

The Relationship Between Subcutaneous and Visceral Fat Thickness and Osteoporosis Incidence in Women Aged ≥ 50 Years at RSUP Prof. Dr. I.G.N.G. Ngoerah

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ABSTRACT

Osteoporosis is a disease characterized by a decrease in bone mass and microarchitecture, as well as an increased risk of bone fractures, especially in older women. Women are more susceptible to osteoporosis due to hormonal and physiological factors. This study aims to evaluate the relationship between subcutaneous and visceral fat thickness and the incidence of osteoporosis in women aged ≥ 50 years. This observational cross-sectional study involved 39 women who underwent DXA examinations at Prof. Dr. I.G.N.G. Ngoerah General Hospital in January–February 2025. Fat thickness was measured using ultrasound, and osteoporosis diagnosis was based on DXA T-score. The results of the analysis showed that abdominal subcutaneous fat thickness ≥ 23.5 mm (OR 19.0, $p < 0.01$) and abdominal visceral fat ≥ 10.2 mm (OR 76.0, $p < 0.01$) were associated with an increased risk of osteoporosis. Thigh subcutaneous fat thickness ≥ 10.5 mm (OR 4.5, $p = 0.041$) and dorsal ≥ 14.5 mm (OR 10.6, $p = 0.003$) also showed a significant association. Logistic regression analysis showed that abdominal subcutaneous fat thickness ≥ 23.5 mm (aOR 5.1, $p = 0.008$) and abdominal visceral fat ≥ 10.2 mm (aOR 12.2, $p = 0.002$) were significant determinants of osteoporosis risk. This study highlights the importance of assessing fat thickness, particularly visceral fat, in identifying the risk of osteoporosis in older women.

KEYWORDS *osteoporosis, subcutaneous fat, visceral fat, ultrasonography, DXA.*



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INTRODUCTION

Osteoporosis is a systemic disease characterized by a decrease in bone mass, a decrease in the quality of bone microarchitecture, and an increase in bone fragility (Castellani, De Martino, & Scapato, 2025; Formosa, Christou, & Makitie, 2024). This process leads to an increased risk of fractures, especially in the elderly female population. Women are more prone to osteoporosis due to hormonal and physiological factors (Morin, Leslie, & Schousboe, 2025; Rupec et al., 2025). About 23% of women aged 50–80 years and 53% of women aged 70–80 years in Indonesia experience osteoporosis (Kusumawardani, Supartono, Hadiwiardjo, & Citrawati, 2025).

Human bones consist of two types, namely cortical bones and trabecular bones (Barak, 2024; Limzider, Rittel, & Shemtov-Yona, 2025). Trabecular bones have a hollow structure and are more metabolically active, making them more susceptible to changes due to osteoporosis (Agnishwaran, Manivasagam, & Udduttula, 2024; Li et al., 2025). The process of loss of bone density in the trabecular bone contributes greatly to the risk of spinal and pelvic fractures (Gebre et al., 2025; Ries et al., 2025). Research shows that increased fat content in the spinal cord is closely related to decreased bone mineral density and bone structure quality.

Obesity has become a global epidemic with major implications for musculoskeletal health (Menoth Mohan, Al Anouti, Kohli, & Khalaf, 2025; Rinaldi, Patel, & Ackerman, 2025). The World Health Organization notes that the prevalence of obesity has increased significantly in the last four decades, especially in developing countries. About 62% of women aged 50–80 years with obesity in Indonesia experience osteoporosis, compared to 25.2% of women who are not obese (Fithra Dieny & Yudi Fitrianti, 2017). Weight gain can cause excessive mechanical load on the spine and contribute to the degeneration of vertebral structures (Song et al., 2020).

Body fat is stored in two main compartments, which are subcutaneous and visceral. Subcutaneous fat is under the skin, while visceral fat surrounds internal organs. Each individual has a different proportion of fat depending on age, gender, and hormonal factors. Women generally have greater subcutaneous fat reserves than men (Piché et al., 2018).

