Body Mass Index, a Body Shape Index, and Waist-to-Height Ratio in Predicting Elevated Blood Pressure

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Abstract

Background: One of the complications of obesity is an elevation in blood pressure which can increase the risk of hypertension. This study aimed to explore body mass index (BMI), a body shape index (ABSI), and waist-to-height ratio (WHtR) in predicting elevated blood pressure (BP).

Methods: This study was conducted in a cross-sectional design on 215 medical students from October 2019 to September 2020. Respondents measured their own weight, height, waist circumference and BP. Receiver operating characteristics (ROC) curve were analyzed using IBM SPSS v.23.

Results: Of the 215 medical students who participated in this study, only 102 met the inclusion criteria. The majority of the students were female (n=71, 69.6%) with a mean age of 19.37 years, and normal blood pressure (n=90, 88.2%). Area under the ROC curve (AUC) of WHtR and ABSI were 0.774 (p-value= 0.002) and 0.766 (p-value= 0.003) respectively, which were still acceptable. However, the AUC of BMI (p-value=0.589) was 0.11, which was considered poor.

Conclusion: The indicators of obesity can be used as a screening value for increased blood pressure in adults, with BMI being the weakest indicator compared to ABSI and WHtR. Further research is needed to examine ABSI and WHtR indicators as predictor of increased blood pressure in adults.

Keywords: ABSI, blood pressure, BMI, obesity, WHtR

Introduction

Obesity is a condition caused by an increase in the size and number of fat cells in the body.[1] One type of obesity that causes health problems and premature death is central obesity. Central obesity is a condition of accumulation of fat cells in the abdominal area. A study revealed that people who have a distended stomach have a higher risk of death than those who are obese but not distended stomach.[1] In addition, central obesity can trigger inflammation or inflammation of the internal organs by releasing cytokine compounds. Intra-abdominal fat has a higher lipogenic activity so that it is metabolically very active releasing free fatty acids into the portal circulation which travels directly to the liver. Excessive free fatty acids can trigger an increase in fat biosynthesis in the liver, causing insulin resistance, hyperlipidemia, glucose intolerance, increased blood pressure, and atherosclerosis.[1] The prevalence of Indonesian adult population (aged over 18 years) with central obesity is 26.6 percent in 2013. This prevalence is higher than in 2007 (18.8%).[2] This increase in cases if ignored could cause problems in the future.

The best method for assessing body fat distribution is by using computed tomography. However, the use of this tool is impractical because it requires high costs and radiation

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exposure. Therefore, anthropometric measurement can be used as another option because it is easier to apply and does not cost a lot of money.[3] Previously, body mass index (BMI) was a fairly effective measuring tool, which was to measure the average obesity in a population. The benefits of the body mass index method are simple formula, cheap, and relatively precise results. However, the disadvantage of body mass index is the disability to differentiate between overweight due to fat or muscle. In addition, the body mass index cannot precisely determine the location of fat deposits in the body.[4] The current effort to overcome the weakness of BMI is to create measurements with a body shape index (ABSI) and waist-to-height ratio (WHtR). ABSI is an indicator of obesity that can predict risk factors for premature death in the general population. Meanwhile, WHtR was reported to be a better predictor of increased blood pressure than BMI.[5]

Hypertension is one of the important factors triggering non-communicable diseases such as stroke, ischemic heart disease, and others. Currently, cardiovascular disease is the number one cause of death in the world.[6] Based on study results from the Research and Development Agency of the Ministry of Health in 15 districts/cities in Indonesia, 17.7% of deaths were caused by strokes and 10% of deaths were caused by ischemic heart disease (IHD).[7] The risk factor for both diseases is hypertension. The interesting fact is that more deaths from stroke and IHD were at home than in hospitals. Thus, it can be said that hypertension is a silent killer.[7,8] Although various obesity indexes have been developed, the best obesity index in predicting elevated blood pressure/prehypertension is controversial. Prehypertension has a high risk of developing hypertension.[9] Several studies found that there is a trend of increasing cases of increased blood pressure in adults due to obesity. Obese adults are 4–10 times more likely to develop hypertension.[10] Unpreventable increases in blood pressure may increase the likelihood of severe cardiovascular disorders. Therefore, aim of this study was to compare several obesity indices in predicting prehypertension. Thus, this study can determine early and accurate prehypertension screening to prevent the progression of prehypertension to hypertension.

Methods

The research design used in this study was a cross-sectional study. The study included 215 medical students at the Atma Jaya Catholic University of Indonesia. Exclusion criteria were those who had a history of medication for hypertension, diabetes mellitus or kidney disorders, consumed caffeine within six hours prior to blood pressure measurement, had a habit of smoking or drinking alcohol, and did not have a blood pressure measuring device. This study has been approved by the Research Ethics Board, School of Medicine and Health Sciences Atma Jaya Catholic University of Indonesia (No: 04/04/KEP-FKUAJ/2020).

