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Physical activity, percent body fat, visceral fat, ASMI, and blood pressure with obesity in indonesian older women: a cross-sectional study

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ABSTRACT

Obesity is increasingly becoming a significant public health issue worldwide, particularly among older adults. In Indonesia, the rise of obesity among older women is particularly alarming, contributing substantially to the burden of chronic illnesses. The primary risk factors for obesity include a sedentary lifestyle, and lower muscle mass, which can increase body fat, weight gain, and other associated health problems. This study investigated the prevalence of sarcopenia and identified associated risk factors, including sociodemographic characteristics, lifestyle factors, and comorbidities, among older women in Integrated Care Post (Posyandu). A cross-sectional design was employed to analyze the prevalence of obesity, low physical activity levels, high percentage of body fat, high level of visceral fat, low level of appendicular skeletal muscle index (ASMI), and elevated blood pressure (BP). A total of 154 older women aged 60 to 69 were selected as respondents from three subdistricts (Gunung Batu, Loji, and Pasir Mulya) using proportional random sampling. Data were collected through physical examinations and interviews utilizing a questionnaire. The results showed the prevalence of obesity was 42.20%, with low levels of physical activity (72.70%), 42.90% have high levels of %BF, while 37.00% exhibit high levels of visceral fat, preserved ASMI (55.20%), 94.80% showing elevated SBP and 83.80% DBP. According to Chi-square test, physical activity (OR = 2.05, 95%CI = 1.00-4.22), %BF (OR = 17.66, 95%CI = 5.75-54.25), VF (OR = 75.29, 95%CI = 21.24-266.85), ASMI (OR = 0.05, 95%CI = 0.02 – 0.12), and SBP (OR = 4.96, 95%CI = 0.96 – 25.45) were significantly associated with obesity ($p<0.05$). All in all, physical activity, %BF, visceral fat, ASMI, and SBP are risk factors for obesity among women aged 60-69. Further research needs to be conducted using a larger sample size and different study designs to explore additional factors associated with obesity in older adults.

KEYWORDS

Aging, body composition, cardiovascular health, chronic disease, exercise, female health, preventive health.

ABBREVIATIONS

ASMI: Appendicular Skeletal Muscle Index.

BMI: Body Mass Index.

DBP: Diastolic Blood Pressure.

IQR: Interquartile Range.

METs: Metabolic Equivalent Task.

SBP: Systolic Blood Pressure.

VF: Visceral Fat.

%BF: Body Fat Percentage.

INTRODUCTION

Obesity is a growing global public health concern, particularly for the elderly[1]. In Indonesia, the number of obese older women has been steadily increasing, which greatly increases the burden of chronic diseases. In Indonesia, the prevalence of overweight and obesity among those aged 60 and over in-

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creased from 13.6% and 21.8%, respectively, in 2018[2] to 14.4% and 23.4%, in 2023[3]. Women had a higher prevalence of poor health (15.3%) and obesity (31.2%) compared to a lower prevalence of poor health (13.6%) and obesity (15.7%) in the past[3]. The primary risk factors for obesity include a sedentary lifestyle, lack of physical activity, alcohol consumption, tobacco use, and lower muscle mass, all of which can contribute to weight gain and other health issues[4-8]. Recent research shows that obesity in older women primarily leads to increased functional decline, physical frailty, and risk of mortality[9,10]. A specific condition known as sarcopenic obesity, which involves both obesity and a decrease in muscle mass, significantly heightens the risk of impairment and limits daily activities[10].

Obesity is directly linked to several metabolic disorders, including diabetes, hypertension, dyslipidemia and cancer[11,12]. Research shows that individuals with a higher body mass index (BMI) are significantly more likely to develop these metabolic conditions, which complicates their overall health situation. Obesity primarily occurs due to an imbalance between energy intake and energy expenditure[13]. When energy intake exceeds energy expenditure, the excess energy is stored as fat and glycogen in subcutaneous adipose tissue (SAT) and in various organs[14]. As people ages, changes in body composition take place. From age 20 and 70, the percentage of fat-free mass, mainly composed of skeletal muscle, decreases by 40%. After age 70, both fat mass and fat-free mass continue to decline. Additionally, fat mass tends to redistribute with age, mainly accumulating in the visceral area, although deposits can also be found in the liver and skeletal muscle. The amount of body fat is determined by the balance between energy intake and expenditure. A significant factor contributing to the increase in fat mass with aging is decreased energy expenditure. Interestingly, energy intake in older adults does not appear to rise substantially and may even decrease over time[15].

