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Research Article

The relationship of body mass index, mid-upper arm circumference, and waist circumference with the blood pressure in elderly

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ABSTRACT

Life expectancy is one of the most popular summary measures for a population's general health. Growing Life Expectancy predicts a rise in senior citizens in the coming years. An increase in health issues among the elderly may result from an aging population. Anthropometric measures of nutritional status can reveal nutritional status, which may contribute to the development of cardiovascular risk; however, research on this topic in the elderly is still lacking. This study uses a cross-sectional design and a sample size of 60 elderly people who live in Muhammadiyah University Palembang's development village. Blood pressure and anthropometric measures were taken by researchers. Throughout the course of five minutes, three separate readings of the blood pressure, waist circumference, mid-upper arm circumference, and body mass index (BMI) were obtained. The means of these measurements were then analyzed. Diastole Blood Pressure/DBP was substantially correlated with BMI, WC, and MUAC (P = 0.001; r = 0.407; P = 0.003; r = 0.381 & P = 0.017; r = 0.307, respectively). In conclusion, systolic and diastolic blood pressure in the elderly are positively associated with anthropometric measures of body fatness, particularly BMI.

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INTRODUCTION

Everyone worldwide should be able to live a long and healthy life (WHO, 2020b). Life expectancy is one of the most widely used summary indicators for the overall health of a population (Luy et al., 2020). Based on data from WHO globally, life expectancy has increased by more than 6 years between 2000 and 2019, from 66.8 years in 2000 to 73.4 years in 2019 (WHO, 2020a). Based on data from Indonesia's Central Statistics Agency, Life Expectancy in 2022 reached 73.6. This figure increased by 0.1 compared to 2021, which was 73.5. Based on data from the Central Statistics Agency of South Sumatra Province, Life Expectancy in 2022 will reach 70.32. This figure increased by 0.34 compared to 2021, which was 69.98 (BPS, 2022). Increasing Life Expectancy (AHH) indicates an increase in the elderly population in the future. An increase in the number of elderly population can cause an increase in health problems in the elderly (Nurhidayati *et al*., 2021). Special challenges in the health sector due to the increasing number of elderly are the emergence of degenerative problems and Non-Communicable Diseases (NCDs), one of which is hypertension. The disease will cause issues if not overcome or prevention is not carried out because this will be a chronic and multi-pathological disease (Kemenkes RI, 2013). Hypertension is considered a silent killer because it initially shows no symptoms but secretly causes damage to subclinical organs in the body (Fatima & Samar, 2021). Hypertension is associated with a high mortality rate and mostly results in death from cardiovascular events such as coronary heart disease, heart failure, and stroke (Hinton et al., 2020). An estimated 1.28 billion adults aged 30-79 worldwide suffer from hypertension, most (two-thirds) living in low- and middle-income countries (WHO, 2023). Hypertension is known to be a significant risk factor for cardiovascular disease, particularly in high-risk populations (Fatchurohmah et al., 2021).

The health of the elderly lies in their nutritional status. In nutrition science, more and less nutritional status is called malnutrition (Mardalena, 2017). Malnutrition is when the body experiences deficiencies, excesses, or imbalances in energy intake, protein, and other nutrients that can hurt physical condition, body functions, and overall health (Sari et al., 2019). Meeting good nutritional needs is very important to maintain the health and quality of life of the elderly because all cell activities or metabolism require adequate nutrients to function appropriately (Kemenkes RI, 2022). A person's nutritional status can be known by anthropometric examinations such as body mass index (BMI) and mid-upper arm circumference (MUAC).

Results from a retrospective cohort study involving 570 adult Japanese individuals indicate that MUAC and BMI may be complementary in predicting prognosis for heart failure patients (Kamiya et al., 2016). Furthermore, greater MUAC has been linked to higher cardiometabolic risk scores in a cross-sectional study of 93 obese pubertal adolescents from Brazil (Araújo et al., 2017). Several studies have shown that there is a relationship between obesity as measured by BMI or WC and the incidence of cardiovascular disease. (Gibran & Uun Nurulhuda, 2023; Kristatnti et al, 2019; Jannah et al, 2019).

