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Original Article / Özgün Araştırma

Evaluation of postmenopausal osteoporosis according to age groups and body mass index categories

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Abstract

Objective: In clinical practice, it is recommended to create different groups when assessing the elderly population (≥65 years). However, differences in groups have not been sufficiently investigated in terms of osteoporosis. We aimed to evaluate age and BMI (kg/m2) groups in postmenopausal women for osteoporosis.

Methods: Postmenopausal women were classified into pre-elderly (50-65 years) and elderly groups: young old and middle old. Additionally, they were categorized as normal weight, overweight, and obesity. These age groups and BMI categories were evaluated in terms of osteoporosis.

Results: Pre-elderly group had significantly lower spine osteoporosis rates than young old and middle old groups ($p<0.05$). However, the two elderly groups exhibited similar spine osteoporosis rates ($p>0.05$). Pre-elderly group had significantly lower hip osteoporosis rates than elderly groups ($p=0.001$), and the young old group had lower hip osteoporosis rates than middle old group ($p=0.001$). Normal weight group had higher spine osteoporosis rates than overweight group ($p=0.005$) and obesity group ($p=0.001$). Also, overweight group had significantly higher spine osteoporosis rates than obesity group ($p=0.001$). Normal weight group had higher hip osteoporosis rates than overweight group and obesity group ($p=0.001$). Also, overweight group had higher hip osteoporosis rates than obesity group ($p=0.001$). Age scores were correlated inversely with T-scores in the spine and hip ($p=0.001$). There were significant positive correlations between BMI and T-scores in the spine and hip ($p=0.001$).

Conclusion: Elderly and thin women are more associated with osteoporosis than pre-elderly and obese women. As age increases and BMI decreases, osteoporosis rates increase.

Keywords: Postmenopausal osteoporosis, aging, body mass index, densitometry

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Yaş gruplarına ve vücut kitle indeksi kategorilerine göre postmenopozal osteoporozun değerlendirilmesi

Öz

Amaç: Klinik uygulamada, yaşlı popülasyonu (≥65 yaş) değerlendirirken farklı gruplar oluşturulması önerilmektedir. Ancak, gruplar arasındaki farklılıklar osteoporoz açısından yeterince araştırılmamıştır. Burada, menopoz sonrası kadınlarda yaş ve BMI (kg/m2) gruplarını osteoporoz açısından değerlendirmeyi amaçladık.

Yöntemler: Menopoz sonrası kadınlar yaşlılık öncesi (50-65 yaş) ve yaşlı gruplara ayrılmıştır: genç yaşlı ve orta yaşlı. Ek olarak, normal kilo, fazla kilo ve obez olarak sınıflandırıldı. Bu yaş grupları ve VKİ kategorileri osteoporoz açısından değerlendirildi.

Bulgular: Yaşlılık öncesi grup, genç yaşlı ve orta yaşlı gruplara göre omurga osteoporozu oranları açısından anlamlı derecede daha düşük oranlara sahipti ($p<0.05$). Ancak, iki yaşlı grup benzer omurga osteoporozu oranları sergiledi ($p>0.05$). Yaşlılık öncesi grup, yaşlı gruplara göre anlamlı derecede daha düşük kalça osteoporoz oranlarına sahipti ($p<0.001$) ve genç yaşlı grup, orta yaşlı gruba göre daha düşük kalça osteoporoz oranlarına sahipti ($p<0.001$). Normal kilolu grup, fazla kilolu gruba ($p=0.005$) ve obez gruba ($p<0.001$) göre daha yüksek omurga osteoporoz oranlarına sahipti. Ayrıca, fazla kilolu grup, obez gruba göre omurgada önemli ölçüde daha yüksek osteoporoz oranlarına sahipti ($p<0.001$). Normal kilolu grup, fazla kilolu gruba ve obez gruba göre daha yüksek kalça osteoporozu oranlarına sahipti ($p<0.001$). Ayrıca, fazla kilolu grup, obez gruba göre daha yüksek kalça osteoporozu oranlarına sahipti ($p<0.001$). Yaş skorları, omurga ve kalçadaki T-skorları ile ters orantılıydı ($p<0.001$). VKİ ile omurga ve kalçadaki T-skorları arasında anlamlı pozitif korelasyon bulundu ($p<0.001$).

Sonuç: Yaşlı ve zayıf kadınlar, yaşlılık öncesi ve obez kadınlara göre osteoporozla daha fazla ilişkilidir. Yaş arttıkça ve BMI düştükçe osteoporoz oranlarının artmaktadır.

Anahtar kelimeler: Postmenopozal osteoporoz, yaşlanma, vücut kitle indeksi, dansitometri.

INTRODUCTION

Osteoporosis is a chronic disease of the skeletal system and metabolism. It is common in postmenopausal women and is a growing global health problem and burden[1]. This disorder is associated with low bone density causing increased bone fragility[1,2]. Although it is known that the risk and burden scores of osteoporosis are highest in postmenopausal women and increase with age[1,2], difficulties are encountered in treating this disorder in older individuals[2]. In addition, age-specific management is still needed to improve bone health in older women[1]. The diagnosis of postmenopausal osteoporosis is typically relied on bone density measurement, and a T score ≤-2.5 is considered as osteoporosis; -1 to -2.5 is osteopenia, and +1 to -1 is normal density, according to WHO criteria[3,4]. Management of osteoporosis typically involves vitamin/mineral supplements, exercise, and bisphosphonates, but there is interest in novel medication-free bone regenerative methods[4].

