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Original Article

Clinical Characteristic of Patients Underwent Bone Mineral Density Examination in Prof. Dr. R. Soeharso Orthopaedic Hospital in 2022 - 2023: A Cross-Sectional Study

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ABSTRACT

Background: In Indonesia, osteoporosis affects roughly 23% of men and women aged 50-70 and a staggering 53% of those over 70. Understanding the characteristics of patients undergoing bone mineral density (BMD) examinations is crucial for developing better strategies for prevention, diagnosis, and treatment. This study investigates the characteristics of patients who had BMD examinations at the Prof. Dr. R. Soeharso Orthopaedic Hospital.
Methods: A cross-sectional study was conducted at Prof. Dr. R. Soeharso Orthopaedic Hospital from April 2022 to April 2023, using a total sampling approach and data extracted from digital medical records. The variables included age, gender, body mass index (BMI), BMD T-score from the lumbar spine, hip, and forearm, frequency and location of fragility fracture (FF), osteoporosis frequency, and fracture risk assessment (FRAX) score for major osteoporotic fracture (MOF) and hip fracture. Patients with incomplete data were excluded.
Results: This study involved 168 patients, mainly women (83%) and men (17%). Most (81.5%) were aged 50-74, with osteoporosis affecting 29.2% and severe osteoporosis affecting 60.7%. The spine was the most common site of FF (88.2%). Osteoporosis severity correlated with higher BMI ($p<0.05$). FRAX scores for MOF and hip fractures were mostly in the low-risk category.
Conclusions: A high prevalence of osteoporosis and severe osteoporosis among women, particularly those in the age of 50 to 74 years, and higher BMI was correlated with greater severity of osteoporosis. FF was found more common among women with the spine as the most frequently affected site.

Keywords: Body mass index; Bone mineral density; Osteoporosis; T-Score; Human and medicine

INTRODUCTION

Bone mineral density (BMD) is an estimate of the mineral proportion in a certain volume of bone, primarily consisting of calcium and phosphorus.[1] In order to assess BMD, a tool is required. The most commonly used tool for this purpose is dual x-ray absorptiometry (DXA). DXA evaluates bone strength and BMD, accounting for approximately 70% of overall bone strength. Thus, understanding bone strength can aid in diagnosing osteoporosis, one of the most common metabolic bone diseases (MBDs) worldwide.[2] There are a variety of BMD examination indications, including age (≥ 70 years old for men; ≥ 65 years old for women), women with postmenopausal and menopausal transition, men and women aged> 50 years old with a history of fracture and/or clinical risk factors such as obesity, diabetes mellitus, smoking, prolonged use of glucocorticoids, high alcohol intake, low body weight (<60 kg), and vertebral fracture identified on radiographs.[2,3]

Osteoporosis is characterized by an imbalance in bone cell function, low bone density, degeneration of bone tissue, and damaged microarchitecture, resulting in decreased

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bone strength and an increased risk of fractures. Diagnostic criteria for osteoporosis include a T-score (standard deviation score compared to the BMD of healthy young adults) of less than or equal to -2.5.[4] Globally, osteoporosis affects both men and women of all races, although women are more susceptible. One out of three women and one out of five men aged >50 years old will have osteoporosis fractures.[1,2] In Indonesia, as of 2013, the prevalence of osteoporosis among men and women aged 50–70 and over 70 was approximately 23% and 53%, respectively. Osteopenia affects approximately 41.7% of the population, meaning that two out of five individuals in Indonesia are at risk of developing osteoporosis.[5] Understanding the clinical characteristics of patients undergoing BMD examinations is crucial for developing effective prevention, diagnosis, and treatment strategies. This knowledge also increases physicians' awareness, particularly orthopedic surgeons, prompting them to order BMD examinations and thus enhance osteoporosis detection.

There is currently a lack of data on the correlation between BMD examinations and the clinical characteristics of patients at Prof. DR. R. Soeharso Orthopaedic Hospital. Therefore, this study aims to investigate the clinical characteristics of patients who underwent BMD examinations at Prof. Dr. R. Soeharso Orthopaedic Hospital over one year (April 2022 - April 2023). As a leading national referral hospital for orthopedic medical services in Indonesia, this serves as a pilot project to analyze BMD examination data and patients' clinical characteristics. The findings from this study will be valuable for future research, particularly in the field of osteoporosis.