From this background, the nutritional status shown by anthropometric measures related to nutritional status can play a role in the occurrence of cardiovascular risk, and there is still a lack of such research in the elderly in South Sumatra. Therefore, researchers are interested in researching the relationship between Body Mass Index, Upper Arm Circumference, and Waist Circumference and the incidence of hypertension in the elderly.

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METHODS

This study, which has a cross-sectional design, has 60 elderly participants from the development village of the Faculty of Medicine, Muhammadiyah University Palembang as its sample. Blood pressure and anthropometric measures were taken by researchers. All anthropometric parameters and blood pressure were measured three times in five minutes, and the means of the measurements were analyzed.

A non-elastic tape measure, SECA 201 (SECA, Germany), was used to measure the circumference of the mid-upper arm and waist to the closest 0.1 cm. At the midpoint between the left arm's tip of the elbow and the shoulder, the mid-upper arm circumference (MUAC) was measured. According to Wenzile et al. (2024), the cutoff for identifying underweight in men and women is 24.5 cm, while the cutoffs for identifying overweight and obese people are >28.0 cm and >30.0 cm, respectively. In a standing position, the waist circumference (WC) was measured at the end of a normal expiration and at the midpoint between the top of the iliac crest and the lower margin of the last palpable rib (Martino et al, 2024). WC of > 90 cm and > 80 cm are considered central obesity in men and women, respectively (WHO, 2020c).

Body weight was measured using Omron HN289 (Omron, Japan) digital weighing scale to the nearest 0.1 kg. Height was measured to the nearest 0.1 cm using a digital height gauge (ONEMED, Indonesia). The body mass index (BMI) of each subject was calculated as weight (kg) divided by height (m^2). Based on the BMI, the subjects were then classified as underweight (< 18.5 kg/m^2), normal (18,5- 22.9 kg/m^2), overweight (23.0-29.9 kg/m^2), and obese (> 30 kg/m^2) (WHO, 2020c).

Blood pressure (BP) was measured using a digital Omron M3 BP (Omron, Japan) in a sitting position for at least five minutes or more. The BP was categorized according to JNC 8 into normal BP (SBP < 120 mmHg and DBP < 80 mmHg); prehypertension (SBP 120-139 or DBP 80-89 mmHg); stage I hypertension (SBP 140 - 159 mmHg or DBP 90 - 99 mmHg); and stage II hypertension (SBP ≥160 mmHg or DBP ≥100 mmHg) (Hernandez-Vila, 2015).

The Kolmogorov-Smirnov test was used to analyze normal data distribution. Continuous data was presented as mean ± standard deviation. Categorical data was presented as frequencies and proportions. As alternative tests, the independent t-test and the Mann-Whitney test were used to compare the continuous data by gender. Chi-square tests were used for categorical variables by gender. A Pearson correlation analysis was performed only to determine the relationship between BMI and SBP, while Spearman correlation analysis was used for other variables. Then, multiple linear regression analysis with a backward method was carried out. All the statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS, 17.0). The statistical significance was set at $P < 0.05$. This research has received approval from the ethical clearance No.223/EC/KBHKI/FK-UMP/XI/2023.

RESULTS

The results of various anthropological and blood pressure data are given in Table 1. Overweight and obesity were significantly ($P = 0.003$) more common in elderly women (13.5%; 24.3%) than elderly men (8.7%; 0), but underweight was most common in elderly men (52.2%). Based on MUAC, elderly women are more likely to be overweight (5.4% VS 4.3%) and obese (16.2% VS 4.3%) than elderly men, but underweight is more common in men (43.5%) than women (43.2%), although the difference was not significant ($P = 0.0576$). Central obesity was significantly ($P = 0.035$) more common in women (70.3%) than men

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(39.1%). Stage 1 and 2 hypertension also occurred more frequently in women (40.5% & 29.7%) than men (39.1% & 21.7%), although it was not significant (P=0.393). BMI and WC were significantly associated with SBP (P = 0.022; r = 0.294 & P = 0.045; r = 0.260, respectively). BMI, WC, and MUAC were significantly associated with DBP (P = 0.001; r = 0.407; P = 0.003; r = 0.381 & P = 0.017; r = 0.307, respectively) (Table. 2).