Subjects were asked to complete an electronic form created by Google Forms inquiring blood pressure and anthropometric data, including their weight, waist circumference and height. The data were than calculated for the BMI, ABSI, and WHtR formulas.[4,5,11]

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height}^2\,(\text{meter}^2)}$$

$$\text{WHtR} = \frac{\text{Waist circumference}}{\text{Height}}$$

$$\text{ABSI} = \frac{\text{Waist circumference (meter)}}{\mathbf{BMI}^{\frac{2}{3}}\left(\frac{\mathbf{kg}}{\mathbf{m^2}}\right)\mathbf{x\ Height}^{\frac{1}{2}}\,(\mathbf{meter})}$$

Table 1 Respondents Characteristics (n=102)

Characteristics	n	%
Gender		
Male	31	30.4
Female	71	69.6
Blood pressure		
Normal	90	88.2
Elevated	12	11.8

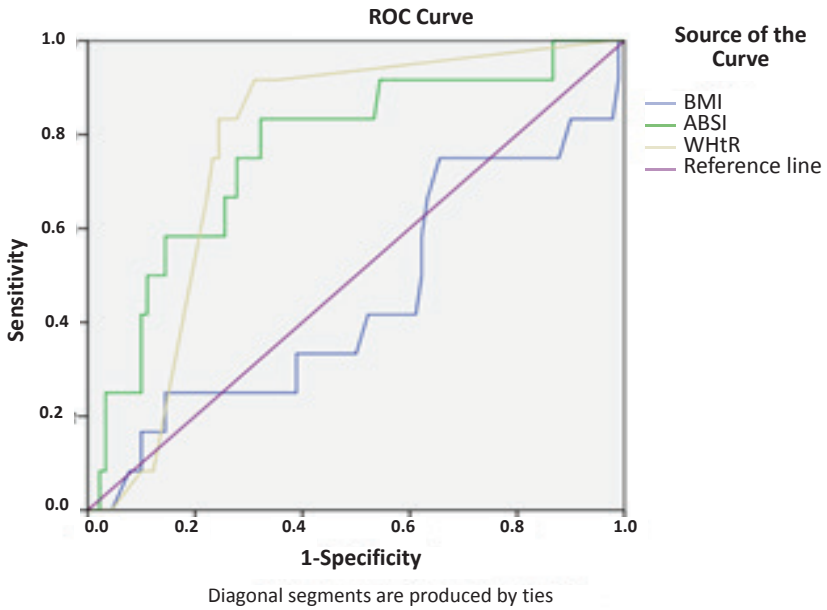

Figure Discriminatory Power of Obesity Indices based on ROC Curve Analysis

Blood pressure data was collected independently using their pre-owned device. Concise blood pressure measurement instructions following current guideline from the American College of Cardiology/American Heart Association (ACC/AHA) were given to each individual. Blood pressure was measured 3 times; upon waking up, in the afternoon, and before going to bed. Measurements were averaged and categorized as normal (systolic blood pressure ≤120 and diastolic blood pressure ≤80 mmHg), or elevated (systolic blood pressure >120 and diastolic blood pressure >80 mmHg).

The analysis used was the receiver operating characteristics (ROC) curve to compare the predictive power of each indicator in predicting the increase in blood pressure in respondents. Area under the ROC curve (AUC) in this study was used to conclude the ability of each indicator in predicting an increase in blood pressure. AUC of 1 was designated as perfect predictive ability; 0.5 indicated that the indicator did not have the ability to predict an increase in blood pressure; AUC of 0.7–0.8 indicated that the indicator was still acceptable; 0.8–0.9 was good; and >0.9 was excellent.[12] The optimal cut-off values of the anthropometric indices to predict the elevated blood pressure were estimated based on the largest value of the Youden index (J=Sensitivity+ Specificity–1).[13]

Analysis was performed using IBM SPSS Statistics for Windows Version 23 (SPSS Inc., Chicago, IL, USA) with ROC curve analysis. Data were presented in table and figure.

Results

Of the 215 medical students who participated in this study, only 102 met the inclusion criteria. The majority of the students were female (n=71, 69.6%), with a mean age of 19.37 years, and normal blood pressure (n=90, 88.2%) (Table 1).