MATERIAL AND METHODS

Study Design and Sampling

This cross-sectional study was conducted at Prof. Dr. R. Soeharso Orthopaedic Hospital in Sukoharjo, Indonesia from April 1, 2022, to April 30, 2023. The hospital is recognized as the top national referral center for orthopedic medical services in Indonesia. The study period was from May 2023 to June 2023. Ethical clearance was granted by the Research Ethical Board of Prof. Dr. R. Soeharso Orthopaedic Hospital, with the approval number IR.03.01/D.XXV.3/5077/2023.

The sampling process of this study involved total sampling, where all data were obtained from the hospital's digital medical records, serving as the primary data source. Demographic information, including age, gender, and BMI (Body Mass Index), was collected from the digital medical records. Age was categorized as follows: (1) <50 years old, (2) 50–74 years old, and (3) ≥75 years old. Gender was divided into (1) men and (2) women. BMI was divided into the following categories according to adult Asians classifications by World Health Organization (WHO) 6: (1) underweight (<18.5 kg/m²), (2) normal (18.5–22.9 kg/m²), (3) overweight (≥23 kg/m²), (4) obese I (25–29.9 kg/m²), and (5) obese II (≥30 kg/m²).

The variables included in this study were the diagnosis of osteoporosis based on the T-score obtained from the BMD examination that was taken from three areas which were from the lumbar spine (L1-L4), hip or femur (femoral neck, total hip, or trochanter), and forearm (distal radius), body mass index (BMI), FRAX (Fracture Risk Assessment) scores for major osteoporotic fracture (MOF) and hip fracture with risk categories based on Canadian guidelines for osteoporosis,[3] frequency of fragility fractures (FF) and non-fracture diagnoses including the area/region of the fracture, and the relationship between osteoporosis diagnosis and fragility fracture status. MOFs are fractures related to vertebrae, hip, forearm, and/or proximal humerus. The inclusion criteria were patients with complete data for the variables, those who underwent BMD examination during the specified period, and patients who were referred for BMD examination by surgeons/physicians at Prof. Dr. R. Soeharso Orthopaedic Hospital. The radiographer and radiologist who evaluated the BMD examination had been certified by the International Society of

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Clinical Densitometry (ISCD). Patients who had a BMD examination but were not ordered by the physician or orthopedic surgeon from Prof. DR. R. Soeharso were excluded.

Data Collections

Bone mineral density was measured using DXA to produce the T-score, which compares the patient's bone mineral density to that of a young, healthy adult. T-scores were obtained from DXA scans of the lumbar spine (L1-L4), hip or femur (femoral neck, total hip, or trochanter), and forearm (distal radius). However, not all patients had all three areas evaluated. At least one area was examined using DXA to determine the T-score, which was sufficient to establish the diagnosis of osteoporosis. The T-scores were categorized for each DXA scan area according to the WHO as follows: (1) not scanned, (2) normal (T-score > -1 SD), (3) osteopenia (T-score -1 < x < -2.5 SD), and (4) osteoporosis (T-score ≤ -2.5 SD).[4]

This study also provided a FRAX score that would help calculate the 10-year probability of hip fractures and MOF. Only women and men aged 40 – 90 years old are eligible to be included in this scoring tool. The FRAX score can be calculated using either BMI + BMD or BMI alone, although the score would be more precise if using the BMI + BMD score. Even though it predicts hip fracture and MOF, the preferred choice of BMD should be based on femoral neck BMD. The FRAX calculator score has different fracture risk stratifications for each country; therefore, this study used the Indonesian population. Data required for input into the FRAX calculator are age, BMD, weight and height (BMI), gender, parental history of hip fracture, rheumatoid arthritis, alcohol intake, oral glucocorticoid use, prior osteoporotic fracture, current smoking history, and secondary osteoporosis cause.[2,7]

The FRAX scores for MOF and hip fracture were presented with mean, minimum, maximum, range, and standard deviation values. These scores were also categorized into three and two groups, respectively. The FRAX score categories for MOF were: (1) low risk (<10%), (2) moderate risk (10 - 20%), and (3) high risk (>20%). The FRAX score categories for hip fracture were: (1) low risk (<3%), and (2) high risk (≥3%). The FRAX score calculations were based on the Indonesian population, and the risk categories are based on recommendations from The Canadian Association of Radiologists and Osteoporosis.[3]

Fragility fracture refers to a bone fracture that occurs either spontaneously or following low-trauma events, such as a fall from standing height or less. These fractures typically affect specific sites, including the vertebrae, hip, forearm, and humerus.[8] The diagnosis of fragility fracture relied on the patient's medical history and the findings in their medical record. Individuals with no history of fragility fracture were categorized as non-fracture or non-fragility fracture. Conversely, patients diagnosed with osteoporosis who have a positive history of fragility fractures were classified as having severe osteoporosis.

