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Association Between Adiposity Indices and Blood Pressure Among Young Adults in South Sumatra Province Indonesia

Asociación Entre los Índices de Adiposidad y la Presión Arterial en Adultos Jóvenes de la Provincia de Sumatra Meridional, Indonesia

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SUMMARY: This study examined the relationship between adiposity indices and blood pressure in young adults. The study, conducted in South Sumatra Province, Indonesia, included 413 young adults aged 18-25. The collected data showed that cases of above-normal blood pressure, as well as high adiposity, were prevalent in the study population. The study found that males had higher values in almost all adiposity indices compared to females. The prevalence of above-normal blood pressure was also higher in males. All adiposity indices, except TESfR, were significantly associated with blood pressure in the study subjects. Body Mass Index (BMI) was found to be the strongest predictor of blood pressure. This study indicates a growing number of young adults with above-normal blood pressure and highlights the importance of monitoring and managing adiposity levels, as well as BMI, to reduce the risk of elevated blood pressure.

KEY WORDS: Adiposity indices; Anthropometric measurements; Blood pressure; Young adults.

INTRODUCTION

Blood pressure is a common clinical parameter determined by the volume of blood pumped by the heart into the arteries, the elasticity of the arterial walls, and the rate of blood flow out of the arteries (Magder, 2018). In certain conditions, a single blood pressure check reaching 160/95 mmHg or two or more blood pressure checks reaching ≥140/90 mmHg is defined as hypertension (Bunsawat *et al*., 2021). Lifestyle modifications, whether individual or group, have been shown to be effective in reducing hypertension, but there is no predictable pattern due to varying results in each lifestyle intervention (Organia *et al*., 2019).

The World Health Organization (WHO) reported that 1.28 billion adults in the world suffer from hypertension (World Health Organization, 2023). Children and adolescents were described as 3 % and 5 % having hypertension and 10 % and 14 % having prehypertension (Song *et al*., 2019). In a global meta-analysis, the prevalence of hypertension was 4.0 %, and prehypertension was 9.7 % (Song *et al*., 2019). The prevalence of hypertension increased from 1.3 % (1990 - 1999) to 6.0 % (2010 - 2014) (Robinson & Chanchlani, 2022). Currently, the prevalence of hypertension is estimated to reach 3.7 % to 8.6 % worldwide (Shin *et al*., 2023).

The 2018 Basic Health Research (Riskesdas) reported that the prevalence of hypertension in Indonesia was 34.1 % of the total adult population, while in South Sumatra Province, it was 30.44 % (Indonesian Ministry of Health, 2013). Additionally, based on the Palembang City Health Profile in 2018, it was reported that 97,636 people experienced hypertension in the city (South Sumatra Provincial Health Office, 2018).

Risk factors for high blood pressure are classified into modifiable and non-modifiable risk factors. Non-modifiable risk factors include a family history of hypertension (HT), age >65 years, and comorbidities such as diabetes or kidney disease. Modifiable risk factors are unhealthy diet, lack of physical activity, tobacco and alcohol consumption, and obesity (Hu *et al*., 2020; World Health Organization, 2023).

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Obesity can be measured using a simple method through anthropometric measurements (Fitriyanti *et al*., 2019). Body mass index (BMI) is still used as the main epidemiologic measure for obesity, which is a condition of excessive accumulation of adiposity (National Academies of Sciences, Engineering, and Medicine *et al*., 2023). Body fat percentage, calculated as total fat mass to total body mass, is also used in measuring adiposity (Mohajan & Mohajan, 2023). However, these indices have limitations in accounting for body fat distribution. Several anthropometric indices have been developed to specifically describe body fat distribution, such as waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), and trunk-to-limbs skinfold ratio (TESfR) (Hu *et al*., 2020).

Having these variations in adiposity indices, some studies have examined the predictive value of hypertension. A study reported that WHtR is a better predictor of hypertension than BMI (Ashwell *et al*., 2012). Another study stated that BMI was better than body fat percentage in predicting blood pressure levels (Mushengezi & Chillo, 2014). More recent studies have shown that WHR has a stronger correlation with blood pressure components than BMI, even in normal individuals. Previous studies have shown that body fat percentage is positively associated with hypertension risk (Herinasari *et al*., 2022).

