

# Analysis relationship between body composition and blood pressure among rural adults<sup>†</sup>



Original article

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**Abstract: Objective:** Hypertension is a serious public health concern that is influenced by a variety of body composition parameters. This study examines the associations between body composition metrics and blood pressure (BP) in a rural population, specifically how variations in body fat distribution and other metrics affect systolic blood pressure (SBP) and diastolic blood pressure (DBP).

**Methods:** A cross-sectional study of 226 participants examined the relationships between body composition metrics—such as total body fat, visceral fat, and body mass index (BMI)—and BP. Correlation and regression analyses were used to assess these relationships.

**Results:** The study found substantial positive correlations between visceral fat and total body fat with both SBP and DBP. Visceral fat was strongly connected with both SBP ( $r = 0.145$ ,  $P = 0.030$ ) and DBP ( $r = 0.331$ ,  $P < 0.01$ ), while total body fat was significantly correlated with DBP ( $r = 0.268$ ,  $P < 0.01$ ) but not SBP. Body composition variables explained 12.8% of the variance in SBP ( $R^2 = 0.128$ ,  $P = 0.001$ ) and 15.0% in DBP ( $R^2 = 0.150$ ,  $P < 0.001$ ).

**Conclusions:** The study found substantial connections between body composition, particularly visceral and subcutaneous fat and systolic and DBP. Higher levels of visceral fat were linked to elevate BP. Body composition accounted for a significant amount of BP fluctuation.

**Keywords:** blood pressure • body composition • hypertension • systolic and diastolic blood pressure • visceral fat

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## 1. Introduction

Hypertension is a major public health concern that affects >1 billion people globally. This disorder is a significant risk factor for cardiovascular disease, the leading cause of mortality worldwide, especially in Indonesia.<sup>1</sup> Hypertension prevalence is increasing, especially in rural regions with limited access to healthcare facilities and prevention measures.<sup>2</sup> According to studies, rural people are frequently neglected in terms of healthcare resources, resulting in undiagnosed and undertreated hypertension.<sup>3,4</sup>

Body composition, defined as the percentage of fat, muscle, bone, and other components in the human body, has long been recognized as a key determinant of cardiovascular health, particularly blood pressure (BP). An increase in body fat, particularly visceral fat, has been associated with a variety of metabolic diseases, including insulin resistance, dyslipidemia, and hypertension.<sup>5</sup>

Excess abdominal fat is thought to contribute to high BP through mechanisms including renin-angiotensin system activation, sympathetic nervous system (SNS)

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stimulation, and vascular inflammation.<sup>6,7</sup> Lean body mass, particularly muscular mass, may provide some protection against hypertension. Higher muscle mass is connected with better glucose uptake and vascular function, both of which are essential for maintaining appropriate BP levels.<sup>4</sup>

Rural communities confront distinct issues with body composition and hypertension, which are influenced by socioeconomic status, physical activity, and gender. Higher body mass index (BMI) and body fat percentage are significant risk factors for hypertension, demanding particular therapies tailored to the unique lifestyle and socioeconomic circumstances of rural communities. Comprehensive health promotion programs centered on lifestyle changes are required to address these hazards successfully.<sup>8,9</sup>

Understanding the interaction between body composition and hypertension in rural settings is crucial for developing effective preventative strategies. Research indicates that the relationship between body composition and hypertension varies significantly by ethnicity and geography.<sup>9</sup>

Rural communities in Indonesia face significant healthcare access barriers, leading to delayed hypertension diagnosis and management. Initiatives like POSBINDU primarily focus on BP measurements but lack comprehensive risk assessments and follow-up due to resource limitations. Urban–rural disparities further exacerbate this issue, with rural areas experiencing inconsistent medication access and unmet healthcare needs influenced by socioeconomic and geographic factors. These challenges underscore the need for targeted public health strategies addressing modifiable risk factors, such as body composition, to improve hypertension management in underserved populations.<sup>10–12</sup>

## 2. Methods

### 2.1. Study design

A cross-sectional study with 226 people investigated the relationship between several body composition indicators—such as age, body age, total body fat, visceral fat, and BMI—and BP. Using both correlation and regression analysis, the study provided thorough insights into how these precise body composition variables influence BP.