Statistical Analysis

The collected data from the digital medical records were analyzed to determine the frequency distribution of each variable. As the baseline characteristic data of the patients were not normally distributed, a non-parametric analysis test, specifically Spearman's rho test, was employed for the statistical analysis. The Spearman's rho correlation test was used to assess the correlation between age groups, BMI, gender, and the diagnosis of osteoporosis, with a statistical significance level of $p<0.05$. The statistical analysis was performed using SPSS version 22.0 (IBM SPSS Statistics, New York, USA).

RESULTS

A total of 212 patients underwent BMD examinations at Prof. Dr. R. Soeharso Orthopaedic Hospital in Indonesia between April 1, 2022, and April 30, 2023. However, 44 patients were excluded from the study due to incomplete data, resulting in a final sample size of 168 patients included in this study. The baseline characteristics of these patients are summarized in Table 1.

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Table 1. Baseline characteristics of patients who underwent BMD examination.

Characteristics	Number of patients (n=168)	Mean ± SD*	%
Gender			
Women	139	-	82.7
Men	29		17.3
Age (years)			
<50	8	65.50 ± 8.855	4.8
50–74	137		81.5
≥75	23		13.7
Body Mass Index (BMI) (kg/m^2)			
Underweight (< 18.5)	15		8.9
Normal (18.5 – 22.9)	65	23.667 ± 4.4872	38.7
Overweight (≥ 23)	30		17.8
Obese I (25 – 29.9)	39		23.2
Obese II (≥ 30)	19		11.4
Osteoporosis Diagnosis from Average T-Score (Lumbar Spine)			
Not Examined	21		12.5
Normal	14	-2.507 ± 1.585	8.3
Osteopenia	57		33.9
Osteoporosis	76		45.2
Osteoporosis Diagnosis from Average T-Score (Hip / Femur)			
Not Examined	0		0
Normal	4	-2.680 ± 1.095	2.4
Osteopenia	58		34.5
Osteoporosis	106		63.1
Osteoporosis Diagnosis from Average T-Score (Forearm)			
Not Examined	22		13.1
Normal	17	-2.827 ± 1.822	10.1
Osteopenia	43		25.6
Osteoporosis	86		51.2
Fragility Fracture			
Fragility Fracture	102	-	60.7
Non-fracture and or non-fragility fracture	66		39.3
Region of Fragility Fracture			
Upper Extremity	3		2.9
Lower Extremity	4		4
Spine	90	-	88.2
Lower Extremity + Spine	4		4
Spine + BMD (metastatic)	1		0.9
Total	**102**		**100**
Region of Non-Fracture and Non-Fragility fracture			
Upper Extremity + Lower Extremity + Spine	1		1.5
Lower Extremity + Rheumatoid Arthritis	8		12.2
Spine	55		83.3
Lower Extremity + metabolic	1		1.5
Osteorenaldystrophy + Chronic Kidney Disease St. V	1		1.5
Total	**66**		**100**

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Table 1. Baseline characteristics of patients who underwent BMD examination

Characteristics	Number of patients (n=168)	Mean ± SD*	%
Osteoporosis Diagnosis Related Fragility Fracture			
Normal	1		0.6
Osteopenia	16		9.5
Osteoporosis	49		29.2
Severe Osteoporosis	102		60.7
FRAX Score of MOF			
Low Risk (<10%)	146		86.9
Moderate Risk (10 – 20%)	20		11.9
High Risk (>20%)	2		1.2
FRAX Score of Hip Fracture			
Low Risk (<3%)	102		60.7
High Risk (≥3%)	66		39.3

