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ORIGINAL ARTICLE

Anthropometric Measures for Predicting the Risk of Hypertension in Young Adults: Insights from a Representative Population

Kanyakumari DH[1], Rudramurthy KG[2], Suresh U Kadli[3] and Harish Rangareddy[4,*]
[1]*Associate professor, Department of Physiology, Haveri Institute of Medical Sciences, Devagiri-Yallapura, Haveri-581110*
[2]*Associate professor, Department of Microbiology, Haveri Institute of Medical Sciences, Devagiri-Yallapura, Haveri-581110*
[3]*Associate professor, Department of General Surgery, Haveri Institute of Medical Sciences, Devagiri-Yallapura, Haveri-581110*
[4]*Assistant Professor, Department of Biochemistry, Haveri Institute of Medical Sciences, Devagiri-Yallapura, Haveri-581110*

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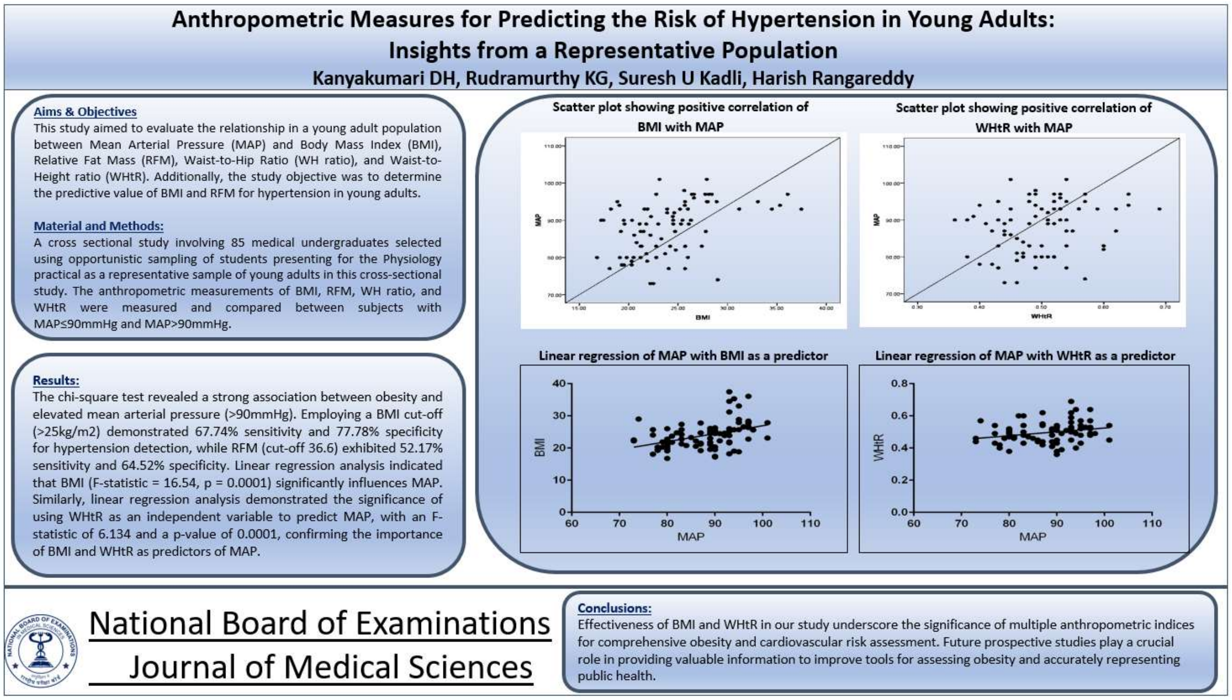
Abstract
Background: Obesity is linked to an unhealthy diet and lack of exercise, elevating the risk of hypertension. Elevated blood pressure and a higher risk of hypertension are linked to an increased BMI. Lifestyle changes in adults, like inactivity and poor diet, contribute to the rise in cardiovascular diseases among younger people. **Objectives:** This study aimed to evaluate the relationship in a young adult population between Mean Arterial Pressure (MAP) and Body Mass Index (BMI), Relative Fat Mass (RFM), Waist-to-Hip Ratio (WH ratio), and Waist-to-Height ratio (WHtR). Additionally, the study objective was to determine the predictive value of BMI and RFM for hypertension in young adults. **Methods:** Participants were selected using opportunistic sampling of medical students presenting for the Physiology practical as a representative sample of young adults in this cross-sectional study. The anthropometric measurements of BMI, RFM, WH ratio, and WHtR were measured and compared between subjects with MAP≤90 mmHg and MAP>90 mmHg. **Results:** The chi-square test revealed a strong association between obesity and elevated mean arterial pressure (>90 mmHg). Employing a BMI cut-off (>25kg/m^2) demonstrated 67.74% sensitivity and 77.78% specificity for hypertension detection, while RFM (cut-off 36.6) exhibited 52.17% sensitivity and 64.52% specificity. There was a significant positive correlation of BMI with MAP ($r = 0.408$, $p < 0.001$) and a significant difference between groups ($p < 0.001$). **Conclusion:** The effectiveness of BMI and WHtR in our study underscore the significance of multiple anthropometric indices for comprehensive obesity and cardiovascular risk assessment. Future prospective studies play a crucial role in uncovering the clinical importance of modern anthropometric measurements and biomarkers, providing valuable information to improve tools for assessing obesity and accurately representing public health.

