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 ≤ 0.020) followed by WtHr (P ≤ 0.500) and waist circumference (P ≤ 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 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.

On the contrary, some researchers argue that sensitivity of BMI is better and it sufficiently correlates with cardiovascular risk factors as hypertension. Yet another group reports BMI and waist circumference both are equally good predictors of cardiovascular risks.

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, which may have a negative synergistic effect if hypertension or prehypertension coexists. Moreover, prognosis of cardiac complications in women may be less satisfactory. 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. 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. 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.

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).

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 an efficacious method of hemoglobin estimation in the field work, 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
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Definitions of variables
BMI was calculated from weight (kg) and height (m) in kg/m². 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/m²), overweight (25–30 kg/m²), obese class I (30–35 kg/m²), obese class II (35–40 kg/m²), severe thinness (<16 kg/m²), moderate thinness (16–17 kg/m²) and mild thinness (17–18.5 kg/m²). Waist to height ratio (WtHr) is a simple ratio. Among Cardiac parameters 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 (+) 0.252188584, 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 = (+) 0.189695033, 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 ≤ 0.020) followed by WtHr (P ≤ 0.500) and waist circumference (P ≤ 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 extent 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
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Sample / BMI Class

| Parameters          | BMI (kg/m²) | Mean ± Standard Deviation | Max-Min | Waist Circumference (cm) | Mean ± Standard Deviation | WHtR (Waist/Height) | Mean ± Standard Deviation | Hemoglobin (g/dl) | Mean ± Standard Deviation | Max-Min |
|---------------------|-------------|---------------------------|---------|----------------------------|---------------------------|----------------------|---------------------------|---------------------|---------------------------|---------|
| Total (n=210)       |             | 21.74028 ± 4.747486632   | 38.96040±0.30903269 | 75.1619 ±11.72755539 | 118–36                    | 0.4872 ± 0.076068866 | 0.746–0.244 | 12.04238 ± 2.080546498 | 15.4–6             |
| Normal Weight       |             | 20.84515 ± 1.801761       | 24.7768–18.5654 | 74.71538 ±0.05548698 | 0.646–0.3566 | 0.48494 ± 0.05548698 | 0.646–0.3566 | 12.11 ± 0.205184167 | 15.4–6             |
| Over weight         |             | 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       |             | 33.00588 ± 1.4669         | 34.7032–30.6306  | 92 ± 0.05897506 | 0.69333–0.512987 | 0.61077 ± 0.05897506 | 0.69333–0.512987 | 12.19 ± 2.612980414 | 12–6.1             |
| Obese Class II      |             | 38.74915 ± 0.259584       | 38.86668–38.46154 | 101 ± 0.075509307 | 0.746935443–0.611510791 | 0.65982 ± 0.075509307 | 0.746935443–0.611510791 | 11.13333 ± 2.307784757 | 12–7               |
| Severe Thinness     |             | 14.87999 ± 1.218643       | 15.82216–12.03202 | 63.2 ± 0.083130022 | 0.53125–0.24497959 | 0.39725 ± 0.083130022 | 0.53125–0.24497959 | 11.61 ± 2.383484844 | 12–6.3             |
| Moderate Thiness    |             | 16.59416 ± 0.31707        | 17.08746–16.0     | 65 ± 0.039722276 | 0.503225806–0.35201258 | 0.42101 ± 0.039722276 | 0.503225806–0.35201258 | 12.08667 ± 1.822034446 | 13–6.2             |
| Mild Thiness        |             | 17.71318 ± 0.34862        | 18.25386–17.11633 | 68.14296 ±0.067714842 | 0.55–0.295774648 | 0.44128 ± 0.067714842 | 0.55–0.295774648 | 11.57143 ± 1.86606479 | 13–6.2             |

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

| Parameters          | Systolic Pressure a | Mean ± Standard Deviation | Max-Min | Diastolic Pressure b | Mean ± Standard Deviation | Max-Min | Pulse Pressure c | Mean ± Standard Deviation | Max-Min | Heart Rate d | Mean ± Standard Deviation | Max-Min |
|---------------------|---------------------|---------------------------|---------|----------------------|---------------------------|---------|-----------------|---------------------------|---------|---------------|---------------------------|---------|
| Total (n=210)       | 113.9619 ± 13.06291277 | 186–100                  | 76.97143 ±9.862879678 | 100–50 | 38.01905 ±12.04238 | 0.746–0.244 | 12.04238 ± 2.080546498 | 15.4–6             |
| Normal Weight       | 113.25385 ± 12.28493218 | 178–90                  | 76.34615 ±9.312583417 | 100–50 | 37.93077 ±12.04238 | 0.746–0.244 | 12.04238 ± 2.080546498 | 15.4–6             |
| Over weight         | 122.92857 ± 17.81786156 | 186–100                  | 80.53571 ±11.40332032 | 100–56 | 40.40741 ±12.04238 | 0.746–0.244 | 12.04238 ± 2.080546498 | 15.4–6             |
| Obese Class I       | 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      | 125.33333 ± 11.54701 | 130–110                  | 90 ± 10.0 | 100–80 | 33.33333 ± 5.773503 | 40–30 | 94.66667 ± 6.506407 | 101–88             |
| Severe Thiness      | 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 Thiness    | 109.2 ± 12.301      | 132–90                  | 71.8 ± 8.60399 | 86–55 | 37.4 ± 10.7762164 | 82–48 | 91.73333 ± 9.49787 | 106–78             |
| Mild Thiness        | 113.57143 ± 10.08206072 | 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 = 2.23371, 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 = 0.68999 , p = 0.68003 , At the 0.5 level, the means are not significantly different.
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Table 3: Age and demography of the population.

| Sample/BMI Class          | Age (years) | Demography |
|---------------------------|-------------|------------|
|                           | Mean        | Standard Deviation | Max-Min | Urban (Number of participants) | Rural (Number of participants) |
| 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 = 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 * | Max-Min | Rate Pressure Product † |
|---------------------------|-----------------|---------|-------------------------|
|                           | 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 | 98.6666–68 | 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 |

*F = 15.20402, P = 0, At the 0.5 level the means are significantly different. †F = 14.83684, P = 0, At the 0.5 level, the means are significantly different.

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

| Parameters | Independent Parameters |
|------------|------------------------|
| BMI        | waist circumference    | WHr        |
| SBP        | r = (+) 0.203482052 P = 0.001 | r = (+) 0.12553489 P = 0.04 | r = (+) 0.121067981 P = 0.04 |
| DBP        | r = (+) 0.252185854 P = 0.0001 | r = (+) 0.227287779 P = 0.0006 | r = (+) 0.217848332 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 = (-) 0.00766853 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
normal individuals. 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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