*SD: Standard Deviation

The baseline demographics of the patients included in this study, as presented in Table 1, revealed a predominance of women undergoing BMD examinations during the one year. Out of the included patients, 139 (82.7%) were women, while 29 (17.3%) were men. Women accounted for nearly five times more BMD examinations than men. The most prevalent age category was 50-74 years old, encompassing 137 (81.5%) patients, of whom 115 were women. This was followed by the ≥75 years old group with 23 (13.7%) patients and the <50 years old group with 8 (4.8%) patients. The mean age of the patients was 65.5 years. However, it is important to note that the distribution of the age data was not normal. The skewness of the age distribution was -0.122 with a standard error of 0.187. Similarly, the distribution of gender categories was not normal, as the number of women was nearly five times higher than men.

Regarding BMI, the most common category observed among the patients was normal weight, with 65 (38.7%) patients falling into this category. On the other hand, the least common category was underweight, which included 16 (9.5%) patients. The mean ± SD of BMI value among the patients was 23.667 ± 4.4872 kg/m², and the highest recorded BMI was 39.4 kg/m². Another notable baseline finding was that the most frequently affected area among patients with a fragility fracture and non-fracture condition was the spine with 90 and 55 patients, respectively.

The T-scores obtained in this study were assessed for three areas: hip or femur (femoral neck, total hip, or trochanter), lumbar spine (L1-L4), and forearm (distal radius) with mean ± SD of each T-score were -2.680 ± 1.0951; -2.507 ± 1.585; -2.827 ± 1.822, respectively. DXA scans were performed on the hip/femur in 168 (100%) patients, followed by the lumbar spine in 147 (87.5%) patients, and the forearm in 146 (86.9%) patients.

Regarding the history of fragility fractures, it was found that 102 (60.71%) patients had experienced fragility fractures, while the remaining 66 patients (39.29%) did not have a history of fragility fractures. Among those with fragility fractures, the spine was the most commonly affected area, with 90 patients (88%). In terms of the severity of osteoporosis, the majority of patients were classified as having severe osteoporosis, comprising 102 (60.7%) patients. The remaining patients were diagnosed with osteoporosis (49 patients, 29.2%) or osteopenia (16 patients, 9.5%). Only one patient (0.6%) had normal bone density.

The mean ± SD of the FRAX score MOF and hip fracture were 6.515 ± 4.746% and 3.326 ± 4.435%, respectively. Despite more than 50% of patients having severe osteoporosis, it is note-

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worthy that more than 50% of patients also fell into the low-risk category for FRAX scores of MOF and hip fracture. Specifically, 146 (86.9%) patients were classified as low risk for MOF, and 102 (60.7%) patients were classified as low risk for hip fracture. The mean FRAX scores were 6.515 and 3.326, respectively.

Table 2 showed that women were more affected by fragility fractures than men, with four times higher incidence (p>0.05). Regarding BMI, a positive correlation with fragility fracture was observed (p <0.05). Patients with more than equal to overweight with fragility fracture compared As shown in Table 3, the age group with the highest number of patients was 50-74 years old, encompassing a total of 137 patients, including 115 women and 22 men. Among patients with normal BMI, women constituted the majority with 50 patients, followed by 15 men. Women with BMI overweight, obese I, and obese II were referred for BMD examination more than men. The results revealed that overweight and obese (type I and type II) patients accounted for 30 (17.8%) and 58 (34.6%) patients, in total for 88 patients (52.4%). In contrast, only 16 (9.5%) patients were underweight. Within the overweight and obese categories, women were again dominant,

Table 2. Distribution of BMI, gender, and age with fragility fracture.

Characteristics	Fragility fracture (n=102)	Non-fracture and or non-fragility fracture (n=66)	*p*-value*
	n	n	
Body Mass Index			
Underweight	12	3	0.015*
Normal	44	21	
Overweight	15	15	
Obese I	23	16	
Obese II	8	11	
Gender			
Men	20	9	0.487*
Women	82	57	
Age (years)			
<50	4	4	0.480*
50–74	83	54	
≥75	15	8	

*Spearman'rho correlation test

Table 3. Distribution of age and body mass index with gender.

