age, demography (urban/rural), ethnicity (data not shown), and medical history were self-reported by the participants. Participants on any medication and with any significant medical history were excluded from the study.

Anthropometric measures

Trained female students of the institute carried out all measurements during college hours. Body weight (kg), height (m), waist circumference (cm) of the participants were collected in college uniform and subsequently adjusted. Measures were taken in relaxed standing position without shoes. Weight was measured in a doctor's weight measuring machine (Krup's) and Height was measured by a standard measuring tape against a wall. Waist circumference (cm) was measured at the midpoint between the lower costal margin and the top of iliac crest, while the participant was in the standing position using a non-stretch tape (WHO [21]).

Blood pressure indices

SBP and DBP (first and fifth Korotkoff sounds, respectively, using Stethoscope, Microtone) were measured to the nearest even digit by auscultation with an appropriate-size cuff and an aneroid sphygmomanometer (Diamond, ISI 3390). Blood pressure measurements were made in nonfasting state in the seated position. Heart rates (HR Times/minute) were measured manually using stop watch (Samsung).

Hematologic parameters

Hemoglobin concentration (gm/dl) were detected by Sahli's method (Marienfeld–Hemoglobinometer) using 0.1N HCl (Merck). Sahli's method is a efficacious method of hemoglobin estimation in the field work[22], and is significantly economical in resource limited set up like in this case. RBC surface antigens were detected (ABO blood typing kit – Tulip Diagnostics) in the participants for database purpose and Rh typing was not done.

Statistical Analysis

Data are expressed as mean, standard deviation, and range (max-min). Mean differences of parameters among the BMI classes are reported with statistical significance for dependent variables (ANOVA). Correlation (r) analysis was used to identify the better (p) indicator of elevated blood pressure (dependent variable) in the studied population and its impact was assessed by

Multiple Regression analysis of parameters. Origin and MS Excel statistical packages were used for the analysis.

Definitions of variables

BMI was calculated from weight (kg) and height (m) in kg/m^2. It was such that the participants could be divided in total seven groups depending upon their BMI class. Normal (BMI 18.5–24.9 kg/m^2), overweight (25–30 kg/m^2), obese class I (30–35 kg/m^2), obese class II (35–40 kg/m^2), severe thinness (<16 kg/m^2), moderate thinness (16–17 kg/m^2) and mild thinness (17–18.5 kg/m^2).Waist to height ratio (WtHr) is a simple ratio. Among Cardiac parameters[23] Pulse pressure (PP) was determined as the difference between SBP and DBP. Mean Pressure was calculated as DP + 1/3 PP, whereas Rate Pressure Product (RPP) was calculated as SP × HR × 10^{-2}.

Results

The sample population (n = 210) could be categorized into seven BMI categories. Anthropometric measures and hemoglobin (g/dl) of the population with sample size (n) is depicted in [Table 1]. Age and demography (urban/rural) is depicted in [Table 3]. It is apparent that mean age of obese (class I/II) and severe thin participants are higher compared with other BMI categories, as well as from the overall population. Blood pressure indices and HR is depicted in [Table 2 and 4]. SBP, DBP, and mean pressure is comparatively higher in obese (I/II) and overweight participants with statistically significant (95.5% confidence) mean differences. BMI is positively correlated to DBP [r (+) 0.252185854, P = 0.0001], mean pressure [r (+) 0.248430338, P = 0.0002] and SBP [r (+) 0.203482052, P = 0.001] [Table 5]. BMI is also positively correlated to RPP and hemoglobin level but the correlation is not significant. Waist circumference is positively correlated with SBP, DBP, mean pressure, RPP, and hemoglobin level; however, significant correlation is found with DBP (r = (+) 0.227278779, P = 0.0006) and mean pressure (r = (+) 0.200640562, P = 0.001). WtHr is also positively correlated with SBP, DBP, mean pressure, RPP, and hemoglobin level and is significantly correlated with DBP (r = (+) 0.217848832, P = 0.0007) and mean pressure (r = (+) 0.189695053, P = 0.002). HR and PP are negatively correlated to BMI, waist circumference, and WtHr but the relationship is not statistically significant. Direct impact of independent variables (BMI, waist circumference, and WtHr) on the dependent variables (SBP, DBP, and mean pressure), which have significant correlation are depicted in [Table 6]. Impact of anthropometric measures with blood pressure indices is most significant for BMI ($P \leq 0.020$) followed by WtHr ($P \leq 0.500$) and waist circumference ($P \leq 0.520$) in the population. 74.88% of the population are from urban Tripura and among RBC antigens "O" (30.80%) is the most common in the population followed by "A" (25.23%) , "B" (24.64%), and "AB" (18.95%).