Recent studies have reported cases of increased blood pressure in young adults. A meta-analysis study of 17 observational cohort studies reported that 4.5 million young adults have hypertension, posing long-term risk of cardiovascular disease (Luo *et al*., 2020). Increased blood pressure in this young adult population is closely related to BMI ($p<0.001$ in males and $p<0.05$ in females) (Hastuti *et al*., 2018). Research conducted in Algeria showed a prevalence of overweight (including obesity) of 20.4 % of the total 20-25-year-old subjects studied (Dahel-Mekhancha *et al*., 2023).

Data on adiposity indices characteristics associated with blood pressure in a population can be used as a basis for establishing obesity and hypertension prevention programs. Therefore, this study needs to be conducted to determine the relationship between adiposity indices, which includes BMI, body fat percentage, WHR, WHtR, and TESfR with blood pressure in young adults.

MATERIAL AND METHOD

Study design and population. This study was an observational analytic study conducted using a cross-sectional design from August to December 2024. The population of this study was young adults aged 18-25 years with a total of 413 subjects. The data collected was primary, and the sampling was selected using a multistage random sampling method.

Data processing used the Statistical Package for Social Science (SPSS) version 25 program and Microsoft Excel 2019. Data were analyzed using the Chi-Square statistical test, t-test, and binary logistic regression test. This study collected 420 subjects, however, there were 7 subjects excluded because they were not willing to participate and were taking antihypertensive drugs. In total, 413 subjects participated in the study.

Anthropometric Measurements. Height was measured without headwear accessories and footwear with an accuracy of 0.1 cm. Body weight was measured with minimal clothing, without any footwear or anything similar, using a scale with a precision level of 0.1 kg. The calculation of body weight (kg) was divided by the square of height (m) in meters (kg/m2) to obtain the body mass index (BMI). Waist and hip circumferences were also measured to the nearest 0.1 cm using non-elastic measuring tape, Waist circumference was measured midway between the lower edge of the last palpable rib and the crest of the iliac crest, while hip circumference was measured at the widest circumference around the buttocks. Waist circumference (cm) was divided from hip circumference (cm) as an interpretation of WHR. Waist circumference (cm) was divided by height (cm) to interpret WHtR. TESfR is obtained from:

$$TESfR = \frac{\textit{total thickness of trunk skin fold (scapula + suprailiac)}}{\textit{total thickness of limb skin fold (biceps + triceps}}$$

Skin thickness was measured with a skinfold caliper with a precision level of 1 mm at four points of the biceps, triceps, subscapular and suprailiac. Each point was measured on the left side for consistency of results. Body fat percentage was calculated using Janatin Hastuti's formula, which is:

Body fat percentage = 17.026 + (0.509 x triceps) + (0.342 x suprailiac) - (5.594 x G)

Notes: sex (1 for male, 0 for female)

RESULTS

As shown in Table I, a total of 413 participants (89 males and 324 females) participated in this study with a mean age of 19.85 (1.25) years. Overall, the mean SBP and DBP levels were 114.91 ± 10.19 mmHg and 74.59 ± 8.12 mmHg, respectively. The prevalence of hypertension was 41.2 % (170/413). The mean (SD) values for BMI, WHR, WHtR,

Table I. Baseline characteristics of study participants by sex.

Characteristics	Total (N = 413)	Male (N = 89)	Female (N = 324)	P value
Age (year)	19.85 ± 1.25	19.96 ± 1.42	19.81 ± 1.2	0.350
Weight (kg)	58.11 ± 15.49	72.53 ± 19.04	54.15 ± 11.59	<0.001
Height (m)	1.6 ± 0.08	1.71 ± 0.06	1.57 ± 0.05	<0.001
Adiposity indices				
BMI	22.49 ± 4.99	24.85 ± 6.22	21.84 ± 4.38	<0.001
WHR	0.82 ± 0.07	0.86 ± 0.08	0.80 ± 0.06	<0.001
WHtR	0.49 ± 0.07	0.51 ± 0.09	0.49 ± 0.06	0.006
Body fat percentage	33.18 ± 5.95	36.50 ± 8.48	32.27 ± 4.66	<0.001
TESfR	1.35 ± 0.32	1.50 ± 0.43	1.31 ± 0.27	<0.001
Blood pressure (mmHg)				
Systolic	114.91 ± 10.19	122.56 ± 9.74	112.80 ± 9.27	<0.001
Diastolic	74.59 ± 8.12	75.89 ± 9.02	74.23 ± 7.83	0.088
Hypertension n (%)	170 (41.2)	65 (73.03)	105 (32.41)	<0.001

BMI: Body Mass Index; WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio; TESfR: trunk -to-limb skinfold ratio.

body fat percentage, and TESfR were 22.49±4.99 kg/m^2, 0.82±0.07, 0.49±0.07, 33.18±5.95, and 1.35±0.32, respectively. Compared to females, males had significantly higher values for weight, height, BMI, WHR, WHtR, body fat percentage, TESfR, systolic blood pressure, diastolic blood pressure, and hypertension (all $P < 0.05$). However, no significant difference was found between sexes in age (all $P > 0.05$).