Characteristics	Women (n=139)		Men (n=29)		*p*-value*
	n	%	n	%	
Age					
<50	7	87.5	1	12.5	0.238
50–74	115	83.9	22	16.1	
≥75	17	73.9	6	26.1	
Body Mass Index					
Underweight	11	73.33	4	26.67	0.007
Normal	50	76.9	15	23.1	
Overweight	23	76.67	7	23.33	
Obese I	37	94.8	2	5.2	
Obese II	18	94.7	1	5.3	

*Spearman'rho correlation test

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accounting for 78 patients (46.4%) compared to only 10 (5.9%) men. The statistical analysis revealed a significant correlation between BMI and gender, with a p-value of 0.007 (<0.05).

Table 4 illustrates the distribution of patients by age, gender, and BMI category in relation to the diagnosis of osteoporosis. A total of 151 patients (89.8% of 168 patients) were diagnosed with osteoporosis and severe osteoporosis. Of these, 127 were women and 24 were men. The highest proportion of patients diagnosed with severe osteoporosis was observed in the 50-74 year age category, comprising 83 (49.4%) patients. However, the correlation analysis using Spearman's rho test showed a p-value of 0.588 (p > 0.05), indicating that there was no statistically significant correlation between age and the diagnosis of severe osteoporosis.

Examining the distribution of osteoporosis severity among men and women across all categories, women accounted for the majority of patients diagnosed with severe osteoporosis (82 patients/ 48.8%), followed by women with osteoporosis (45 patients/ 26.78%). Among men, severe osteoporosis was the most prevalent category, with 20 (11.9%) patients. Regarding the relationship between body mass index and the severity of osteoporosis, Spearman's rho correlation analysis revealed a significant correlation with a p-value of 0.01. This implies that there is a correlation between higher BMI and greater severity of osteoporosis.

In Table 5, the FRAX scores for both MOF and hip fracture predominantly fell within the low-risk category for both men and women. Among men, 26 patients were classified as low-risk for MOF, while

Table 4. Distribution of age, gender, and body mass index with osteoporosis diagnosis.

	Normal (n=1)	Osteopenia (n=16)	Osteoporosis (n=49)	Severe Osteoporosis (n=102)	*p*-value*
	n	n	n	n	
Age					
<50	0	1	3	4	0.588
50 - 74	1	12	41	83	
≥75	0	3	5	15	
Gender					
Men	0	5	4	20	0.579
Women	1	11	45	82	
Body Mass Index					
Underweight	0	0	3	12	0.01
Normal	0	5	16	44	
Overweight	1	4	10	15	
Obese I	0	3	13	23	
Obese II	0	4	7	8	

*Spearman'rho correlation test

Table 5. FRAX score with gender.

FRAX Score	Men (n=29)	Women (n=139)	*p*-value*
	n	n	
MOF			
Low Risk (<10%)	26	120	0.732
Moderate Risk (10 – 20%)	1	19	
High Risk (>20%)	2	0	
Hip Fracture			
Low Risk (<3%)	20	82	0.320
High Risk (≥3%)	9	57	

*Spearman'rho correlation test

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Table 6. FRAX score with age.

FRAX Score	<50 years old (n=8)	50 – 74 years old (n=137)	≥75 years old (n=23)	*p*-value*
	n	n	n	
MOF				
Low Risk (<10%)	5	121	20	0.290
Moderate Risk (10 – 20%)	2	15	3	
High Risk (>20%)	1	1	0	
Hip Fracture				
Low Risk (<3%)	5	84	13	0.675
High Risk (≥3%)	3	53	10	

*Spearman'rho correlation test

only 2 patients were categorized as high-risk. Conversely, among women, 120 patients were classified as low-risk for MOF, with none falling into the high-risk category. Similarly, in terms of FRAX scores for hip fracture, the low-risk category was more dominant for both men and women. Among women, 82 patients were categorized as low-risk, while 57 patients fell into the high-risk category, with a difference of 25 patients. Although the p-value indicated no statistical correlation ($p > 0.05$), it is important to note and address these findings.

In Table 6, the low-risk category for both FRAX scores of MOF and hip fracture was predominantly represented by the age group of 50-74 years old, with 121 and 84 patients, respectively. However, within this age group, despite half of the patients having FRAX scores indicating low risk for hip fracture, a significant number of patients (53 patients/31.5%) were still categorized as high risk. While this correlation was not statistically significant, it warrants further attention and investigation.