Subcutaneous and visceral fat thickness can be assessed using a variety of methods, including dual X-ray absorptiometry (DXA), bioimpedance, CT-scan, MRI, and ultrasonography. Ultrasound provides the advantages of being low-cost, non-invasive, non-radiation-free, and able to display results in real-time (Wagner, 2020). Research by Pratt shows that ultrasound has good reliability in measuring fat tissue thickness compared to other methods (Pratt, Narici, Boreham, & De Vito, 2025).

The thickness of dorsal fat tissue has a significant relationship with degenerative processes in the spine. Research by Kanbayati et al. showed that every 1 mm increase in dorsal fat thickness at L1–L2 increased the risk of disc degeneration by 37% in adult women (Shi et al., 2022). Visceral fat tissue is also known to produce proinflammatory molecules such as leptin, IL-6, and TNF- α , which can accelerate bone resorption processes and decrease bone mineral density (Cao, 2011).

Research by Kwon showed a positive correlation between visceral and subcutaneous fat thickness with increased body mass index as well as increased metabolic risk (Kwon & Han, 2019). In addition, Erkek et al. reported a relationship between muscle thickness and fat in the upper extremities and bone density in adult men. The biological mechanisms between body fat and bone are not yet fully understood, but there is strong evidence that adipose tissue can interfere with bone homeostasis through inflammatory and hormonal pathways (Kwon & Han, 2019).

This study aimed to evaluate the relationship between subcutaneous and visceral fat thickness and the incidence of osteoporosis in women aged ≥ 50 years. This study is expected to contribute to the understanding of modified osteoporosis risk factors and support a prevention approach based on body composition.

METHOD

This study is an analytical observational study with a cross-sectional design that aims to determine the relationship between subcutaneous and visceral fat thickness (measured by ultrasound) and the incidence of osteoporosis (based on T-score DXA) in women aged ≥ 50 years. The research was conducted at the Radiology Installation of Prof. Dr. I.G.N.G. Ngoerah Hospital in January–February 2025 and involved various disciplines, including radiology, internal medicine, orthopedics, endocrine, geriatrics, and rheumatology.

The target population is women aged ≥ 50 years who undergo DXA examination. Samples were selected by consecutive sampling method based on inclusion criteria: age ≥ 50 years and willing to undergo ultrasound. Exclusion criteria include unreadable DXA results, active osteoporosis therapy, inability to undergo ultrasound, or refusal of informed consent. Based on the calculation of two proportions, a sample of at least 39 subjects was obtained with a prevalence of osteoporosis in obesity of 62.3% and non-obesity of 25.6% ($\alpha=0.05$, power=90%).

Data were collected using GE Logic P7 and PACS to measure subcutaneous fat thickness, as well as Lunar iDXA for DXA results. The examination was carried out by two radiologists, 2–3 times each, with average results. A T-score value of ≤ -2.5 is used for the diagnosis of osteoporosis. Data analysis includes descriptive statistics, chi-square for bivariate tests, as well as binary logistic regression for multivariate analysis. This research was approved by the Ethics Commission of FK Unud/RSUP Ngoerah, with independent financing by the researcher.

RESULT AND DISCUSSION

Based on the inclusion criteria, 39 research subjects with characteristics as in Table 5.1 were obtained. The average age of the subjects was 61.05 ± 8.11 years, with an age range of 50–81 years. Nutritional status based on body mass index showed an average of 23.66 ± 3.91 . A total of 1 subject (1.1%) was severely underweight, 29 subjects (74.4%) were normal, 2 subjects (5.1%) were overweight, and 7 subjects (17.9%) were obese; There were no subjects with mild underweight. The average thickness of abdominal subcutaneous fat was 22.17 ± 7.19 mm; dorsal length 14.32 ± 6.23 mm; 12.48 ± 4.85 mm; and visceral fat 10.22 ± 3.99 mm. The results of the DXA analysis showed that 18 subjects (46.2%) had osteoporosis, while 21 subjects (53.8%) did not. Full results are presented in table 1.