Keywords: waist-hip ratio, waist-to-height ratio, body mass index, hypertension

*Corresponding author: Harish Rangareddy
Email: harishreddy1349@gmail.com

Graphical Abstract



Introduction

Cardiovascular diseases remain a global concern, requiring thorough risk assessment. Anthropometric measurements are significant indicators, associated with cardiovascular risk factors [1]. The classification of overweight and obesity is done by body mass index (BMI), a trend that is on the rise worldwide. Obesity is associated with a poor diet and lack of physical activity, increasing the chance of developing hypertension [2]. Higher BMI is linked to elevated blood pressure and greater chance of developing hypertension [3,4]. Changes in lifestyle, such as lack of physical activity and unhealthy eating habits, are leading to an increase in cardiovascular diseases among younger individuals [5]. Relative fat mass (RFM) calculates body fat percentage using waist circumference, height, and gender. RFM is more effective at anticipating dyslipidemia and metabolic syndrome [6]. Our study explores the link between anthropometric measures and hypertension in young adults. The primary objectives of this study were to assess the correlation between Body Mass Index (BMI), Relative Fat Mass (RFM), Waist-to-Hip Ratio (WH ratio), and Mean Arterial Pressure (MAP) in a young adult population. Additionally, the study aimed to determine the predictive value of BMI and RFM for hypertension in young adults.

Methods

Study setting and design

Cross-sectional study conducted at a tertiary medical center and teaching hospital.

Sample size was determined using the formula:

$$
\begin{aligned}
n &= Z^2 \times \frac{p \times q}{e^2} \\
&= 1.96^2 \times \frac{0.50 \times 0.50}{0.1^2} \\
&= 97
\end{aligned}
$$

where, at 95% Confidence Interval (CI), Z= 1.96 and n=minimum necessary sample size When calculating the maximum sample size, p= prevalence is taken to be 50%.
q = 1-p, e = 10% margin of error
For a finite population, the sample was modified as follows:
97 / [1+{97-1) / 600}] = n' = n / [1+{(n-1) / N}]= 83.6
In this case, n'= modified sample size
N= finite population of medical students in the Medical College, 600
The calculated minimum required sample size was 84.

Participants

The study involved a sample of 85 young adults (aged 18-21 years) recruited from Basaveshwara Medical College Hospital and Research Center, Chitradurga. Participants were selected using opportunistic sampling of medical students presenting for the Physiology practical and is a representative sample of young adults. Subjects suffering from any cardiovascular disease, respiratory illness any other chronic illness were excluded. Young adults were defined as age spanning between 18 to 26 years according to the Committee on Improving the Health, Safety, and Well-Being of Young Adults; Board on Children, Youth, and Families; Institute of Medicine; National Research Council of United States of America [7].