The loss of fat-free mass is the primary cause of the 2-3% per decade decline in resting metabolic rate that occurs after the age of 20. About half of the loss in total energy expenditure with aging is due to a drop-in physical activity and an increase in inactive time, in addition to a decrease in resting metabolic rate[15]. The central redistribution of body fat leads to the production of pro-inflammatory cytokines[16]. Cytokines such as tumor necrosis factor alpha (TNF-α) and interleukin 6 (IL-6) contribute to muscle loss and sarcopenia due to their catabolic effects[17]. This reduction in muscle mass results in negative outcomes, including decreased mobility and increased frailty. The accumulation of fat in the central regions of the body results in the release of inflammatory cytokines, which, in turn, cause muscle loss and sarcopenia[16]. The decline in muscle mass has detrimental effects, leading to weakened muscles and reduced mobility[17]. Adipocyte hypertrophy and hyperplasia contribute to the growth of adipose tissue by causing fat to accumulate due to excessive calorie intake. Visceral fat develops when the amount of accessible fat exceeds the adipocyte's capacity to store it. This excess fat can then circulate and forms ectopic deposits in other organs. In addition to causing hypoxia, oxidative stress, and endoplasmic reticulum (ER) stress, visceral fat can impair vascularization and play role in the development of various related disorders[18].

The RISKESDAS 2018 report indicates that the prevalence of obesity among individuals over 18 years old is 38.46%, which is higher than the prevalence of 36.66% in West Java Province[19]. Based on previous research findings and reports, the factors related to obesity and its health risks require further investigation. Therefore, this study aimed to explore the factors associated with obesity among older women aged 60 to 69 in Bogor City.

RESEARCH METHOD

Study Design

A cross-sectional study was conducted in three subdistricts (Gunung Batu, Loji, and Pasir Mulya), West Bogor district of Bogor City, Indonesia, from September to October 2024. The study included 154 elderly women aged 60 to 69 years who were participants in the *Chronic Disease Management Program* and registered at an *Integrated Care Post* (Posyandu) within the Pasir Mulya Public Health Center's working area.

Data Collection

The sample selection was done using *proportional random sampling*. This process began with counting the number of subjects in each integrated care post, followed by the random selection of elderly subjects based on the established proportions. The inclusion criteria for this study are women aged 60 to 69 years who can communicate effectively and stand properly. Participants must have fasted for 10 to 12 hours before the visit. Respondents will be excluded if they miss either of the two scheduled visits. Information about the visits will be communicated by the respective *integrated care post cadres* via telephone or social media.

Data on exercise habits were gathered through interviews using a questionnaire. Specifically, the *International Physical Activity Questionnaire-Short* (IPAQ-SF) was used to collect information about daily physical activity over the past seven days. This questionnaire assesses an individual's physical activity level based on *Metabolic Equivalent Task* (MET) values for different activity types. The MET score is calculated by multiplying the type of physical activity by the intensity in minutes and days. The MET values are as follows: walking = 3.3 MET, moderate activity = 4.0 MET, and vigorous activity = 8.0 MET. Physical activity levels are classified as follows: Low: less than 600 MET-minutes per week; Moderate: 600 to less than 1500 MET-minutes per week; High: 1500 MET-minutes or more per week[20]. This questionnaire contains seven questions regarding the physical activity performed by the respondent over the past week, collected through an interview using the IPAQ Short Form.

The BMI measurement was conducted using a *Bio Impedance Analysis* (BIA) Karada Scan Body Composition Monitor (model HBF-375, OMRON, Japan) to assess weight, and a stadiometer (One Health) to measure height. The BMI categories follow the Asian population standards, which are defined as follows: underweight (BMI < 18.5); normal weight (BMI ≥ 18.5 and < 24.9); overweight (BMI ≥ 25.0 and < 27.0 kg/m²); and obese (BMI ≥ 27.0 kg/m²) [2]. Adipose tissue and other components of the body were categorized based on body fat percentage data. According to Gallagher et al., women were classified into three groups: normal (25%–34.9%), high (35.0%–39.9%), and very high (≥ 40%) [21]. The visceral fat levels were classified into two categories: Low (less than 10 points) and High (more than 10 points), based on the OMRON HBF-375 Guideline.