### 2.2. Setting and samples

The study was undertaken in 2 rural areas: Cihanjunag Rahayu village in West Bandung Regency, West Java, and Mangirejo village in Madiun East Java. Primary researchers collected data in partnership with local

research assistants. Before beginning, the research protocol was ethically reviewed and approved by the institutional ethics committee. Following ethical clearance, formal written permission was sought and given by village leaders in both locations, allowing the research team to continue with data collection activities. Formal approval was required to engage local people and ensure conformity with ethical norms. Participants were chosen based on tight inclusion and exclusion criteria to ensure the dataset's relevance and robustness.

Male and female participants ranged in age from 30 years to 65 years, Comprehension: To collect valid data, participants must thoroughly comprehend the study's directions and requirements, Willingness: Only participants who were willing to offer consent, fill out the relevant paperwork, and have their body composition and BP measured were considered eligible, Availability: Participants required to be physically present in the communities during the data collecting period to ensure timely measurement, individuals with acute illnesses or medical problems that could potentially influence the study's primary outcomes were excluded from participation to ensure data integrity.

A purposeful sample strategy was used, with participants who these parameters were deliberately chosen to provide a representative sample of the rural population. This strategy ensured the acquisition of high-quality data that was closely related to the research objectives.

### 2.3. Data collection

Body composition was assessed using the **Omron Karada Scan HBF-375**, a bioelectrical impedance analysis (BIA) device known for its high precision in evaluating parameters such as total body fat percentage and visceral fat levels. The device was consistently operated under standardized conditions to ensure uniformity across all participants. To further ensure the accuracy of the measurements, new batteries were installed after every 50 participants to prevent battery depletion from affecting the device's performance. BP measurements were obtained using the **Omron Automatic Blood Pressure Monitor**, a device recognized for its validated accuracy and reliability in both clinical and field settings. Similar to the body composition device, batteries were replaced after every 50 participants to maintain consistent power output and precise measurements.

The data collection process was carefully structured to minimize potential errors and ensure the highest quality data. Upon arrival at the designated data collection sites, participants were first screened for eligibility based on the inclusion criteria. Those who met the criteria were provided with detailed information about the study's objectives and procedures, after which they

signed informed consent forms. Subsequently, participants completed a demographic questionnaire that captured essential data such as age, sex, and relevant health history.

Participants then underwent body composition analysis using the Omron Karada Scan HBF-375 (Manufactured by Krell Precision [Yangzhou] Co., Ltd.), with measurements taken in a controlled environment to reduce variability due to external factors. Following this, BP readings were taken with the Omron Automatic Blood Pressure Monitor, adhering to best practices, including ensuring that participants were seated and rested for several minutes before measurement.

All data were meticulously recorded in a secure, digital database and cross-verified by research assistants to prevent any errors in data entry. Throughout the study, strict quality control measures were enforced, including regular equipment checks and timely battery replacements, to maintain the reliability and precision of the instruments used in the data collection process.

## 2.4. Data analysis

Data were gathered directly from participant input and the outcomes of body composition and BP measurements, which were then combined into an Excel spreadsheet to arrange participant information. Each participant's scores on the relevant factors were calculated and grouped based on their degree. Given the data's non-normal distribution, Spearman's rho correlation was used with SPSS Version 27 (IBM Corporation, Armonk, New York, United States) to assess the link between body composition and BP. A correlation was considered statistically significant if the *P*-value was <0.05, showing a meaningful link between body composition and BP in the study population.

## 2.5. Ethical considerations

The study was approved by the Ethics Committee at Universitas Advent Indonesia. All participants provided informed consent and were fully told about the study's aims. Data confidentiality was secured by issuing a unique code to each participant, who remained anonymous throughout the research process. Participation was completely voluntary, with no compulsion, and participants had the choice to refuse or withdraw from the study at any time without penalty.

## 3. Results

Table 1 shows the demographics and clinical features of the 226 study participants. The majority were females