Data Collection

Anthropometric Measurements

The waist and hip circumferences were measured with a flexible tape measure. Waist circumference (WC) was calculated by measuring the horizontal distance across the abdomen at the navel level. Hip circumference (HC) was measured as the horizontal distance between the two top hip bones (ilia).

Height was measured with a roll ruler wall-mounted growth stature meter and body weight was measured using a medical scale with SECA 803 digital flat scale respectively, by a standardized procedure with an accuracy of 0.1 kg and 0.1 cm, respectively. Participants stood with their backs straight, heels together, barefoot, and in light clothing for both measurements.

Indicators of Obesity

To assess obesity in women, the following factors were examined:

- BMI was computed using the formula: BMI = body weight (kg)/height (m) ^{2}. Participants were classified as underweight (<18.5 kg/m^2), normal weight (18.5-22.9 kg/m^2), overweight (23.0-24.9 kg/m^2), or obese (≥25 kg/m^2) based on consensus guidelines for the diagnosis of obesity among Asian Indians [8].
- The relative fat mass (RFM) index was calculated using the formula:

RFM = 76 – [20 × {height (m)/waist circumference (m)}] [9]

RFM aims to provide a more accurate assessment of body fat percentage, particularly in individuals with different body shapes or proportions.

- The waist-to-hip ratio (WH ratio) was computed using the following formula:
  Waist circumference (WC) in cm / Hip measurement in cm
- The waist-to-height ratio (WHtR) was obtained using the formula:
  (WC) (cm)/height (cm)

Blood Pressure Measurement

The method of Korotkoff sound was utilized for blood pressure measurement using a digital sphygmomanometer. Measurements were conducted based on the guidelines provided by the American Heart Association. The right upper limb artery was examined while sitting. Before measuring blood pressure, it was ensured that the body was in the correct position, a period of rest was taken, an appropriately-sized cuff was used, and external factors that could affect blood pressure (such as drinking coffee and tea) were minimized. The Mean Arterial Pressure (MAP) was determined by using the equation: MAP = DBP + 1/3 (SBP - DBP).

Data Analysis

The normality of the data was evaluated using the Kolmogorov-Smirnov test and was determined to be normally distributed. Mean ± SD was used to present descriptive statistics. The researchers performed independent samples t-tests to compare anthropometric measures between individuals with hypertension and individuals with normal blood pressure. Correlations between BMI, RFM, WH ratio, and MAP were evaluated using Pearson correlation coefficients. A significance level of $p < 0.05$ was established. Data analysis was performed using Statistical Product and Service Solutions (SPSS), SPSS Statistics for Windows, version 16.0 (SPSS Inc., Chicago, Ill., USA).

The study followed ethical standards by obtaining permission from the Institutional Ethics Committee. All participants provided consent prior to taking part in the study, with only the 85 individuals who volunteered being included. Information was made anonymous in order to safeguard the privacy of participants.

Results

This cross-sectional study involved a sample of 85 young adults aged 18-21 years, comprising 48 males and 37 females. The subjects were classified considering the MAP as Group 1 MAP≤90mmHg and Group 2 MAP>90mmHg. The means were compared using the Independent 't' test as shown in Table 1.

Table 1. Comparison of means between the two groups using the Independent 't' test

Parameter	Group 1, n=51 (MAP≤90mmHg) Mean ± SD	Group 2, n=34 (MAP>90mmHg) Mean ± SD	'p' value
Mean arterial pressure (mmHg)	83.41±5.03	94.79±2.47	**<0.001**
Body mass index (kg/m^2)	22.31±2.84	26.44±4.78	**<0.001**
Relative fat mass (%)	29.83±7.32	31.46±7.07	0.311
Waist-hip ratio	0.83±0.06	0.84±0.05	0.253
Waist-to-Height ratio	0.4782±0.0577	0.5224±0.0651	**<0.01**

Out of the 34 students with MAP>90mmHg, 7 had family history of either the father or mother having hypertension. Chi-square test results indicated a robust association between obesity and increased mean arterial pressure (>90mmHg). Utilizing a BMI cut-off of >25kg/m^2, we observed a sensitivity of 67.74% and specificity of 77.78% for detecting hypertension in young adults. Conversely, RFM with a cut-off of 36.6% exhibited a sensitivity of 52.17% and specificity of 64.52% for predicting hypertension.