To calculate muscle mass, the percentage of total skeletal muscle relative to body weight is multiplied by 100. The appendicular skeletal muscle mass index (ASMI) is then determined by dividing the total skeletal muscle mass by the square of height (in kg/m²). For women, a low muscle mass is defined as an ASMI of less than 5.45 kg/m², while an ASMI greater than 5.45 kg/m² indicates preserved muscle mass[22,23]. Blood pressure (systolic and diastolic) was measured using an OMRON HEM-7120 digital sphygmomanometer. According to the Joint National Committee (JNC VIII), the classification of systolic and diastolic blood pressure is as follows: 1) Normal (<120 mmHg and <80 mmHg); 2) Prehypertension (120-139 mmHg or 80-89 mmHg); 3) Stage 1 hypertension (140-159 mmHg or 90-99 mmHg); 4) Stage 2 hypertension (≥160 mmHg or ≥100 mmHg) [24].

Statistical Analysis

Blood pressure, ASMI, visceral fat, physical activity, and body fat percentage are the independent variables, and BMI is the dependent variable. The continuous variable's normality was examined using the Kolmogorov-Smirnov test. For continuous variables and normal data distributions, the mean and standard deviation were used, whereas for non-normal data distributions, the median, minimum, and maximum were used. The categorical variables were expressed as frequency and percentage. To examine the association between the variables, a Chi-square test was used. Statistical significance was established at a p-value of less than 0.05.

Ethical Approval

The present study adhered to the principle of Declaration of Helsinki 2013 (latest revised in Finland 2024)[25], regarding research on human subjects. The study was approved by the Ethics Committee of the Research Ethics Committee Semarang State Health Polytechnic which granted ethical permission for this study with number 1062/EA/KEPK/2024. All subjects signed the informed consent forms before collecting the data.

RESULT

A total of 154 respondents (100%) completed the study protocol, as shown in Table 1. The findings indicate that the ma-

Table 1. Sociodemographic, anthropometric and clinical characteristics of the respondents

Characteristics	n = (154)	%
Occupation		
Employed	6	3.90
Unemployed	148	96.10
Physical activity		
Low	112	72.70
Moderate	19	12.30
High	23	14.90
Body Mass Index (BMI)		
Wasting	4	2.60
Normal	57	37.00
Overweight	28	18.20
Obese	65	42.20
Percent Body Fat (%BF)		
Normal	31	20.10
High	66	42.90
Very High	57	37.00
Visceral Fat (VF)		
Low	4	2.60
High	57	37.00
Appendicular Skeletal Muscle Index (ASMI)		
Low	69	44.80
Preserved	85	55.20
Systolic Blood Pressure (SBP)	22	14.30
Hypertension	146	94.80
Not Hypertension	8	5.20
Diastolic Blood Pressure (DBP)		
Hypertension	129	83.80
Not Hypertension	25	16.20

jority of respondents are unemployed (96.10%), engage in low levels of physical activity (72.70%), and are categorized as obese (42.20%). Additionally, 42.90% have high levels of body fat, while 37.00% exhibit high levels of visceral fat. Most respondents are classified as having preserved ASMI (55.20%). Furthermore, a significant number of respondents have hypertension, with 94.80% showing elevated systolic blood pressure and 83.80% demonstrating elevated diastolic blood pressure.

Table 2 shows that the median level of physical activity is 146.00 METs-min/week. The minimum recorded physical activity level is 0 METs-min/week, while the maximum is 19155 METs-min/week. This indicates a wide range of physical activity levels among the respondents. It appears that at least one respondent has the lowest physical activity level, while at least one has the highest. Lower levels of physical activity are associated with increased health risks, including obesity, heart disease, and type 2 diabetes.