(70.4%, *n* = 159), while males made up 29.6% (*n* = 67). The age distribution was fairly balanced, with the highest representation in the early adulthood (27%, *n* = 61)

| Classification                | Frequency | Percentage (%) |
|-------------------------------|-----------|----------------|
| <i>Gender</i>                 |           |                |
| Female                        | 159       | 70.4           |
| Male                          | 67        | 29.6           |
| <i>Age (years)</i>            |           |                |
| Early adulthood               | 61        | 27.0           |
| Late adulthood                | 48        | 21.2           |
| Early elderly                 | 58        | 25.7           |
| Late elderly                  | 59        | 26.1           |
| <i>Body age</i>               |           |                |
| Early adulthood               | 30        | 13.3           |
| Late adulthood                | 33        | 14.6           |
| Early elderly                 | 75        | 33.2           |
| Late elderly                  | 56        | 24.8           |
| Advanced age                  | 32        | 14.2           |
| <i>Total body fat</i>         |           |                |
| Low                           | 4         | 1.8            |
| Normal                        | 47        | 20.8           |
| High                          | 56        | 24.7           |
| Very high                     | 119       | 52.7           |
| <i>Visceral fat</i>           |           |                |
| Normal                        | 123       | 54.4           |
| Elevated                      | 55        | 24.3           |
| Very high                     | 48        | 21.2           |
| <i>Whole body skeletal</i>    |           |                |
| Low                           | 180       | 79.6           |
| Normal                        | 23        | 11.6           |
| High                          | 6         | 2.6            |
| Very high                     | 14        | 6.2            |
| <i>BMI (kg/m<sup>2</sup>)</i> |           |                |
| Underweight                   | 7         | 3.1            |
| Normal                        | 93        | 41.2           |
| Overweight                    | 81        | 35.8           |
| Obesities                     | 45        | 19.9           |
| <i>SBP</i>                    |           |                |
| Normal                        | 45        | 19.9           |
| Prehypertension               | 90        | 39.8           |
| HT-Grade 1                    | 53        | 23.5           |
| HT-Grade 2                    | 38        | 16.8           |
| <i>DBP</i>                    |           |                |
| Normal                        | 49        | 21.7           |
| Prehypertension               | 67        | 29.6           |
| HT-Grade 1                    | 68        | 30.1           |
| HT-Grade 2                    | 42        | 18.6           |

Note: BMI, body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure.

**Table 1.** Frequencies demographic data of subject in rural area.

and late elderly (26.1%,  $n = 59$ ) groups. A considerable proportion of participants were classified as early old based on body age (33.2%,  $n = 75$ ), whereas 14.2% ( $n = 32$ ) had advanced body age, indicating rapid aging in this subset.

In terms of body composition, more than half of the participants (52.7%,  $n = 119$ ) had extremely high body fat, whereas just a small minority (1.8%,  $n = 4$ ) had low body fat levels. A significant proportion of the population (54.4%,  $n = 123$ ) had normal visceral fat; nevertheless, 45.5% indicated elevated or extremely high visceral fat, known risk. Factors contributing to metabolic disorders. Notably, 79.6% ( $n = 180$ ) had low skeletal muscle mass, which contributed to possible functional deterioration, compared to 8.8% ( $n = 20$ ) who had high skeletal mass. In terms of BMI, 41.2% ( $n = 93$ ) were within the normal range, 35.8% ( $n = 81$ ) were considered overweight, and 19.9% ( $n = 45$ ) were obese.

BP analysis found that 39.8% ( $n = 90$ ) of subjects had systolic prehypertension, with about 40% being hypertensive (Grade 1 and 2). Only 19.9% (45) had normal systolic blood pressure (SBP). Similarly, 29.6% ( $n = 67$ ) had diastolic prehypertension, whereas nearly half (48.7%,  $n = 110$ ) were hypertensive (Grade 1 or 2). Only 21.7% (49) had normal diastolic blood pressure (DBP). These results from a sample of 226 rural adults highlight that this population has a considerable burden of hypertension and associated cardiovascular risks.

The research of 226 participants provides a thorough review of major health parameters such as age, body composition, and BP (Table 2). The subjects' ages ranged from 30 years to 65 years (mean = 46.12, standard deviation (SD) = 11.370), but their body ages

ranged from 17 years to 88 years (mean = 51.70, SD = 13.031), demonstrating significant variation in physiological aging across the community.

In terms of body composition, total body fat percentage ranged from 8% to 48% (mean = 31.77, SD = 7.827), while visceral fat levels ranged from 1 to 56 (mean = 10.85, SD = 7.798), indicating a wide range of adiposity. The whole body subcutaneous fat values ranged from 6 to 47 (mean = 26.62, SD = 8.752), Whole-body subcutaneous fat levels varied from 6 to 47 (mean = 26.62, SD = 8.752), whereas fat distribution in the trunk, arms, and legs was studied individually, with trunk fat ranging from 8 to 54 (mean = 24.46, SD = 8.828) and leg fat ranging from 13 to 84 (mean = 35.71, SD = 11.707). Notably, skeletal muscle mass was assessed, with a mean of 25.07 (SD = 5.300) for the entire body and a trunk-specific value of 20.37 (SD = 6.249).