Discussion

The present study was conducted among 210 female adolescent and young adult students of Tripura to analyze the fidelity of using BMI as an indicator of suboptimal blood pressure in apparently healthy females. The schematic representation of the decision pathway is illustrated in Figure 1. Analysis of mean of parameters helped to initially identify significant independent (anthropometric measures) and dependent factors (Blood pressure indices, HR, and so on). Significance of correlation was used to pinpoint the most sensitive anthropometric index and the regression analysis fortified the argument. Overweight and Obese (I/II) participants (according to BMI categories) have WtHr more than 0.50 , the cutoff value for all age groups.[24] SBP, DBP, and mean pressure is comparatively higher in obese (I/II) and overweight participants (95.5% confidence). When anthropometric parameters were correlated to Blood pressure indices, HR, and so on, it was observed that DBP and mean pressure are positively correlated to anthropometric measures to a significant extant followed by SBP. Therefore, DBP seems to be better responder in correlating anthropometric measures with blood pressure indices in the studied population. DBP is an important parameter that dictates cardiovascular outcome and is related to physiological stress[25] and causality due to cardiac failure.[26] Its significance in prevention and management of cardiovascular complications is established by the fact that a small reduction of 2 mmHg in DBP in the mean of the population distribution could have a great public health impact on the number of CHD and stroke events prevented.[27] It is observed that PP, as well as, HR negatively correlates to anthropometric measures in the studied population. PP is a reliable indicator of vascular distensibility[28], whereas HR is an indicator of sympathovagal regulation.[29] The negative correlation (anthropometric measures and PP/HR), although insignificant but can be explained on the basis of autonomic function and or energy metabolism in women with the aid of female steroid hormones.[30,31] On the contrary, BMI among independent parameters is significantly correlated to most of the dependent factors (blood pressure indices and so on) than that of WtHr and waist circumference and the direct impact of BMI on the Blood Pressure indices are also more significant statistically.

Although it is observed that the Blood Pressure indices in the studied population is not alarming but normal BP in higher margin and hypertensive BP is regarded as a cause of concern in women.[32] In the studied population 20% of the participants are either overweight or obese and have risk of developing cardiovascular complications. Individuals with prehypertensive levels of blood pressure have an increased risk of developing

Table 1: Mean (±SD) of BMI , waist circumference , waist to height, and hemoglobin level in the population