The average BMI among respondents was 26.25 kg/m² (SD = 4.35), categorizing the mean value as overweight. The median percentage of body fat (%BF) among respondents was 38.95%. The minimum and maximum %BF recorded were 22.90% and 48.20%, respectively, indicating a wide range of body fat levels among individuals, with some having relatively low levels and others exhibiting relatively high levels. The median value of visceral fat among respondents was 10.50, with a minimum of 1.50 and a maximum of 55.0. This also shows a broad range of visceral fat levels, with some individuals having low levels and others having high levels. The median ASMI among respondents was 5.40, while the minimum and maximum values were 3.20 and 10.80, respectively. This indicates variability in ASMI, with some individuals having lower values and others maintaining higher levels of ASMI. The average SBP among respondents was 150.9 mmHg (SD = 4.35 mmHg), categorizing this average as hypertension. The median DBP was 90 mmHg, which also falls into the hypertensive category. The minimum and maximum DBP values ranged from 59 mmHg to 187 mmHg.

The relationships between physical activity, blood pressure, appendicular skeletal muscle mass index (ASMI), visceral fat (VF), body fat percentage (BF), and obesity are summarized in Table 3. The analysis revealed that the prevalence of obesity was significantly higher among respondents and significantly associated with low levels of physical activity ($p = 0.040$), high %BF ($p < 0.001$), high visceral fat ($p < 0.001$), low ASMI ($p < 0.001$), and elevated SBP ($p = 0.040$). However, no statistically significant association was found between DBP and obesity ($p = 0.340$).

DISCUSSION

The finding of this cross-sectional study was the relationship between physical activity, body fat percentage (%BF), visceral fat, appendicular skeletal muscle mass index (ASMI), and blood pressure concerning obesity. The prevalence of obesity among the participants in this study was 42.20%. This aligns with another cross-sectional study conducted in Indonesia that included 330 older women aged 60 years and above, which reported an obesity rate of 37.30% among the respondents[26]. A study conducted in China found that 19.4% of older women aged 60 and above were obese among a sample of 1,368 participants[27]. Another study conducted in Taiwan included 13,978 women aged 60 years and older, showing a prevalence of obesity at 36.64%[28]. Previous studies support the findings of this current research, indicating that older adults aged 60 and over tend to experience obesity in later life. Although the mean BMI in this study was 26.25±4.35, categorizing it as overweight, this condition—along with obesity—is a critical indicator of higher percentages of body fat and visceral fat[29].

Another body composition parameter measured in this study was body fat percentage (%BF) and visceral fat. Based on Table 1 and Table 2, more than half of the respondents

Table 2. Measurement of Physical Activity, BMI, %BF, VF, ASMI, and Blood Pressure

Variable	Mean±SD	Median (IQR)	95% CI
Physical Activity (METs-min/week)		146.00 (693)	
Body Mass Index (BMI) (kg/m²)	26.25±4.35		25.55-26.94
Percent Body Fat (%)		38.95 (5.5)	
Visceral Fat (point)		10.50 (6.6)	
Appendicular Skeletal Muscle Index (ASMI) (kg/m²)		5.40 (1.2)	
Systolic Blood Pressure (SBP) (mmHg)	150.91±20.98		147.57-154.25
Diastolic Blood Pressure (DBP) (mmHg)		90 (16)	

Table 3. Association of Physical Activity, % BF, VF, ASMI, and Blood Pressure with Obesity

Variable	Obese		Not Obese		p-value	OR value (95%CI)
	n	%	n	%		
Physical Activity						
Low	73	65.20	39	34.80	0.040	2.05 (1.00-4.22)
High	20	47.60	22	52.40		
Percent Body Fat (%BF)						
High	89	72.40	34	27.60	<0.001	17.66 (5.75-54.25)
Normal	4	12.90	27	87.10		
Visceral Fat (VF)						
High	74	96.10	3	3.90	<0.001	75.29 (21.24-266.85)
Low	19	24.70	58	75.30		
Appendicular Skeletal Muscle Index (ASMI)						
Low	19	27.50	50	72.50	<0.001	0.05 (0.02-0.12)
Preserved	74	87.10	11	12.90		
Systolic Blood Pressure (SBP)						
Hypertension	91	62.30	55	37.7	0.040	4.96 (0.96-25.45)
Not Hypertension	2	25.00	6	75.0		
Diastolic Blood Pressure (DBP)						
Hypertension	80	62.00	49	38.00	0.340	1.50 (0.63-3.56)
Not Hypertension	13	52.00	12	48.00		

(72.40%) had a high %BF, with a median of 38.9%, categorized as "high" according to Gallagher et al. Almost all respondents had high visceral fat, with a median of 10.50, which is considered "high" based on the cut-off point provided by the BIA Omron used for analysis.