BP readings show a mean systolic pressure of 135.58 mmHg (SD = 22.833) and a diastolic pressure of 87.77 mmHg (SD = 14.978), indicating a high prevalence of increased BP in the cohort. Furthermore, BMI ranged from 16 to 53 (mean = 26.41, SD = 5.589), highlighting the different body composition profiles in this population.

The study looked into the links between various body composition measures and BP in a rural population (Table 3). The study found that total body fat did not have a significant correlation with SBP ( $r = 0.087$ ,  $P = 0.190$ ), but it did have a significant positive correlation with DBP ( $r = 0.268$ ,  $P < 0.01$ ), indicating that higher total body fat is associated with increased diastolic pressure. Visceral fat has a strong correlation with both SBP ( $r = 0.145$ ,  $P = 0.030$ ) and DBP ( $r = 0.331$ ,  $P < 0.01$ ),

| Classification             | Min | Max | Mean   | Std. deviation |
|----------------------------|-----|-----|--------|----------------|
| Age (years)                | 30  | 65  | 46.12  | 11.370         |
| Body age                   | 17  | 88  | 51.70  | 13.031         |
| Total body fat             | 8   | 48  | 31.77  | 7.827          |
| Visceral fat               | 1   | 56  | 10.85  | 7.798          |
| Whole body subcutaneous    | 6   | 47  | 26.62  | 8.752          |
| Subcutaneous-trunk         | 8   | 54  | 24.46  | 8.828          |
| Subcutaneous-arms          | 10  | 59  | 38.30  | 12.949         |
| Subcutaneous-legs          | 13  | 84  | 35.71  | 11.707         |
| Whole body skeletal muscle | 13  | 45  | 25.07  | 5.300          |
| Skeletal muscle-trunk      | 10  | 49  | 20.37  | 6.249          |
| Skeletal muscle-legs       | 13  | 61  | 38.22  | 7.248          |
| Systolic                   | 90  | 225 | 135.58 | 22.833         |
| Diastolic                  | 60  | 180 | 87.77  | 14.978         |
| BMI (kg/m <sup>2</sup> )   | 16  | 53  | 26.41  | 5.589          |

Note: BMI, body mass index.

**Table 2.** Descriptive demographic data of subject in rural area ( $n=226$ ).

| Independent variable              | Dependent variable |         | Verbal interpretation |
|-----------------------------------|--------------------|---------|-----------------------|
|                                   | SBP                | DBP     |                       |
| <i>Total body fat</i>             |                    |         |                       |
| Correlation                       | 0.087              | 0.268   | SBP not significant   |
| Sig. (2-tailed)                   | 0.190              | 0.000** | DBP significant       |
| <i>Visceral fat</i>               |                    |         |                       |
| Correlation                       | 0.145              | 0.331   | SBP significant       |
| Sig. (2-tailed)                   | 0.030*             | 0.000** | DBP significant       |
| <i>Whole body subcutaneous</i>    |                    |         |                       |
| Correlation                       | 0.153              | 0.293   | SBP significant       |
| Sig. (2-tailed)                   | 0.021*             | 0.000** | DBP significant       |
| <i>Subcutaneous-trunk</i>         |                    |         |                       |
| Correlation                       | 0.113              | 0.274   | SBP not significant   |
| Sig. (2-tailed)                   | 0.091              | 0.000** | DBP significant       |
| <i>Subcutaneous-arms</i>          |                    |         |                       |
| Correlation                       | 0.070              | 0.189   | SBP not significant   |
| Sig. (2-tailed)                   | 0.297              | 0.004** | DBP significant       |
| <i>Subcutaneous-legs</i>          |                    |         |                       |
| Correlation                       | 0.070              | 0.225   | SBP not significant   |
| Sig. (2-tailed)                   | 0.297              | 0.001** | DBP significant       |
| <i>Whole body skeletal muscle</i> |                    |         |                       |
| Correlation                       | −0.086             | −0.106  | SBP not significant   |
| Sig. (2-tailed)                   | 0.196              | 0.111   | DBP not significant   |
| <i>Skeletal muscle-trunk</i>      |                    |         |                       |
| Correlation                       | −0.194             | −0.223  | SBP significant       |
| Sig. (2-tailed)                   | 0.003**            | 0.000** | DBP significant       |
| <i>Skeletal muscle-legs</i>       |                    |         |                       |
| Correlation                       | −0.031             | 0.021   | SBP not significant   |
| Sig. (2-tailed)                   | 0.645              | 0.750   | DBP not significant   |
| <i>BMI (kg/m²)</i>                |                    |         |                       |
| Correlation                       | 0.197              | 0.386   | SBP significant       |
| Sig. (2-tailed)                   | 0.003**            | 0.000** | DBP significant       |