Males had a higher mean systolic blood pressure than females (122.56 mmHg and 112.80 mmHg). Meanwhile, diastolic blood pressure did not show a statistically significant difference in values in sexes. A total of 41.2 % of the subjects had blood pressure classified as prehypertension, grade 1 hypertension, and grade 2 hypertension, with males having a higher proportion across all three groups than females.

The blood pressure divided into 4 categories based on JNC (Joint National Committee) VII is shown in Table II. After analysis, all tables did not meet the assumption for the Chi-Square test. Furthermore, table cells in the blood pressure category were merged into 3 categories by combining hypertension degrees 1 and 2 and analyzed. However, there was still a table that did not meet the Chi-Square test requirements. Finally, the table cells were merged into 2 categories, namely normal and above normal, and all tables met the requirement for the Chi-Square test.

Table III shows the relation between age and blood pressure. The analysis revealed a P value = 0.025 ($P<0.05$), indicating a significant relationship between age and blood pressure. Similarly, the chi-square test results in Table IV showed a P value <0.001 ($P<0.05$), confirming a statistically significant relationship between sex and blood pressure.

Table II Distribution of subjects by blood pressure (N=413)

Variables	Total		Male		Female	
	n	%	n	%	n	%
Normotension	243	58.80	24	26.97	219	67.59
Pre-hypertension	154	37.30	55	61.80	99	30.56
Stage 1 hypertension	14	3.40	9	10.11	5	1.54
Stage 2 hypertension	2	0.50	1	1.12	1	0.31

Table III Relationship between age and blood pressure (N=413).

Age	Blood pressure		Total (n)	P value
	Above normal n (%)	Normal n (%)		
≤19	50 (34.25)	96 (65.75)	146 (100)	
20	55 (41.67)	77 (58.33)	132 (100)	
21	47 (44.34)	59 (55.66)	106 (100)	0.036
≥22	18 (62.07)	11 (37.93)	29 (100)	
Total	170 (41.16)	243 (58.84)	413 (100)	

Males have a chance of having blood pressure above normal by 2.745 times compared to females.

Statistical results using the Chi-Square test in Table V show $P<0.001$ ($P<0.05$), meaning there is a statistically highly significant relationship between BMI and blood pressure. Likewise, the Chi-Square test results in Table VI show a P value = 0.003 ($P<0.05$), indicating a statistically significant relationship between WHR and blood pressure. Subjects with WHR>0.82 have a chance to have blood pressure above normal by 2.795 times compared to subjects with WHR≤0.82.

Table IV Relationship between sex and blood pressure (N=413).

Sex	Blood pressure		Total n (%)	P value	RR (95% CI)
	Above normal n (%)	Normal n (%)			
Male	65 (73.03)	24 (26.97)	89 (100)		
Female	105 (32.41)	219 (67.59)	324 (100)	<0.001	2.254(1.842-2.757)
Total	170 (41.16)	243 (58.84)	413 (100)		

Table V. Relationship between BMI and blood pressure (N=413).

BMI	Blood pressure		Total n (%)	P value
	Above normal n (%)	Normal n (%)		
Obese	29 (96.67)	1 (3.33)	30 (100)	
Overweight	45 (64.29)	25 (35.71)	70 (100)	
Normoweight	74 (32.31)	155 (67.69)	229 (100)	<0.001
Underweight	22 (26.19)	62 (73.81)	84 (100)	
Total	170 (41.16)	243 (58.84)	413 (100)	

BMI: Body Mass Index.

Table VI Relationship between WHR and blood pressure (N=413).

WHR	Blood pressure		Total n (%)	P value	RR (95% CI)
	Above normal n (%)	Normal n (%)			
>0.82	90 (49.45)	92 (50.55)	182 (100)		
≤0.82	80 (34.63)	151 (65.37)	231 (100)	0.003	1.428 (1.134-1.797)
Total	170 (41.16)	243 (58.84)	413 (100)		

WHR: Waist-to-hip ratio.

Table VII Relationship between WHtR and blood pressure (N=413).