Regarding BMI, a positive correlation was noted with MAP ($r = 0.408$, $p < 0.001$) which was statistically significant as shown in Figure 1. The t-test revealed a notable difference in BMI between groups ($t = -4.986$, $df = 83$, $p < 0.001$). However, for RFM, no significant correlation with MAP was found ($r = -0.039$, $p = 0.725$), and the t-test indicated no significant difference in RFM between groups ($t = -1.019$, $df = 83$, $p = 0.311$).

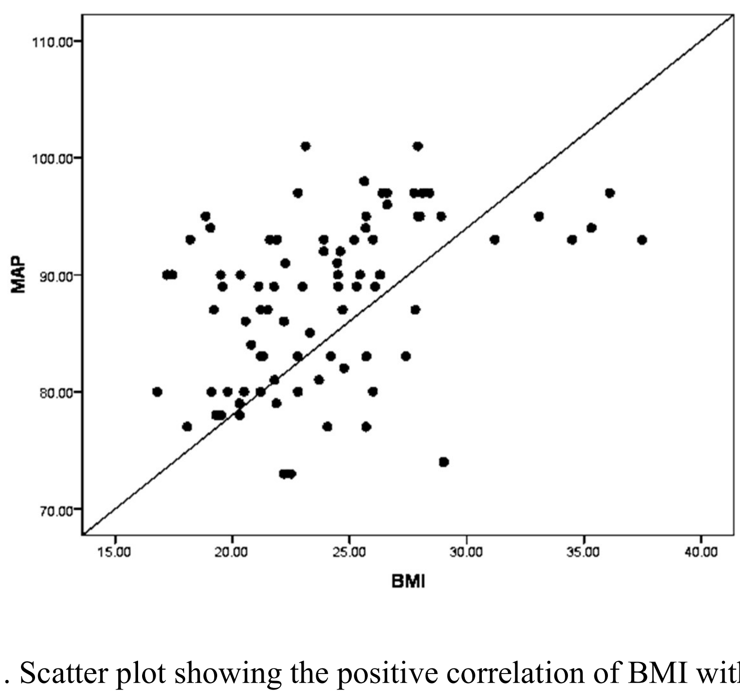


Figure 1. Scatter plot showing the positive correlation of BMI with MAP

Similarly, there was no significant correlation between the WH ratio and MAP (r = 0.102, p = 0.353), and the t-test revealed no notable variation in WH ratio between the groups (t = -1.151, df = 83, p = 0.253). WHtR showed a significant positive correlation with MAP (r=0.2623, p=0.015) as shown in Figure 2, Independent 't' test revealed significant difference between groups (t=-3.279, p<0.01).

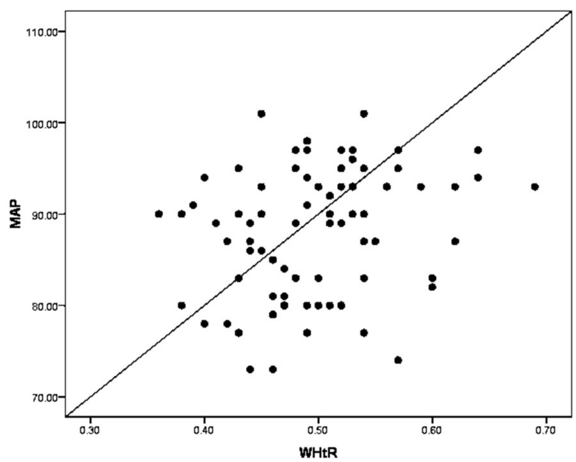


Figure 2. Scatter plot showing the positive correlation of WHtR with MAP

The linear regression analysis using BMI as a predictor and MAP as the dependent variable showed an F-statistic of 16.54 (Y = 0.2468*X + 2.252) with a p-value of 0.0001, indicating a significant impact of body fat mass on MAP. Moreover, when conducting linear regression analysis using WHtR as an independent variable and MAP as the target variable, the F-statistic yielded 6.134 (Y = 0.002408*X + 0.2841) with a significant p-value of 0.0001. Therefore, BMI and WHtR were found to be important predictors of MAP in the examination, as demonstrated in Figure 3 and Figure 4, respectively.