Note: Significance level. \* $P < 0.05$ , \*\* $P < 0.01$ ; BP, blood pressure; BMI, body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure.

**Table 3.** Overview of the relationship between body composition and BP among rural adults ( $n = 226$ ).

suggesting that higher amounts of visceral fat are linked to raised BP.

There was a strong positive connection between whole body subcutaneous fat and both SBP ( $r = 0.153$ ,  $P = 0.021$ ) and DBP ( $r = 0.293$ ,  $P < 0.01$ ), highlighting the importance of fat distribution in hypertension. Whole body trunk fat was strongly linked with DBP ( $r = 0.274$ ,  $P < 0.01$ ) but not with SBP ( $r = 0.113$ ,  $P = 0.091$ ), indicating that trunk fat primarily affects diastolic pressure.

Increased fat in the arms ( $r = 0.189$ ,  $P < 0.01$ ) and legs ( $r = 0.225$ ,  $P < 0.01$ ) was linked to greater DBP. Whole-body skeletal muscle, on the other hand, had no significant correlation with either SBP ( $r = -0.086$ ,

$P = 0.196$ ) or DBP ( $r = -0.106$ ,  $P = 0.111$ ), indicating that it has a limited impact on BP in this cohort.

BMI showed a strong positive connection with SBP ( $r = 0.197$ ,  $P = 0.003$ ) and DBP ( $r = 0.386$ ,  $P < 0.01$ ), indicating the impact of body fat on BP. These findings highlight the importance of addressing body composition, namely visceral and subcutaneous fat, in controlling and preventing hypertension, particularly in rural areas where such characteristics may be more prominent.

The regression study examined the effects of various body composition variables on BP (Table 4). The variables total body fat, visceral fat, whole body trunk fat, whole body legs fat, whole body skeletal muscle, and BMI explained 12.8% of the variance in SBP

| Variables and dependent                                                                                                      | <i>R</i> | <i>R</i> <sup>2</sup> | ANOVA-sig. | Interpretation |
|------------------------------------------------------------------------------------------------------------------------------|----------|-----------------------|------------|----------------|
| Total body fat, visceral fat, whole body trunk, whole body legs, whole body skeletal, whole body trunk, whole body legs, BMI |          |                       |            |                |
| Systolic BP                                                                                                                  | 0.358    | 0.128                 | 0.001      | Significant    |
| Diastolic BP                                                                                                                 | 0.388    | 0.150                 | 0          | Significant    |

Note: BMI, body mass index; BP, blood pressure.

**Table 4.** Regression analysis of body composition and BP among rural adults.

( $R^2 = 0.128$ ), with a significant overall model (ANOVA  $P = 0.001$ ). This suggests a moderate, but statistically significant, link between these body composition parameters and SBP.

For DBP, a model with the same variables explained 15.0% of the variation ( $R^2 = 0.150$ ), with a highly significant overall model (ANOVA  $P < 0.000$ ). This shows that these body composition parameters have slightly more explanatory power for DBP than SBP.

Overall, these findings show that body composition has a considerable impact on both systolic and DBP. The findings emphasize the necessity of incorporating several body composition measurements in hypertension studies and offer potential areas for focused therapies to effectively manage BP.