DISCUSSION

The study findings revealed substantial demographic information about these patients, including their gender, age, and BMI, as well as the diagnostic profile of osteoporosis based on BMD T-scores, the frequency of fragility fractures, the areas that warrant BMD examination, and the FRAX score for ten-year probability of fracture.

A total of 49 patients (29.2%) were diagnosed with osteoporosis, while 102 patients (60.7%) were diagnosed with severe osteoporosis. Women accounted for a larger number than men, with 139 (82.7%) and 29 (17.3%) patients, respectively. Among women, the majority (115, 83.9%) of those who underwent BMD examination were in the age range of 50 to 74 years, compared to only 22 (16.1%) men.

BMD is the gold standard for diagnosing osteoporosis.[2] Globally, women over 50 years old are three times more likely to be affected than men.[5] Another comprehensive systematic review by Salari, et al.[9] reported a prevalence of 18.3% for osteoporosis among a sample size of 103,334,579 people aged 15 to 105 years. In that study, women were also more commonly affected than men, with a prevalence of 23.1% and 11.7%, respectively. Consequently, women are more commonly referred to BMD examination than men.

Obesity and overweight, characterized by a disproportionate amount of fat, pose a threat to health.[10] According to the World Health Organization's classification for adult Asians, individuals with a BMI ≥23 kg/m^2 are considered overweight, while those with a BMI ≥25 kg/m^2 are classified as obese.[6] It is well known that overweight and obesity have a protective effect on bone health for two main reasons. First, the higher mechanical loading because of the higher body loading mechanism and strain due to the higher body fat mass. This effect results in a lower turnover rate of the bone, meaning that bone resorption happens less than in those with a lean body

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weight. Second, the more adipose tissue available, the more estrogen is produced. This hormone, assembled with the help of adipose tissue, not only functions as a gender hormone but also benefits the bone by its capability to reduce bone resorption and increase bone formation.[10] This theory is supported by a systematic review done by Turcotte, et al., who stated that a reduction of hip fracture risk rises to 41% for men with obesity compared to without it.[11]

However, this study's results showed an opposite trend to the previously described theory. Among the patients, 127 women (75.6%) were diagnosed with osteoporosis (45 patients) and severe osteoporosis (82 patients). In contrast, only 4 men were diagnosed with osteoporosis, and 20 men were diagnosed with severe osteoporosis. Out of all patients diagnosed with osteoporosis and severe osteoporosis, 76 had a BMI classified as overweight or obese, while only 15 patients had a lower BMI. These findings indicate a positive correlation between higher BMI and greater severity of osteoporosis ($p = 0.01$). This phenomenon could be explained by the influence of a high-fat diet (HFD) leading to obesity, which increases bone resorption and reduces trabecular bone density.[10]

The study identified 102 patients with fragility fractures, with women aged 50 to 74 years being the most affected group (83 patients), followed by age range ≥75 and <50 years old, with 15 and 4 patients, respectively. Out of all the women in this study, four out of five women in this study had a history of fragility fracture (82 patients). While women were more commonly affected, the difference was not statistically correlated ($p > 0.05$). Compared to a study by Baccaro, et al.[12] that showed women aged ≥50 years old with a history of fragility fracture accounted for only 65 patients (10.8%) out of 622 women. The spine/vertebrae was the most commonly affected site of fragility fractures, accounting for 90 out of the 102 patients. In osteoporosis, the osteoclast activity is more active than the osteoblast activity. Therefore, it causes destruction of the microstructure, especially the cancellous bone, because bone resorption (osteoclast activity) acts more rapidly on cancellous bone than on cortical bone. Consequently, bones with a composition rich in cancellous bone, such as the spine, are seen to be affected first, followed by the hip and other bones with less cancellous bone than the spine.[2,4,13] A retrospective study by Li, et al.[14,] evaluated chest radiographs to evaluate the spine from T4 – L1. They found 295 patients with vertebrae fractures. The prevalence of vertebrae fractures in the age range 50 – 59 years old was 2.4% and remarkably increased up to >20% for patients age range ≥70 years old. The most common form of vertebrae fracture associated with osteoporosis is vertebrae compression fracture (VCF), which accounts for 1–1.5 million per year. Anatomically, these fractures occur in the anterior half of the vertebrae body and disrupt the anterior longitudinal ligament (ALL) due to axial loading and the damaged cancellous bone caused by the osteoporosis condition.[15]