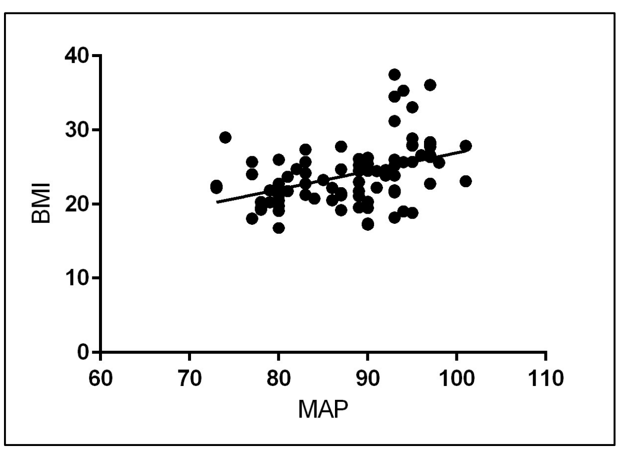


Figure 3. Linear regression of MAP with BMI as a predictor

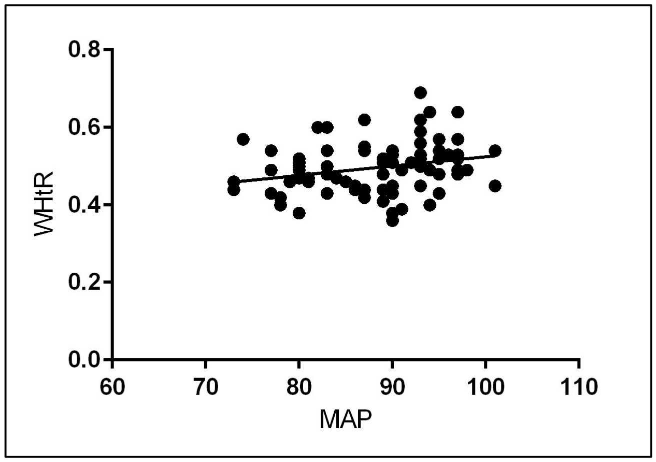


Figure 4. Linear regression of MAP with WHtR as a predictor

These findings shed light on the complex relationships between anthropometric measures and hypertension risk in young adults, emphasizing the importance of BMI and WHtR as predictors of increased mean arterial pressure.

Discussion

Our study revealed that approximately 40% of medical students fell into the category of obesity based on the BMI cut-off. This finding is slightly higher compared with the prevalence reported in a study conducted in Nepal by Aryal V et al, estimating obesity prevalence as 31.67% [10]. However, our results show a lower prevalence compared to the Korean population, where obesity prevalence reached around 50% [11]. In contrast, studies conducted in a teaching hospital in northern Israel and an urban slum of Karachi reported much higher obesity prevalence, reaching 83.70% and 89%, respectively, surpassing the prevalence observed in our study [12,13]. Gender-based distribution of obesity in our study revealed a higher proportion in males (41.66%) compared to females (29.72%) which contrasts the findings by Aryal et al. [10]. The diversity in obesity prevalence underscores the importance of understanding regional and population-specific variations in anthropometric measures. A study conducted by Purohit G et al found that BMI showed negative correlation with SpO_2 ($r = -0.0504$, $p<0.05$) and pulse rate, but positive correlation with systolic blood pressure ($r=0.2736$) and diastolic blood pressure ($r=0.0275$) [14].