## 4. Discussion

Based on the findings, the study emphasizes the relationship between systolic and DBP and various body fat and muscle mass components, as well as the importance of these interactions. Here's a debate on the findings:

The study found no significant relationship between total body fat and SBP, however, a significant correlation exists between total body fat and DBP. The findings of this study align with previous research, which also found no significant association between total body fat and SBP.<sup>13,14</sup> but demonstrated a significant correlation between total body fat and DBP.<sup>13,15</sup> The higher relationship between body fat and DBP can be attributable to increasing fat mass, which increases vascular resistance, particularly in the microcirculation. The increased resistance during diastole raises diastolic pressure. Furthermore, excess adiposity causes metabolic changes, such as systemic inflammation and hormone dysregulation, which worsen vascular stiffness and diastolic hypertension, contributing to the etiology of hypertension.<sup>16</sup>

There are a significant connection between visceral fat and both systolic and diastolic. These findings are consistent with previous research demonstrating the critical function of visceral fat in increasing both SBP and DBP, which correlates with an elevated

cardiovascular risk.<sup>17–19</sup> Several mechanisms by which visceral fat affects BP include the following: (1) SNS Overactivity: Visceral fat contributes to hypertension by increasing SNS activity, particularly in the kidneys, which leads to raised BP through improved sodium retention and increased plasma volume.<sup>20,21</sup> Activation of the nervous system in relation to the increased leptin produced by visceral fat. Leptin itself has the effect of activating the SNS, which innervates various organs, including the kidneys, leading to the activation of the renin-angiotensin-aldosterone system (RAAS).<sup>22,23</sup> Visceral fat, particularly that which surrounds the kidneys, exerts pressure on the kidneys and results in the activation of (2) RAAS: Obesity, particularly visceral obesity, stimulates the RAAS. This system is often overactive in individuals with high visceral fat.<sup>20,21</sup> RAAS increases sodium reabsorption from the renal tubules, increases blood volume, and plays a role in generating angiotensin II, which is a vasoconstrictor. The increase in blood volume and vasoconstriction of blood vessels causes an increase in BP. High visceral fat also plays a role in metabolic disturbances associated with insulin resistance and hyperinsulinemia, which are the main mediators in increasing BP related to obesity.<sup>24</sup>

Visceral fat also elevates BP by secreting various adipokines and inflammatory cytokines, such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-alpha), which contribute to endothelial dysfunction and increased vascular resistance, thereby raising BP.<sup>25,26</sup> This study found a significant association between whole body subcutaneous fat and both systolic and diastolic. These findings are confirmed by research, which emphasizes the association between subcutaneous fat area (SFA) and elevated BP in both genders, implying that higher levels of total body subcutaneous fat may lead to increased cardiovascular risk.<sup>27</sup>

This study discovered that subcutaneous trunk fat showed no significant link with SBP, but did show a significant correlation with DBP, which is consistent with earlier research. Studies have repeatedly shown that trunk subcutaneous fat, especially the trunk/extremity skinfold ratio, is significantly associated with DBP in both men and women. Furthermore, it is an independent predictor of DBP, particularly in middle-aged males,

even after accounting for total body fat and cardiovascular fitness. This relationship is also observed in younger populations, such as children and adolescents, where a truncal pattern of fat distribution is linked to higher DBP, demonstrating the constancy of this interaction throughout age groups.<sup>28–30</sup>

Subcutaneous fat in the arms was found to have no significant relationship with SBP, but a substantial correlation with DBP. This finding is corroborated by studies, which show that subcutaneous fat has a stronger connection with DBP than with SBP. Similarly, a study conducted on a rural West African population found that more subcutaneous fat was associated with higher DBP among women, emphasizing the differential influence of upper body fat on DBP.<sup>31,32</sup>

Finally, subcutaneous fat in the legs showed no significant association with SBP but exhibited a significant relationship with DBP. This finding aligns with studies indicating that lower body subcutaneous fat, particularly in the trunk/extremity ratio, is significantly correlated with DBP, as observed in men. Additionally, research on obese children and adolescents supports this connection, showing higher DBP levels in individuals with increased subcutaneous fat and central distribution, highlighting the complex role of fat distribution in BP regulation.<sup>28,33</sup>

The findings of this study show that there is no significant relationship between whole-body skeletal muscle mass and either SBP or DBP. These findings are consistent with previous research, which demonstrated no direct association between total skeletal muscle mass and BP levels. This shows that skeletal muscle mass is unlikely to be the sole determinant of BP regulation.<sup>34–36</sup>

Although it is mentioned that a lack of muscle mass affects the occurrence of hypertension.<sup>37</sup> It is also stated that the deficiency in both quantity and quality of skeletal muscle accelerates the progression of metabolic syndrome, which includes high BP.<sup>38</sup> Hypertension in individuals with low muscle mass is associated with the occurrence of arterial stiffness. The mechanism of arterial stiffness is part of the process of insulin resistance and chronic inflammation, which are linked to the accumulation of body fat.<sup>39</sup>