WHtR	Blood pressure		Total n (%)	P value	RR (95% CI)
	Above normal n (%)	Normal n (%)			
>0.5	102 (56.67)	78 (43.33)	180 (100)		
≤0.5	68 (29.18)	165 (70.82)	233 (100)	<0.001	1.634 (1.356-1.969)
Total	170 (41.16)	243 (58.84)	413 (100)		

WHtR Waist-to-height ratio.

Table VIII Relationship between body fat percentage and blood pressure (N=413)

Body fat percentage	Blood pressure		Total n (%)	P value
	Above normal n (%)	Normal n (%)		
>35%	80 (64.00)	45 (36.00)	125 (100)	
25% - 35%	87 (31.18)	192 (68.82)	279 (100)	<0.001
<25	3 (33.33)	6 (66.67)	9 (100)	
Total	170 (41.16)	243 (58.84)	413 (100)	

Table IX Relationship between TESfR and blood pressure (N=413).

TESfR	Blood pressure		Total n (%)	P value	RR (95% CI)
	Above normal n (%)	Normal n (%)			
>1.35	83(45.36)	100(54.64)	180(100)		
≤1.35	87(37.83)	143(62.17)	233(100)	0.149	1.199 (0.953-1.509)
Total	170(41.16)	243(58.84)	413(100)		

TESfR trunk-to-extremity skinfold ratio.

The statistical results using the Chi-Square test in Table VII also show P<0.001 (P<0.05), indicating a statistically highly significant relationship between WHtR and blood pressure. Subjects with WHtR≥0.5 have a chance to have blood pressure above normal by 1.634 times compared to subjects with WHtR.

The relationship between body fat percentage and blood pressure is shown in Table VIII. Statistical test results using Chi-Square showed a P value<0.001 (P<0.05), confirming a significant relationship between the percentage of body fat and blood pressure.

Conversely, the results of statistical tests with the Chi-Square between TESfR and blood pressure in Table IX yielded a P value = 0.149 (P>0.05) indicating no statistically significant relationship.

Furthermore, to determine the most significant predictors of blood pressure, binary logistic regression analysis was performed (Table X). The results identified that the most significant predictors of blood pressure are sex and BMI with a P<0.001 (P<0.05). However, the subject with a high BMI had a chance of developing increased blood pressure by 2.508 times compared to those with a lower BMI.

Table X Multivariate analysis by binary logistic regression.

Variables	B	P	Exp	95 % CI
Age	0.154	0.213	1.166	0.915-1.485
Sex	-1.703	<0.001	0.182	0.100-0.331
BMI	0.920	<0.001	2.508	1.639-3.839
WHR	-0.279	0.313	0.757	0.440-1.300
WHtR	-0.431	0.181	0.650	0.346-1.222
Body fat percentage	0.043	0.888	1.044	0.574-1.899
TESfR	0.335	0.159	1.398	0.877-2.226
Constant	-1.894	0.143	0.150	

BMI Body Mass Index; WHR Waist-to-hip ratio; WHtR Waist-to-height ratio; TESfR trunk-to-extremity skinfold ratio.

DISCUSSION

This cross-sectional study explored the association of various adiposity indices and hypertension by young adult age. The main findings revealed that anthropometric indices (BMI, WHR, WHtR, and body fat percentage) were positively and significantly associated with the prevalence of hypertension, with BMI emerging as the strongest predictor. However, TESfR showed no association with blood pressure.

Previous studies have reported that increased blood pressure was found at higher BMI. This indicates that BMI may have a direct effect on blood pressure regardless of other clinical risk factors (Hu *et al*., 2020; Dahel-Mekhancha *et al*., 2023). However, the use of BMI is questionable in terms of distinguishing between overfat individuals and high muscle individuals, cannot reflect the distribution of body fat (Hu *et al*., 2020). Dysfunction of adipose tissue activates the renin-angiotensin-aldosterone system, which increases blood pressure. The process begins with angiotensin II (Ang II), which is secreted in large amounts by subcutaneous adipose tissue from the abdomen of obese individuals. Next, the excessive production of angiotensinogen in the tissue contributes to the elevation of blood pressure. Additionally, adipocytes require AngII in the process of aldosterone production. Finally, mineralized corticotropin released from adipose tissue stimulates adrenocortical cells to release aldosterone. Various hormones secreted by adipose tissue are also known to be associated with hypertension:

- Leptin is a hormone produced by adipocytes, where leptin levels increase in obesity and trigger increased sympathetic nerve activity, which in turn increases heart rate and blood pressure.
- Resistin is significantly increased in obesity, plays a role in the development of insulin resistance, and can trigger hypertension through an increase in angiotensinogen.
- Lipocalin secretion is decreased in obese patients, leading to decreased endothelial nitric oxide synthase and prostaglandin I2 synthase, thereby reducing vasodilation and increasing blood pressure.