Table 1. Characteristics of Subjects

Characteristics	Men (N = 23)	Women (N = 37)	*P-value*
Age (Year)	66 ± 6.67	64.35 ± 6.98	0.307
Height (cm)	170.26 ± 10.85	147.94 ± 9.35	<0.001
Weight (kg)	54.65 ± 9.24	48.41 ± 11.05	0.027
BMI (kg/m^2)	18.94 ± 3,30	21.90 ± 4.32	0.007
Underweight, n (%)	12 (52,2)	8 (21.6)	
Normal, n (%)	9 (39,1)	15 (40.5)	0.003
Overweight, n (%)	2 (8.7)	5 (13.5)	
Obese, n (%)	0	9 (24.3)	
MUAC (cm)	25.39 ± 2.87	26,19 ± 4,62	0.884
Underweight, n (%)	10 (43.5)	16 (43.2)	
Normal, n (%)	11 (47.8)	13 (35.1)	0.576
Overweight, n (%)	1 (4.3)	2 (5.4)	
Obese, n (%)	1 (4.3)	6 (16.2)	
WC (cm)	86.48 ± 9.89	87.46 ± 10.97	0.653
Normal, n (%)	14 (60.9)	11 (29.7)	0.035
Central obesity, n (%)	9 (39.1)	26 (70.3)	
SBP (mmHg)	146.96 ± 18.40	152.00 ± 26.62	0.429
DBP (mmHg)	80.87 ± 9.47	84.49 ± 16.78	0.341
BP categories			
Normal, n (%)	1 (4.3)	1 (2.7)	
Prehypertension, n (%)	8 (34.8)	10 (27)	0.393
Stage I Hypertension, n (%)	9 (39.1)	15 (40.5)	
Stage II Hypertension, n (%)	5 (21.7)	11 (29.7)	

(BMI: body mass index; WC: waist circumference; MUAC: mid-upper arm circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; BP: blood pressure)

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Table 2. Independent association between BMI, WC, MUAC, and blood pressure (SBP and DBP).

Independent Variables	Dependent Variables			
	SBP		DBP	
	p	r	*p*	r
BMI	0.022	0.294	0.001	0.407
WC	0.045	0.260	0.003	0.381
MUAC	0.078	0.229	0.017	0.307

(BMI: body mass index; WC: waist circumference; MUAC: mid-upper arm circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; BP: blood pressure)

Table 3. Multivariate analysis of factors associated with SBP and DBP

No	Model	SBP			DBP		
		β	Adjusted R^2	P	β	Adjusted R^2	P
1	BMI	0.223	0.040	0.154	0.162	0.116	0.019
	WC	0.031			0.072		
	MUAC	0.060			0.203		
2	BMI	0.245	0.056	0.072	0.213	0.130	0.007
	MUAC	0.064			0.210		
3	BMI	0.294	0.071	0.022	0.376	0.127	0.003

(BMI: body mass index; WC: waist circumference; MUAC: mid-upper arm circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; BP: blood pressure)

Multiple linear regression analysis was carried out as the relationship between all independent variables and systolic and diastolic blood pressure had a P-value <0.25. Of the three models in the multivariate analysis, the third model, BMI, has the highest predictive value for SBP (Adjusted R^2 = 0.071; β = 0.294; P = 0.022) and DBP (Adjusted R^2 = 0.127; β = 0.376; P = 0.003) (Table 3)

DISCUSSION

The study result reported that body mass index is associated positively with SBP and DBP. This study is in line with other previous studies that also have shown a positive association between BMI and systolic and diastolic blood pressure among the elderly (Kurniawan et al, 2021; Anwar et al, 2019; Kumar et al, 2016; Masaki et al, 1997). This study showed that systolic and diastolic blood pressure will be

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high in groups with high body mass index. The relationship between obesity and hypertension can be explained through the activation of the sympathetic nervous system and the renin-angiotensin-aldosterone system, increased endothelial dysfunction, an increase in arterial stiffness, and renal functional abnormalities, as well as disturbances of leptin signaling (Pikilidou et al, 2013).