RFM, utilizing height and waist circumference, emerged as a simple model for assessing obesity in our study. The mean RFM values for MAP≤90 mmHg and MAP>90mmHg individuals were 29.83±7.32 and 31.46±7.02, respectively. The values in this study are similar to those found by Paek et al. in the Korean adult population, where RFM displayed a diagnostic accuracy in identifying excess body fat percentage that was similar to BMI [15]. Despite the promising aspects of RFM, our study did not demonstrate its effectiveness in predicting hypertension when compared to BMI. Notably, our study did not include other parameters, preventing a comprehensive assessment of RFM's superiority in predicting different risk factors. These findings are similar to the study in the Chinese population by Yu P et al who prospectively observed that both men and women showed that WHtR and RFM had the highest area under the curve (AUC) values in analysis of ROC, but they were not statistically different from BMI and WC in men or women. The predictive ability of the RFM-based model was similar to that of the anthropometric measures viz., BMI, WC, and WHtR in predicting hypertension in the Chinese population, indicating that RFM could be a reliable predictor. However, in terms of predictive accuracy it does not outperform WC, WHtR and BMI [16].

Kankaria et al, observed that among the residents of Manipur, boys and hypertensive individuals exhibited elevated mean Waist-to-Height Ratio (WHtR), with WHtR positively correlating with weight and male gender; however, the diagnostic efficacy of WHtR for hypertension, as indicated by the AUC in ROC was low [17].

In the CASPIAN-IV study by Payab M et al, the intake of sweetened beverages showed a notable relationship with both body measurements and blood pressure readings. Furthermore, an important relationship was found between fast food intake, blood pressure, and body measurements (except for WHtR and WHR). Consuming sweetened beverages showed a strong connection with anthropometric measurements while consuming salty snacks was only linked significantly to height, hip circumference, and waist-to-hip ratio (WHR). Individuals who rarely ate sweets had a reduced chance of developing overall obesity and abdominal obesity in comparison to those who ate them every day. Likewise, students who rarely drank sweetened beverages were less likely to be generally obese compared to those who consumed them every day [18]. In our study dietary history was not considered. However, following the study the students with obesity and MAP>90mmHg were advised to exercise regularly and diet charts were provided.

Armitage et al. conducted an experimental study using rabbits equipped with telemetric devices to measure renal sympathetic activity and hemodynamic parameters. They found that rabbits on a high-fat diet exhibited a rapid increase in renal sympathetic tone, blood pressure, and heart rate, along with a decrease in baroreflex function [19]. However, the mechanisms underlying renal denervation influencing blood pressure regulation in obesity remain unclear. It is uncertain whether disrupting sympathetic vasomotor connections outside the kidneys could lead to improvements in blood pressure and other cardiovascular alterations in obesity. Additionally, animal models with obesity-related mutations in the ob gene or LepR often develop heart failure, suggesting a potential connection between leptin and cardiovascular disease [20]. Studies have shown that blocking leptin receptor signaling in pro-opiomelanocortin (POMC) neurons can prevent exogenous leptin from elevating blood pressure, reinforcing the role of leptin as a crucial hormone linking hypertension and obesity [21].

Obesity is characterized by increased plasma volume and sodium accumulation, which are relevant factors in the development of high blood pressure. Studies conducted over time have demonstrated that changes in kidney excretory function precede the onset of obesity-related hypertension in both animals and humans, suggesting that kidney dysfunction may contribute to elevated blood pressure in obesity [22,23,24].

Large prospective studies are essential to uncover the long-term clinical significance of newer anthropometric measurements, shedding light on their potential advantages over traditional measures. These studies could provide valuable insights into refining obesity assessment tools for a more accurate representation of the population's health status.

Conclusion

In conclusion, this study sheds light on the intricate link between anthropometric measurements and cardiovascular risk in a representative young adult population. The significant associations found, particularly with BMI, WHtR, and MAP, advocate for the inclusion of comprehensive anthropometric assessments in cardiovascular risk stratification models for this demographic. Further research is warranted to validate and extend these findings, ultimately contributing to enhanced preventive strategies for cardiovascular diseases in young adults.

Acknowledgment

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Authors' contributions

KKDH and SUK were involved in the initial writing, revision, idea presentation, initial design, and data collection and analysis of the manuscript. RKG HR took part in reviewing the manuscript, analyzing data, and making revisions to the manuscript. Additionally, all authors take on the responsibility for the validity of the content in the current manuscript and endorse the final draft of the manuscript.

Conflict of interests

The authors declares that they do not have conflict of interest.

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