In this study, although there was no significant relationship between muscle mass and BP, trunk skeletal muscle demonstrated a significant negative correlation with both SBP and DBP. These findings align with a growing body of research indicating that increased trunk muscle mass is inversely associated with both SBP and DBP across diverse populations and age groups. The underlying mechanisms may involve enhanced metabolic health and reduced cardiovascular risk. Specifically, greater muscle mass improves insulin sensitivity and diminishes arterial stiffness, both of which play pivotal roles in lowering BP. This supports the hypothesis that trunk muscle mass contributes to better cardiovascular function

through these physiological adaptations.<sup>34,36,40,41</sup> High muscle mass increases insulin sensitivity and improves metabolism, even in the presence of fat accumulation at a young age.<sup>42</sup> On the contrary, loss of skeletal muscles is associated with obesity due to lack of physical activity and a sedentary lifestyle. Reduced muscle mass leads to lower levels of myokines, which are chemical substances released by muscles during contraction. Myokines play a positive role in metabolic regulation and have anti-inflammatory effects, which help reduce issues such as insulin resistance and inflammation that can induce hypertension.<sup>37,43,44</sup>

Although trunk skeletal muscle showed significant results, skeletal muscle in the legs did not show a significant relationship with BP. This finding is consistent with prior research, which indicates that muscle mass in the lower extremities may not be a significant factor in BP regulation. These findings lend support to the idea that regional disparities in muscle mass can have varied effects on cardiovascular health.<sup>34–36</sup>

Increasing skeletal muscle mass is important for cardiovascular health, particularly in controlling BP. The quality of skeletal muscle is inversely related to the incidence of hypertension. This skeletal muscle quality can be improved through resistance training.<sup>45</sup> Exercise and diet play a crucial role in stimulating the synthesis of amino acids necessary for muscle formation.<sup>46</sup> Regular physical activity, combined with an alkaline diet that provides adequate protein and vitamin D, can effectively prevent the decline in muscle mass that typically begins in middle adulthood.<sup>47</sup> Resistance training is known to enhance both muscle mass and strength, while endurance training improves metabolism by optimizing mitochondrial function in muscle cells to produce energy. Both types of exercise rely on protein synthesis for their effectiveness.<sup>48</sup> Furthermore, the consumption of natural foods rich in flavonoids has demonstrated beneficial effects in increasing muscle mass in individuals with sarcopenia.<sup>49</sup>

The investigation of BMI found substantial correlations with both SBP and DBP. These findings are consistent with previous research, which has shown that higher BMI is associated with higher SBP and DBP across a variety of demographics and circumstances.<sup>7,50,51</sup>

The study's findings shed light on the association between body composition and BP in rural populations in West and East Java. However, certain limits should be acknowledged. The sample size, while sufficient for discovering connections, may limit generalizability to larger populations because it only includes 2 rural areas. Furthermore, the cross-sectional design prevents the establishment of causal links, making it impossible to tell whether body composition directly affects BP or if other factors, such as physical activity or food, are involved. Future studies could overcome these limitations by

examining bigger, more diverse groups and doing longitudinal studies to evaluate temporal dynamics.

Intervention-based studies and investigations into genetic, environmental, and psychosocial factors could broaden our understanding, while incorporating wearable technologies might enhance data accuracy. Addressing these issues will help to develop more effective public health policies for cardiovascular health in remote communities.

## 5. Conclusions

This study underlines the vital links between body fat and muscle mass components and systolic and DBP, which are important in nursing practice. Notably, total body fat has a substantial correlation with DBP but not with SBP, highlighting the need for targeted fat distribution studies in cardiovascular health.

The study also found that visceral fat has a substantial impact on both BP measurements, whereas trunk skeletal muscle protects against hypertension. Furthermore, the link between BMI and high BP emphasizes the importance of efficient weight-management techniques.

Incorporating these ideas into clinical practice can improve patient care and effectively treat hypertension in a variety of demographics.

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## Ethical approval

The study protocol was ethically approved by the Ethics Committee under reference number 389/KEPK-FIK.UNAI/EC/V/24, dated 23 May 2024. Additionally, approval was obtained from the local authorities of Cihanjuang Rahayu and Malang for the conduct of the research.

## Conflicts of interest

All contributing authors declare no conflicts of interest.

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