Higher levels of %BF and visceral fat are associated with increased health risks, including obesity, heart disease, and type 2 diabetes. As shown in Table 3, %BF displayed a significant association with obesity ($p < 0.001$; OR = 17.66). This odds ratio indicates that respondents with higher %BF are 17.66 times more likely to be obese compared to those with normal %BF. A similar association was found with visceral fat levels ($p < 0.001$; OR = 75.29) regarding obesity. This suggests that respondents with higher visceral fat levels have a greater tendency to become obese compared to those with normal visceral fat. These findings align with a study by Tay et al., which also identified a correlation between higher BMI and increased %BF and visceral fat in older adults with obesity[29].

A study found that a higher percentage of body fat is associated with increased age ($p<0.050$). As women age, they naturally experience an increase in body fat and a decrease in lean muscle mass. Research indicates that older women tend to have higher body fat percentages than men, which may lead to an increased risk of sarcopenia (muscle loss) and other metabolic issues[27]. Visceral fat, which accumulates around internal organs, is particularly harmful because it contributes to inflammation and metabolic dysfunction. Research has shown that higher levels of visceral fat are linked to poorer health outcomes in older women, including an increased risk of chronic diseases. Additionally, visceral fat is more metabolically active than subcutaneous fat, posing greater health risks[30]. Visceral fat accumulates when the amount of available fat exceeds what adipocytes can store. This excess fat can circulate in the body and create deposits in other organs. Along with causing hypoxia, oxidative stress, and endoplasmic reticulum (ER) stress, visceral fat may impede the formation of blood vessels and contribute to the development of various related health issues[18].

According to Table 3, there is a significant relationship between physical activity and obesity ($p = 0.040$; OR = 2.05). Among respondents with low levels of physical activity, 65.20% were obese, compared to only 47.60% of those with high levels of physical activity. The odds ratio indicates that respondents with lower physical activity levels are 2.05 times more likely to become obese than those with higher activity levels. This finding aligns with previous studies that suggest a link between physical activity and obesity[31,32], particularly among the elderly with physical mobility issues[32]. Research has indicated that older women who are overweight or obese spend an average of 9.2 hours each day being sedentary. This lack of physical activity increases their risk of various health issues, including inflammation and poor bone health[33]. A cross-sectional study involving 964 older adults found that 55% of the participants were female. The results showed that women were less physically active than men. Among the respondents, the most significant functional impairments were observed in obese women. Older women who are obese have significant impairments in their mobility and general functional ability, with lower extremity abilities like walking and stair climbing being the most affected[34]. According to current research, respondents with low physical activity are often characterized by sedentary behavior. The mechanisms through which low physical activity contributes to bone mass loss in overweight and obese populations are varied and physiologically plausible. Studies have shown that bone cells in the body can be significantly affected by mechanical stress and possess the ability to sense pressure[35]. When older adults who are overweight or obese engage in low levels of physical activity, their lower limbs remain inactive and weak for long periods. This lack of movement prevents bone cells from detecting changes in body weight, leading to a loss of bone mass in the lower extremities[33,35].

Skeletal muscle mass (SMM) is crucial for body composition, and its loss accelerates with age, increasing the risk of osteoporosis, fractures, poor quality of life, functional impairment, and mortality[36,37]. To assess whether older individuals have low lean mass or sarcopenia, a common measure used is the appendicular skeletal muscle index (ASMI). This index is calculated by taking the total skeletal muscle mass of the upper and lower extremities and correcting it for the square of height, using bioelectrical impedance analysis (BIA)[38-40].