Regarding the discriminatory power of obesity indices based on ROC Curve analysis, it could be seen that the WHtR line was closest to the Y line (0,1), followed by the ABSI line in second place, whereas the BMI line was farthest from the Y line. The Y line was called a perfect classification. The closer the line was to the Y line, the better the obesity index predicted an elevation in blood pressure (Figure). In Table 2, it showed that the AUC of WHtR and ABSI scores were higher than BMI. The AUC of WHtR and ABSI were 0.774 (p-value=0.002) and 0.766 (p-value=0.003) respectively, which were still acceptable. However, the AUC of BMI (p-value=0.589) was 0.11, which was considered poor. After determining the highest Youden Index for each indice, the optimum cut-offs of WHtR, ABSI, and BMI in predicting the elevation of blood pressure were 0.49, 0.08, and 28.2, consecutively. Based on ROC analysis, the sensitivity of WHtR, ABSI, and BMI were 91.67%, 83.33%, and 25% consecutively. Meanwhile, the specificity of WHtR, ABSI,

Table 2 Optimal Cut-off Values, Sensitivities, Specificities, Youden Index, and AUC of Anthropometric Indices in Predicting Elevate

Anthropometric Indices	Cut-off	Sensitivity (%) (95% CI)	Specificity (%) (95% CI)	Youden Index	AUC (95% CI)	p-value
BMI	28.20	25.00	85.56	0.11	0.452	0.589
ABSI	0.08	83.33	67.78	0.51	0.766	0.003
WHtR	0.49	91.67	68.89	0.61	0.774	0.002

Note: BMI=Body mass index, ABSI=A body shape index, WHtR=Waist-to-height ratio, AUC=Area under the ROC curve

and BMI were 68.89%, 67.78%, and 85.56% respectively.

Discussion

Easy-to-use screening tools are essential in detecting the risk of prehypertension for early intervention. This is because the prevalence of prehypertensive people who are obese is increasing.[14] This study provides information about the optimal cutoff and compares three indicators of obesity (BMI, ABSI, and WHtR) in predicting increased blood pressure.

BMI is a poor indicator of predicting increased blood pressure. This is indicated by the very low AUC results (AUC=0.452) and p-value >0.05 (p=0.589). Among all the indicators tested in this study, the ROC BMI curve is the farthest from the Y line (0.1). This is because BMI is not able to measure fat distribution. In addition, BMI cannot differentiate between fat tissue and muscle mass in a person's body so that many individuals with high body fat composition are not detected based solely on BMI measurements. Therefore, the use of a BMI indicator in predicting elevated blood pressure is not recommended.[15,20]

Indicators that show central obesity such as WHtR can predict cardiometabolic risk better than BMI. This is indicated by the high AUC results (AUC=0.774) and p-value <0.05 (p=0.02). Among all the indicators tested in this study, the WHtR ROC curve is closest to the Y line (0.1) so it can be concluded that the WHtR indicator has a reliable ability to predict an increase in blood pressure in respondents. The cut off value of WHtR that has the highest sensitivity and specificity based on Youden Index in predicting elevated blood pressure is 0.49. The WHtR cutoff in predicting increased blood pressure was only slightly lower than the cutoff for obesity (WHtR> 0.5). Cut-off WHtR> 0.5 has a sensitivity and specificity that can still be relied upon in predicting elevated blood pressure above normal (sensitivity=83.3%, specificity=72.2%). However, for screening needs it is recommended to use a cut-off that has a higher sensitivity. So, WHtR cut-off> 0.49 is more recommended in predicting an increase in blood pressure. This study is consistent with the results of a meta-analysis study conducted by Tee et al.[5] which examined more than 513 adolescents from Malaysia. WHtR is the best indicator as an initial screening for prehypertension, while BMI is the worst indicator as an initial screening for prehypertension.[6,19]

The ABSI indicator was good at predicting an increase in blood pressure in respondents. The AUC ABSI score was only slightly lower than the WHtR (AUC=0.766). The ABSI cut-off value in predicting an increase in blood pressure is 0.08. The results of this study are not so surprising given that a high ABSI score has a strong correlation with the visceral fat fraction, which has metabolic effects that are harmful to health.[16–18]

Limitation of this study is that it was a cross-sectional study. Cross-sectional design can explain the relationship between the two variables, but this study cannot show the direction of the causal relationship between the two observed variables. Besides, anthropometric measurements such as weight, height, waist circumference and blood pressure were measured independently by the respondents using the tools they had. Due to COVID-19 pandemic, researchers must implement health protocol by limiting social gathering so that measurements carried out by respondents independently cannot rule out human error in the data collection process.

To conclude, indicators of obesity can be used as a screening for increased blood pressure in adults. However, BMI is the weakest indicator compared to ABSI and WHtR. Therefore, BMI is not recommended as an initial screening for elevated blood pressure. WHtR and ABSI can be considered as

a good predictors of elevated blood pressure in adults. Further research is needed to examine WHtR and ABSI as predictors of increased blood pressure in adults.

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