This study found a positive association between waist circumference and systolic and diastolic blood pressure. This finding is consistent with those of previous studies (Pramaningtyas et al, 2021; Wang et al, 2020). An increase in waist circumference shows excessive intraabdominal fat, resulting in central obesity. This will cause a decrease in adiponectin which increases blood pressure (Gotera et al, 2006; Kim et al, 2013). Adiponectin can lower blood pressure by improving vascular endothelial function and stimulating nitric oxide production (Kim et al, 2013). We also found that central obesity was more common in females than in males. Other studies also reported the same findings (Prasad et al, 2020; Deepa et al, 2007; Janghorbani et al, 2007; Park et al, 2003). These gender differences are more common among women in developing countries. Physical activity levels, sociocultural beliefs, biological factors, and the degree of urbanization are possible factors for observed gender differences (Prasad et al, 2020).

Physical activity is also one of the risk factors. If physical resistance is good, it can increase arterial elasticity and reduce systemic vascular resistance, which is the main factor in lowering blood pressure. In addition, physical activity also helps reduce weight, which correlates with a decrease in blood pressure (Pater Hayers et al, 2022). One of the things related to sociocultural beliefs is associated with the eating habits or eating patterns of the local community, such as consuming foods high in salt. A person with a high sodium intake can experience an increase in blood pressure levels. This is related to water retention, increased systemic peripheral resistance, changes in endothelial function, changes in the structure and function of large elastic arteries, modification of sympathetic activity, and the modulation of autonomic neurons in the cardiovascular system (Grillo A et al, 2019).

Biological factors include things like hormone effects, physical performance, muscular capacity, and immune system reaction. Men tend to have higher muscle mass and strength than women because they have higher testosterone levels, while women typically have higher levels of upper-body adiposity (Mthethwa et al, 2024).

Our study reported that MUAC was higher in females than in males and that there was a positive association between MUAC and blood pressure, especially DBP. The previous study also reported that MUAC was positively associated with blood pressure (Wenzile et al, 2024; Hou et al, 2019). It is reported that MUAC has a strong association with atherosclerosis among the elderly. The biological differences between men and women, such as hormone effect, muscle capacity, and physical function cause body fat to redistribute to the upper body and preferential adiposity around the waist with age was more obvious in women than in men (Hou et al, 2019).

The exact mechanism underlying the relationship between MUAC and blood pressure is still unclear. Still, there is evidence that elevated subcutaneous fat of the upper body, as determined by MUAC, is substantially linked to increased visceral fat and plays a role in developing metabolic diseases and high blood pressure, regardless of body mass

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index. Systematic free fatty acids secreted by the upper subcutaneous fat can lead to ectopic fat deposition, insulin resistance, inflammation, and increased triglyceride production. Elevated free fatty acid levels can also bring on oxidative stress because they boost the generation of oxygen free radicals, which overwhelm the antioxidant system. Vascular smooth muscle cells may proliferate, hypertrophy, and deposit collagen as a result of exposure to oxygen-free radicals, thickening the vascular media and constricting the vascular lumen. Furthermore, oxidative stress has been associated with increased vascular contractile activity, compromised endothelium-dependent vascular relaxation, and endothelial damage, all of which contribute to elevated blood pressure. Thus, one possible explanation for the relationship between MUAC and BP could be excess free fatty acid release from arm subcutaneous adipose accumulation (Mthethwa et al, 2024).

CONCLUSION

In conclusion, anthropometric indicators of body fatness, especially BMI, are associated positively with systolic and diastolic blood pressure in the elderly.

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