This study found that out of 168 patients, those with BMI classified as overweight (BMI ≥ 23 kg/m^2) for 30 patients and obese (BMI ≥ 25 kg/m^2) for 58 patients, 46 of them had a history of fragility fractures, while only 12 patients were underweight (BMI < 18.5 kg/m^2) and 65 patients were normal weight (BMI 18.5–22.9 kg/m^2). There was a statistically significant positive correlation between BMI and fragility fractures ($p < 0.05$). A high body mass index with an increase in fat mass results in an osteoprotective effect on the bone by maintaining the bone density through the mechanical loading effect on the skeletal and a low body mass index with less fat mass increases the risk of fracture due to the declining bone density. This theory applies only if the muscle mass is preserved. Muscle and bone have a complex working relationship, such as the low muscle mass in patients with sarcopenia having a detrimental effect on bone, including increasing the risk of developing osteoporosis up to 1.66 times in women with sarcopenia.[16–18] A cross-sectional study by Kim, et al.[19] stated that fat mass had an inverse relationship with BMD. Another study by Kim, J. et al.[18] conducted a study on Korean postmenopausal women and found that both the obese and underweight groups had a significantly higher

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number of patients who suffered fragility fractures up to 3.33 and 5.48 times higher, respectively, than the normal weight group. It also showed a higher risk of developing vertebrae fractures up to 5.49 times for the underweight group.

All 168 patients included in this study had FRAX scores for MOF and hip fracture. The youngest and the oldest were 42 and 87 years old, respectively, therefore valid for being input into the FRAX score calculator. The majority of both MOF and hip fracture scores fell into the low-risk category, with the age group of 50 to 74 years being the most prevalent, constitute for 121 (72%) and 84 (50%) patients, respectively ($p>0.05$). Comparing these findings to Mustamsir, et al.'s study,[20] which had an epidemiological cross-sectional study of risk fracture in the elderly based in Malang, East Java Province, Indonesia, their risk category of low-risk for FRAX score MOF was <20%. Whereas in our study, the MOF FRAX score was divided into low, moderate, and high. Therefore, in order to compare, the total of the low and moderate risk categories of the same age group of FRAX score MOF in our study was summed for 136 (80.9%) patients. In their study, the number of low-risk categories both FRAX score of MOF and hip fracture within the same age group of 50 – 74 years old were 116 (87.8% of 132) and 112 (84.8% of 132) participants, respectively. Our study had a lower percentage of the same category of FRAX score, both MOF and hip fracture, compared to Mustamsir et al.'s study.

Despite the valuable insights gained from this study, it is important to acknowledge its limitations. Firstly, even though the study was conducted in the national top referral for orthopaedic service in Indonesia, it was limited to a single hospital. This may limit the generalizability of the findings to other populations and healthcare settings. Additionally, the sample size of 168 patients could be considered relatively small. This could impact the statistical power and precision of the results. Moreover, the study's cross-sectional design does not allow for causal inferences. It also relied on retrospective data collection, which is subject to inherent limitations such as potential missing or incomplete information. Furthermore, the study focused on clinical characteristics and diagnostic profiles. It did not explore other potential factors that could influence the development and severity of osteoporosis, such as lifestyle factors, genetic predisposition, or medication use. Therefore, caution should be exercised when interpreting and applying the findings of this study. Further research incorporating a larger and more diverse population, a prospective study design, and a comprehensive assessment of potential influencing factors is warranted to provide a more comprehensive understanding of the clinical characteristics of patients with osteoporosis.

CONCLUSION

The findings provided valuable insights into the demographic profile of the patients who underwent BMD examination at Prof. Dr. R. Soeharso Orthopaedic Hospital, Indonesia. The study revealed a high prevalence of osteoporosis and severe osteoporosis among women aged 50-74. Contrary to common belief, higher BMI was associated with more severe osteoporosis. Women experienced more fragility fractures, primarily in the spine. These findings contribute to our understanding of osteoporosis and its clinical characteristics in this specific hospital setting. Further research with larger, diverse populations and comprehensive assessments is crucial to provide a more robust understanding of the clinical characteristics of patients with osteoporosis and develop more tailored preventive measures and interventions to address the complexities of osteoporosis and fragility fractures effectively.

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