Table 1. Characteristics of Research Subjects

Characteristics	n (%)
Age (years)*	
Average $\pm$ standard deviation	61.05 ± 8.11
Body Mass Index (kg/m²)*	
Average $\pm$ standard deviation	23.66 ± 3.91
Severe Underweight	1 (2,6%)
Mild Underweight	0 (0%)
Normal	29 (74,4%)
Overweight	2(5.1%)
Obese	7 (17.9%)
Abdominal Subcutaneous Fat Thickness*	
Average $\pm$ standard deviation	22.174 ± 7.19
Dorsal Subcutaneous Fat Thickness*	
Average $\pm$ standard deviation	14.32 ± 6.23
Thigh Subcutaneous Fat Thickness*	
Average $\pm$ standard deviation	12.477 ± 4.85
Visceral Abdomen Fat Thickness *	
Average $\pm$ standard deviation	10.22 ± 3.99
Incidence of Osteoporosis	
Yes	18 (46.2%)
No	21 (53.8%)

source: processed data

Table 2 shows a significant association between subcutaneous and visceral fat thickness and the incidence of osteoporosis in women aged ≥ 50 years. Abdominal subcutaneous fat thickness ≥ 23.5 mm had an odds ratio (OR) of 19.0 (95% CI: 3.2-109.9, $p < 0.01$), abdominal visceral fat thickness ≥ 10.2 mm OR 76.0 (95% CI: 9.5-602.1, $p < 0.01$), thigh subcutaneous fat thickness ≥ 10.5 mm OR 4.5 (95% CI: 1.0-20.5, $p = 0.041$), and dorsal subcutaneous fat thickness ≥ 14.5 mm OR 10.6 (95% CI: 1.9-58.6, $p = 0.003$). All variables showed an increased risk of osteoporosis in women with higher fat thickness, with abdominal visceral fat thickness showing the strongest association.

Table 2. Relationship of Subcutaneous and Visceral Fat Thickness Characteristics with the Incidence of Osteoporosis in Women Aged ≥ 50 Years

Characteristics	Incidence of Osteoporosis		OR	95% CI	Nilai <i>p</i>
	Ya	No			
Thickness Lemak subcutaneous abdomen					
≥23.5 mm	12 (85.7%)	2 (14.3%)	19.0	3.2-109.9	<0.01
<23.5 mm	6 (24%)	19(76.3%)	Ref		
Thickness lemak visceral abdomen					
≥10.2 mm	16 (88.9%)	2 (11.1%)	76.0	9.5-602.1	<0.01
<10.2 mm	2 (9.5%)	19 (90.5%)	Ref		
Thickness of subcutaneous thigh fat					
≥10.5 mm	15 (57.7%)	11 (42.3%)	4.5	1.0-20.5	0.041
<10.5 mm	3 (23.1%)	10 (76.9%)	Ref		
Thickness subcutaneous fat dorsal					
≥14.5 mm	16 (64.0%)	9 (36.0%)	10.6	1.9-58.6	0.003
<14.5 mm	2 (14.3%)	12 (85.7%)	Ref		

source: processed data

Table 3 shows the results of logistic regression analysis that identifies the determinants of osteoporosis incidence. An abdominal subcutaneous fat thickness of ≥ 23.5 mm was significantly associated with an increased risk of osteoporosis, with an aOR of 6.1 (95% CI 1.8-45.5, $p = 0.015$) in the baseline model and an aOR of 5.1 (95% CI 3.8-29.9, $p = 0.008$) in the final model. Abdominal visceral fat thickness ≥ 10.2 mm was also significant, with an aOR of 10.2 (95% CI 1.5-69.1, $p = 0.010$) in the baseline model and an aOR of 12.2 (95% CI 2.0-743, $p = 0.002$) in the final model. Thigh subcutaneous fat thickness ≥ 10.5 mm showed no significant association (aOR = 1.3, $p = 0.503$), however dorsal subcutaneous fat thickness ≥ 14.5 mm was significant with an aOR of 4.2 (95% CI 1.0-45.5, $p = 0.025$) in the baseline model and an aOR of 5.1 (95% CI 1.8-29.9, $p = 0.010$) in the final model. Age and BMI variables were not significantly associated with the incidence of osteoporosis, with p values of 0.318 and 0.386 for obesity and 0.999 for overweight, respectively, suggesting that neither affected the risk of osteoporosis.