Sample / BMI Class	Parameters											
	BMI(kg/m²)			Waist Circumference (cm)			WHtR (Waist/Height)			Hemoglobin (g/dl)		
	Mean	Standard Deviation	Max-Min	Mean	Standard Deviation	Max-Min	Mean	Standard Deviation	Max-Min	Mean	Standard Deviation	Max-Min
Total (n=210)	21.74028	±4.747486632	38.96604938–12.03202369	75.1619	±11.97255539	118–36	0.48728	±0.076068866	0.746–0.244	12.04238	±2.080546498	15.4–6
Normal Weight (n=130)	20.84515	±1.801761	24.7768 –18.5654	74.71538	±0.055485698	0.6466–0.3566	0.48494	±0.055485698	0.6466–0.3566	12.11	±2.051841676	15.4–6
Over weight (n=28)	27.27112	±1.530030623	30.0328 –25.21408	81.67857	±0.078301198	0.65359–0.284810	0.53232	±0.078301198	0.65359–0.284810	12.13929	±2.162703946	14–6
Obese Class I (n=10)	33.00588	±1.4669	34.7032 –30.6306	92	±0.05897506	0.693333–0.512987	0.61077	±0.05897506	0.693333–0.512987	12.19	±2.612980418	12–6.1
Obese Class II (n=03)	38.74915	±0.259584	38.96605 –38.46154	101	±0.075509307	0.746835443–0.611510791	0.65982	±0.075509307	0.746835443–0.611510791	11.13333	±2.307784757	12–7
Severe Thinness (n=10)	14.87939	±1.218643	15.82216 –12.03202	63.2	±0.083130002	0.53125–0.244897959	0.39725	±0.083130002	0.53125–0.244897959	11.61	±2.383484844	12–6.3
Moderate Thinness (n=15)	16.59416	±0.31707	17.0874–16	65	±0.039722276	0.503225806–0.352201258	0.42101	±0.039722276	0.503225806–0.352201258	12.08667	±1.822034446	13–6.2
Mild Thinness (n=14)	17.71318	±0.34862	18.2563–17.1163	68.14286	±0.067714842	0.55–0.295774648	0.44128	±0.067714842	0.55–0.295774648	11.57143	±1.86606479	13–6.2

Table 2: Mean (±SD) of SBP, DBP, pulse pressure, heart rate in the population.

Sample / BMI Class	Parameters											
	Systolic Pressure [a]			Diastolic Pressure [b]			Pulse Pressure [c]			Heart Rate [d]		
	Mean	Standard Deviation	Max-Min	Mean	Standard Deviation	Max-Min	Mean	Standard Deviation	Max-Min	Mean	Standard Deviation	Max-Min
Total (n=210)	113.9619	±13.06291277	186–100	76.97143	±9.862879678	100–50	38.01905	±10.54494228	86 - 20	89.58571	±9.652070989	109 - 65
Normal Weight (n=130)	113.25385	±12.28493218	178–90	76.34615	±9.312583417	100–50	37.93077	±10.77622164	82 - 48	89.4	±9.350704	108 - 67
Over weight (n=28)	122.92857	±17.81786156	186–100	80.53571	±11.40332032	100–56	40.40741	±12.9051	86–20	86.92857	±8.88164387	103 - 65
Obese Class I (n=10)	122	±9.521905	130–100	80.6	±4.880801	88–70	36.4	±9.834181	50–20	92	±11.35292	103 - 74
Obese Class II (n=03)	125.33333	±11.54701	130–110	90	±10.0	100–80	33.33333	±5.773503	40–30	94.66667	±6.506407	101 - 88
Severe Thinness (n=10)	109.4	±11.27633	122–90	72.9	±11.23932	88–52	36.5	±7.677529	50–30	91.6	±12.98888	109 - 72
Moderate Thinness (n=15)	109.2	±12.301	132–90	71.8	±8.60399	86–55	37.4	±10.77622164	82–48	91.73333	±9.49787	106 – 78
Mild Thinness (n=14)	113.57143	±10.08208072	130–96	75.57143	±10.81817762	98–60	38	±12.9051	86–20	90.07143	±11.0416	104 - 70

a F = 1.62679, *P* = 0.12602, At the 0.5 level, the means are significantly different. [b] F = 2.23731, P = 0.03049 , At the 0.5 level, the means are significantly different. [c] F = 0.35067, P = 0.92991 , At the 0.5 level, the means are not significantly different. [d] F = 0.68959 , p = 0.68093 , At the 0.5 level, the means are not significantly different.

Table 3: Age and demography of the population.