Thus, excess adipose tissue can cause hormonal, inflammatory, and endothelial changes that contribute to increased insulin resistance, higher sympathetic activity, activation of the renin-angiotensin-aldosterone system, endothelial dysfunction, as well as sodium reabsorption by the kidneys, further leading to increased blood pressure (Reneau *et al*., 2018; Koenen *et al*., 2021).

While four out of five adiposity indices in this study were positively and significantly associated with hypertension, one adiposity index (TESfR) showed a less strong association with hypertension. TESfR is an index that has not been widely used in predicting blood pressure. The mean value for TESfR in this study (1.35) was greater than a reported study in a similar age group in Algeria (1.28) (Dahel-Mekhancha *et al*., 2023). However, this result, contrary to another study, reported a significant association (P<0.05) (Dahel-Mekhancha *et al*., 2023). Nevertheless, TESfR is considered no better than other indices in predicting blood pressure (Dahel-Mekhancha *et al*., 2023). TESfR, which is obtained through skinfold measurements, has the disadvantage of differentiating abdominal visceral adipose tissue from saturated adipose tissue since this measurement is limited to the assessment of subcutaneous fat only. Skinfold thickness has a low correlation with fat-free mass (Silveira *et al*., 2020). Moreover, no study has recommended the use of the skinfold ratio as an indicator in describing body fat patterns (Hastuti etal., 2020).

The Multivariate analysis results in this study illuminated that sex and BMI had a highly statistically significant association with blood pressure, with BMI as the strongest predictor. This result aligns with a study conducted on young adults aged 33-45 years, which stated that increased BMI was independently associated with higher fat tissue (p<0.0001). Apart from adiposity, BMI also has a significant relationship with skeletal muscle in males and females, but the pattern varies by sex. Males had relatively higher skeletal muscle than fat tissue across all BMI ranges. However, in individuals with higher BMI, the amount of fat tissue increased following the proportion of skeletal muscle. In contrast, females had more skeletal muscle than fat tissue across the normal BMI range. Yet, fat tissue was observed to increase to exceed the proportion of skeletal muscle in the high BMI group (Heymsfield *et al*., 2024). Being overweight, which certainly affects BMI, can lead to an increase in body fluid volume, peripheral resistance e.g., hyperinsulinemia, cell membrane changes, and a hyperactive renin-angiotensin system, which contribute to functional constriction and structural hypertrophy. Additionally, excess weight can elevate cardiac output, which in turn will lead to higher blood pressure.

CONCLUSION

Four of the five adiposity indices (BMI, WHR, WHtR, and percentage body fat) were positively and significantly associated with hypertension (elevated blood pressure). Among the four indices, BMI was the best adiposity index for predicting hypertension. Overall, the mean values for the components of adiposity indices were higher in males than females, except for biceps, triceps, and subscapular skinfold thickness.

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LEGIRAN; TRI SUCIATI; AZHAR, M. B.; SEPTADINA, I. S.; JANNAH, A. M. & IZZAH, A. N. Asociación entre los índices de adiposidad y la presión arterial en adultos jóvenes de la provincia de Sumatra Meridional, Indonesia. *Int. J. Morphol., 43(4)*:1273-1278, 2025.

RESUMEN: Este estudio examinó la relación entre los índices de adiposidad y la presión arterial en adultos jóvenes. El estudio, realizado en la provincia de Sumatra Meridional, Indonesia, incluyó a 413 adultos jóvenes de entre 18 y 25 años. Los datos recopilados mostraron que la presión arterial por encima de lo normal, así como la adiposidad alta, eran prevalentes en la población estudiada. El estudio reveló que los hombres presentaban valores más altos en casi todos los índices de adiposidad que las mujeres. La prevalencia de presión arterial por encima de lo normal también fue mayor en los hombres. Todos los índices de adiposidad, excepto el TESfR, se asociaron significativamente con la presión arterial en los sujetos del estudio. El índice de masa corporal (IMC) resultó ser el predictor más sólido de la presión arterial. Este estudio indica un número creciente de adultos jóvenes con presión arterial por encima de lo normal y destaca la importancia de monitorear y controlar los niveles de adiposidad, así como el IMC, para reducir el riesgo de hipertensión.

PALABRAS CLAVE: Índices de adiposidad; Mediciones antropométricas; Presión arterial; Adultos jóvenes.

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