Table 3. Determinants of Osteoporosis Incidence

Variable	Early Models			Final Model		
	aOR	95% CI	Value p	aOR	95% CI	Value p
Thickness						
Lemak subcutaneous abdomen						
≥23.5 mm	6,1	1,8-45,5	0,015	5,1	3,8-29,9	0,008
<23.5 mm	Ref			Ref		
Thickness lemak visceral abdomen						
≥10.2 mm	10,2	1,5-69,1	0,010	12,2	2,0-743	0,002
<10.2 mm	Ref			Ref		
Subcutaneous thigh fat						
≥10.5 mm	1,3	0,9-6,2	0,503	-	-	-
<10.5 mm	Ref					
Thickness lemak subcutaneous dorsal						
≥14.5 mm	4,2	1.0-45,5	0,025	5,1	1,8-29,9	0,010
<14.5 mm	Ref			Ref		
Age						
62-81	0,2	0,0-3,3	0,318	-	-	-
50-61	Ref					
BMI						
Obese	1,4	0,2-6,2	0,386	-	-	-
Overweight	0,5	N/A	0,999	-	-	-
Normal	0,8	N/A	0,886	-	-	-
Severe Underweight	Ref					

source: processed data

The study involved 39 subjects with an average age of 61.05 ± 8.11 years and an age range between 50 and 81 years, most of whom were in the elderly age group at high risk of osteoporosis. Age factors, particularly in postmenopausal women, increase their susceptibility to osteoporosis due to decreased bone mass and changes in bone metabolism (Fithra Dieny & Yudi Fitrianti, 2017) Subjects' nutritional status was measured by body mass index (BMI) showing an average of 23.66 ± 3.91 kg/m², with most subjects (74.4%) having normal nutritional status, 17.9% obese, 5.1% overweight, and 2.6% severely underweight. Individuals with lean bodies or poor nutritional status are at higher risk of osteoporosis (Fatmawati & Mahmudiono, 2021)

Subcutaneous fat thickness in different areas of the body, such as abdomen (22.17 ± 7.19 mm), dorsal (14.32 ± 6.23 mm), thighs (12.48 ± 4.85 mm), and abdominal visceral fat (10.22 ± 3.99 mm), showed significant variation in affecting bone health. Excessive visceral fat, especially in the abdominal area, is associated with systemic inflammation that accelerates bone resorption and increases the risk of osteoporosis (Shi et al., 2022) The DXA results showed that 46.2% of subjects developed osteoporosis, in line with previous findings that osteoporosis is often found in postmenopausal women (12). These findings confirm the importance of evaluating the thickness of body fat, particularly visceral fat, in assessing the risk of osteoporosis in the elderly population.

The results of this study showed that the thickness of abdominal subcutaneous fat had a significant relationship with the incidence of osteoporosis. Subjects who had an abdominal subcutaneous fat thickness of ≥ 23.5 mm were 19 times more likely to develop osteoporosis

compared to individuals with an abdominal subcutaneous fat thickness of < 23.5 mm. These findings indicate that the buildup of subcutaneous fat, especially that accumulated around the abdomen, plays an important role in increasing the risk of osteoporosis. Previous research has shown that body fat, especially that accumulated in the abdominal area, can affect bone health through hormonal and metabolic mechanisms (Shi et al., 2022)(3). Increased subcutaneous fat, particularly in the abdominal area, can increase estrogen levels which, although they have a protective effect on bones, if excessive can accelerate bone resorption faster than their formation, thereby reducing bone density and increasing the risk of osteoporosis (Cao, 2011)(5). This is reinforced by research showing that visceral fat functions as a reservoir of the hormone estrogen, which affects the activity of osteoclasts and osteoblasts in the process of bone balance (2).