Sample/BMI Class	Age (years)			Demography	
	Mean	Standard Deviation	Max-Min	Urban (Number of participantts)	Rural (Number of participantsts)
Total (*n* = 210)	17.92857	±1.267799	22–16	158	52
Normal Weight (*n* = 130)	17.96154	±1.296410346	22–16	100	30
Over weight (*n* = 28)	17.92857	±1.358882205	22–16	25	3
Obese Class I (*n* = 10)	18	±1.247219	21–17	6	4
Obese Class II (*n* = 03)	18.66667	±1.527525	20–17	1	2
Severe Thinness (*n* = 10)	18.1	±1.37032	21–17	8	2
Moderate Thinness (*n* = 15)	17.93333	±1.2228	20–17	10	5
Mild Thinness (*n* = 14)	17.28571	±0.61125	19–17	8	6

Table 4: Mean (±SD) of mean pressure and RPP in the population.

Sample/BMI Class	Mean Pressure [e]			Rate Pressure Product [f]		
	Mean	Standard Deviation	Max-Min	Mean	Standard Deviation	Max-Min
Total (*n* = 210)	89.2541	±9.804509388	123.6666667–63.33333333	88.57619	±17.32855815	191.58 - 67
Normal Weight (*n* = 130)	87.99744	±9.102204269	123.3333333–63.33333333	101.366	±16.237	179.78 - 67
Over weight (*n* = 28)	92.61728	±12.2036	118.6666–70	104.46889	±22.21127	191.58 – 83.64
Obese Class I (*n* = 10)	91.73333	±4.961083116	98.6666–86.6666	106.386	±13.4222	127.72 – 83.6
Obese Class II (*n* = 03)	101.11111	±10.1835	110–90	116.73333	±13.55151	131.3 – 104.5
Severe Thinness (*n* = 10)	85.06667	±10.6537	98.66667–68	101.018	±21.42305	120.78 – 70.2
Moderate Thinness (*n* = 15)	84.26667	±8.964834293	101.3333333–66.66666667	100.296	±16.30974	137.8 - 75.6
Mild Thinness (*n* = 14)	88.2381	±9.917978649	108.6666667–76.66666667	102.84571	±18.5181	127.4 - 70.08

[e]F = 15.20402, *P* = 0 , At the 0.5 level the means are significantly different. [f]F = 14.83684, P = 0, At the 0.5 level, the means are significantly different.

Table 5: Correlation analysis among Dependent and Independent parametrs in the population.

	Parameters	Independent Parameters		
		BMI	waist circumference	WtHr
Dependent Parameters	**SBP**	**r = (+)** 0.203482052 *P* = 0.001	**r = (+)** 0.125533489 *P* = 0.04	**r = (+)** 0.121067981 *P* = 0.040
	DBP	**r = (+)** 0.252185854 *P* = 0.0001	**r = (+)** 0.227278779 *P* = 0.0006	**r = (+)** 0.217848832 *P* = 0.0007
	PP	**r = (-)** 0.01703932 *P* = 0.40	**r =** (-) 0.05861571 *P* = 0.2	**r =** (-) 0.055253295 *P* = 0.20
	RPP	**r = (+)** 0.101180938 *P* = 0.07	**r = (+)** 0.077448618 *P* = 0.10	**r = (+)** 0.073916816 *P* = 0.10
	MP	**r = (+)** 0.248430338 *P* = 0.0002	**r = (+)** 0.200640562 *P* = 0.001	**r = (+)** 0.189695053 *P* = 0.002
	Hb Level	**r = (+)** 0.043079332 *P* = 0.3	**r = (+)** 0.034317406 *P* = 0.30	**r = (+)** 0.036030393 *P* = 0.20
	HR	r = (-) 0.05137057 *P* = 0.2	r = (-) 0.009685077 *P* = 0.4	r = (-) 0.007666853 *P* = 0.4

cardiovascular disease relative to those with optimal levels and the association is pronounced among those with high BMI.[33] Also, high-normal blood pressure is associated with an increased risk of cardiovascular disease.[34] Therefore, this study is significant and aids to identify participants at risks. In the studied population, it is observed that BMI is significantly associated with blood pressure indices and, therefore, is a good indicator of cardiovascular risks. It has been observed that the long-term reproducibility of BMI is superior[5] and it significantly correlates to hypertension and prehypertension[35] in various age groups even in