ASMI was one of the variables measured in this study. The prevalence of ASMI, as shown in Table 1, was 44.80%, while the median ASMI was 5.40 kg/m² (as indicated in Table 2), which is considered lower than the cut-off points of 5.45 kg/m². Chi-square analysis revealed that lower ASMI was significantly associated with the presence of obesity ($p < 0.001$; OR=0.05). Among respondents with low ASMI, over one-quarter (27.50%) were classified as obese; surprisingly, 87.10% of respondents with preserved ASMI were also considered obese. The odds ratio suggested that respondents with low ASMI were 0.05 times less likely to be obese compared to those with preserved ASMI. Interestingly, this study also found a greater proportion of obesity among individuals with preserved levels of ASMI. In comparison to a previous study conducted by Liu et al, there are similarities in findings. That study discovered that obesity was a protective factor for sarcopenia when measured by BMI ($p = 0.001$; OR = 0.69), but acted as a risk factor when measured by body fat percentage (BF%) ($p = 0.002$; OR = 1.38). This suggests that the likelihood of sarcopenia decreases as BMI increases[27].

The appendicular skeletal muscle index (ASMI) can be used as a predictor for assessing the risk of muscle mass decline in obese populations, depending on how obesity is defined. In this study, obesity status was determined based on BMI rather than percentage body fat (%BF). Although a small number of obese participants showed low ASMI values, the calculated odds ratio, which was less than 1, should not be interpreted as a predictor of obesity. Instead, this odds ratio suggests that obesity may act as a protective factor against low ASMI. In older adults with obesity, multiple factors—including hormonal influences (such as leptin and myostatin), inflammatory responses, metabolic dysregulation (like insulin resistance), mechanical stimuli from physical activity, dietary intake, and complex cellular signaling pathways—play a role in regulating appendicular muscle mass through various mechanisms[41,42].

Blood pressure was the only blood parameter measured in this study. According to Table 1, almost all respondents were classified as hypertensive based on either systolic blood pressure (SBP) or diastolic blood pressure (DBP). As indicated in Table 3, only SBP showed a significant relationship with obesity ($p = 0.040$; OR = 4.96), while DBP did not show a significant relationship ($p = 0.340$). The odds ratio suggests that SBP is a predictor of obesity among the respondents. This finding aligns with two longitudinal studies: the Framingham Heart Study and the Nurses' Health Study. The Framingham Heart Study highlights that the likelihood of developing hypertension significantly increases with obesity. Individuals in the highest body mass index (BMI) quartile have an SBP approximately 16 mmHg higher and a DBP about 9 mmHg higher than those in the lowest quartile. Specifically, systolic blood pressure increases by roughly 4 mmHg for every 4.5 kg increase in weight[43]. According to the Nurses' Health Study, women who gained over 25 kg were 5.2 times more likely to develop hypertension than those who maintained their weight[44].

Blood pressure and obesity are connected through several mechanisms, including insulin resistance, increased sympathetic nerve activity, and changes in kidney function. Obesity can impair the kidneys' ability to excrete sodium and can lead to increased sodium reabsorption, which negatively affects overall kidney function. This can result in high blood pressure, driven by the activation of the sympathetic nervous system and the renin-angiotensin system[43]. The sympathetic nervous system is activated by the increased visceral fat associated with obesity. This activation leads to vasoconstriction and an increase in cardiac output, both of which contribute to elevated blood pressure. Additionally, insulin resistance often occurs alongside obesity. This condition promotes vascular smooth muscle contraction and causes endothelial dysfunction, which can further lead to hypertension[43].

CONCLUSION

This study highlights the association between low physical activity, high percentage of body fat (%BF), high visceral fat, and high systolic blood pressure (SBP) as risk factors for obesity among women aged 60-69. Interestingly, obesity in this study appeared to protect against low appendicular skeletal muscle index (ASMI) among the respondents. Although diastolic blood pressure (DBP) did not show a statistically significant relationship with obesity, it may still play a role in the clinical development of DBP in individuals with obesity. Since this study defined obesity using body mass index (BMI), considering the percentage of body fat may provide a clearer relationship with the other variables. We suggest conducting further research on obesity among the elderly population, using a larger sample size and different study designs, such as randomized controlled trials with exercise or dietary interventions. This would help to examine the effects of these interventions, or employing mixed methods to explore additional factors associated with obesity in older adults.

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