In addition, this study also confirmed that the thickness of the visceral fat of the abdomen is significantly related to the incidence of osteoporosis. Individuals with a $\geq$ abdominal visceral fat thickness of 10.2 mm were 76 times more likely to develop osteoporosis compared to individuals with an abdominal visceral fat thickness of < 10.2 mm. Visceral fat buildup plays an active role in the regulation of hormones and inflammation of the body that affects bone metabolism. Visceral fat is more harmful because it not only serves as an energy reserve, but also promotes systemic inflammation that damages bone tissue (Kwon & Han, 2019)(Shi et al., 2022) Previous research has shown that visceral fat can increase estrogen levels leading to increased bone resorption, which ultimately decreases bone density and increases the risk of osteoporosis (Cao, 2011)(Bredella et al., 2021) In addition, visceral fat also increases inflammation which affects the activity of osteoclasts and worsens bone damage (Piché et al., 2018) The results of logistic regression analysis support a significant association between visceral fat thickness and osteoporosis incidence, suggesting that visceral fat plays a major role in increasing the risk of osteoporosis.

In contrast to abdominal and visceral subcutaneous fat thickness, thigh subcutaneous fat thickness did not show a significant association with osteoporosis incidence. Although there is a significant relationship based on chi-square analysis, logistic regression results show that its effect on osteoporosis incidence is not statistically significant (Bredella et al., 2021)(Piché et al., 2018) This insignificance is understandable because subcutaneous fat on the thighs is more likely to have a mechanical effect on bones than hormonal effects, in contrast to visceral fat which has a direct influence on bone metabolism through increased estrogen levels. Previous research has also shown that visceral fat is more associated with changes in bone microstructures, thus increasing the risk of osteoporosis compared to subcutaneous fat in the thighs (Shi et al., 2022)(Baker et al., 2023)).

The study also found that dorsal subcutaneous fat thickness was significantly associated with the incidence of osteoporosis. Individuals with a dorsal subcutaneous fat thickness of ≥ 14.5 mm were 10.6 times more likely to develop osteoporosis compared to individuals with a dorsal subcutaneous fat thickness of < 14.5 mm. These findings highlight the importance of body fat distribution, especially in the dorsal area, in influencing the risk of osteoporosis. The accumulation of subcutaneous fat in the back area can affect bone metabolism both mechanically through increased pressure on the spine and through increased estrogen levels which can accelerate bone resorption (Piché et al., 2018)(Baker et al., 2023) The results of

logistic regression analysis reinforce these findings, showing that dorsal subcutaneous fat thickness plays a significant role in increasing the risk of osteoporosis in elderly individuals.

Overall, the study shows that subcutaneous and visceral fat thickness, especially those accumulated in the abdomen and dorsal, is closely related to an increased risk of osteoporosis. Visceral fat thickness, which affects hormonal balance and inflammation, has been shown to have a greater impact on the risk of osteoporosis compared to subcutaneous fat in other areas of the body (Cao, 2011)(Shi et al., 2022) Therefore, monitoring of body fat thickness, especially in the abdominal and dorsal areas, can be an important indicator in osteoporosis risk assessment and aid in the development of more focused prevention strategies in high-risk individuals.

CONCLUSION

This study indicates that subcutaneous fat thickness in areas such as the abdomen, thigh, and dorsal regions significantly impacts the risk of osteoporosis, with abdominal visceral fat exerting the greatest influence on bone density reduction. Fat accumulation around the abdomen and back affects bone metabolism through hormonal and inflammatory pathways that promote bone resorption. Monitoring body fat thickness in these key areas can serve as an effective indicator of osteoporosis risk, especially among the elderly. For future research, it is recommended to explore the effectiveness of specific interventions, such as targeted diet and exercise programs, in reducing fat accumulation and subsequently lowering osteoporosis risk, along with longitudinal studies to assess long-term outcomes of such preventive measures.

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