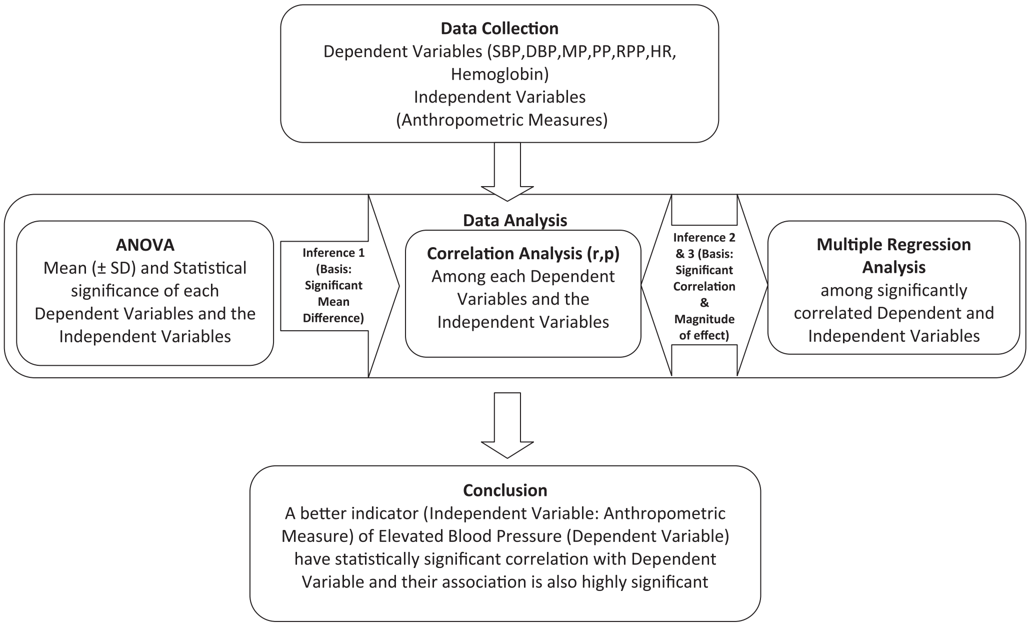

Figure 1: Schematic representation of the decision pathway (ORIGINAL FIGURE)

Table 6: Multiple regression analysis among the significantly correlating dependent and Independent parameters in the population.

Variables		Dependent variables											
		DBP				SBP				Mean pressure			
		β	T	P	R^2	β	T	P	R^2	β	T	P	R^2
Independent Variables	BMI	0.41422	2.2669	0.020	0.07461	0.59622	2.42122	0.010	0.04385	0.46132	2.53007	0.010	0.06943
	waist circumference	0.22247	1.13635	0.260		0.17111	0.64855	0.520		0.22733	1.16366	0.246	
	WHtR	2.9167	0.68198	0.500		4.10964	0.67214	0.500		1.27435	0.88169	0.379	

normal individuals.[36,9] Therefore, BMI is a superior predictor of cardiovascular risks in apparently healthy adolescent and young adult female students of Tripura.

Limitations

The participants included in this academic study were the students of Women's Polytechnic , Govt. of Tripura. About 20% populations is overweight/obese and another 20% population is thin. Stroke volume was not estimated to indicate vascular distensibility. Demographical considerations were not addressed in analysis.

Conclusion and Recommendation

BMI is a superior indicator of blood pressure indices and can identify participants at risk of cardiovascular complications even in apparently healthy adolescent and young adult females. Screening on the basis of BMI may aid to awareness generation and prevention of complications. Identified participants were informed about the risk factors accordingly.

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Conflicts of interest

There are no conflicts of interest.

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