In clinical practice, when evaluating and comparing elderly population (≥65 years), it has been suggested that various groups should be established. For example, the European Medicines Agency has divided individuals aged 65-74 into "young old", the 75-84 age range into "middle old", and those aged 85 and above into "oldest old"[5,6]. In addition, the WHO has established body mass index (BMI) categories: underweight (BMI is <18.5), normal weight (BMI is ≥18.5 and <25.0), overweight (BMI is ≥25.0 and <30.0), and obesity (BMI is ≥30.0)[7]. It has been determined that the frequency of osteoporosis, the rates of morbidity and mortality, and hospital stays increase with age and low BMI levels are mostly associated with osteoporosis in postmenopausal and older women[1,8,9]. However, differences in the age

groups and BMI categories have not been sufficiently established in terms of osteoporosis.

This study aimed to evaluate and compare bone mineral density scores in postmenopausal women, to determine the characteristics of age groups and BMI categories in terms of densitometry results, and to clarify differences in these aspects. Given the need for specific approaches in the management of osteoporosis in elderly women[1], the findings of this study may contribute to this effort.

METHODS

After obtaining ethical approval (decision number: 685; date: November 07, 2025), data of postmenopausal women who underwent bone densitometry between November 2024 and November 2025 were recorded. Since the study design was retrospective, voluntary participation or written consent from patients was not possible.

The following conditions were accepted as exclusion criteria for the study: age <50 years, pre-menopausal women, male gender, and missing assessment parameters. Bone density was measured using an X-ray bone densitometer machine (Model: Primus, OsteoSys Co., Ltd, Korea) yielding T-scores of the spine (L1-L4) and hip (femur neck) regions.

In this study, according to the common definition, patients between the ages of 50-64 were considered as pre-elderly group, and those over age of 64 were classified in the elderly groups[10]. According to the European Medicines Agency's classification, elderly individuals (≥65 years) were grouped into the 65-74 age range (young old), the 75-84 age range (middle old), and those aged 85 and over (oldest old)[5,6]. In addition, based on the WHO's BMI classification, the patients were categorized as underweight, normal weight, overweight, and obesity[7].

To examine and clarify differences in the aforementioned age groups and BMI categories in terms of bone mineral density, statistical comparisons were performed. This approach can allow for a better understanding of differences among specific age groups and may help determine which age group and BMI category is at higher risk for osteoporosis and bone fractures.

Statistical analysis

Statistical analysis was performed by using IBM SPSS Statistics (V27), and outcomes were presented in accordance with recommendations in medical literature[11]. The Kolmogorov-Smirnov test was applied to assess the normality status of continuous variables. The Independent Samples Kruskal-Wallis test was used to compare the groups. Then, significance levels were adjusted by the Bonferroni correction for multiple tests. The Spearman test was used to assess the significance of correlations between continuous data. Chi-square test was used to determine the significance of the relationship between categorical variables. Comparative data were presented as median (IQR) mean ± SD or n (%). Correlational data were presented as r and p values. A $p<0.05$ level was considered statistically significant.

RESULTS

Table I presents the characteristics of patients (n=1308). The mean age was 64.06±9.01 years (range 50-99) and the mean BMI was 32.05±5.80 kg/m^2 (range 15.6-49.5). According to bone density measurements, the mean T-scores in the lumbar spine and hip were -1.80±1.5 and -0.66±1.2, respectively. The osteoporosis rates in the spine and hip were 35.17 and 6.50, respectively (Table I).

Table I: The characteristics of patients (n=1308)

Age, years	64.06±9.01 (50-99)
Weight, kg	77.53±14.17 (36-155)
Height, m	1.56±0.07 (1.37-1.86)
Body mass index, kg/m^2	32.05±5.80 (15.58-49.49)
Lumbar spine T-score	-1.80±1.51 (-6.10-8.30)
Femur neck T-score	-0.66±1.21 (-7.10-3.00)
Lumbar spine	
Normal	327 (25.0)
Osteopenia	521 (39.83)
Osteoporosis	460 (35.17)
Femur neck	
Normal	844 (64.53)
Osteopenia	379 (28.98)
Osteoporosis	85 (6.50)

Data are presented as mean±SD (min-max) or n (%).

Table II shows comparisons of age groups for BMI, T-scores, and osteoporosis rates. The oldest group (n=29) was excluded from Table II due to concerns that the relatively low number of cases could reduce the power and reliability of the statistical comparisons. Since the Independent Samples Kruskal-Wallis test exhibited significant differences across samples (p=0.001), significance values were adjusted by the Bonferroni correction for multiple tests.

When considering BMI scores in the Table II, pre-elderly group was similar to young old group, but these two groups were statistically more obese than the middle old group ($p<0.05$). When considering spine T-scores, pre-elderly group had significantly higher spine T-scores and lower osteoporosis rates than elderly groups (young old and middle old) ($p<0.05$). However, these two elderly groups were similar in terms of spine T-scores and osteoporosis rates ($p>0.05$). When considering hip T-scores, pre-elderly group had significantly higher hip T-scores and lower osteoporosis rates than elderly groups (p=0.001), and young old group had significantly higher T-scores and lower osteoporosis rates than middle old group (p=0.001) (Table II).

Table II: Comparison of age groups for age, BMI, and T-scores

	Pre-elderly (n=743)^A	**Young old (n=390)^B**	**Middle old (n=146)^C**	**p**
Age, years	58.0 (7.0) 57.57±4.16 (50-64)	69.0 (5.0) 69.4±2.9 (65-74)	78.0 (5.0) 77.9±2.5 (75-84)	0.001^{AvsB} 0.001^{AvsC} 0.001^{BvsC}
BMI, kg/m^2	(7.6) 32.4±5.7 (18.3-49.3)	32.03 (7.8) 32.2±5.8 (15.6-48.04)	28.99 (8.2) 30.7±6.6 (17.3-49.5)	0.900^{AvsB} 0.001^{AvsC} 0.001^{BvsC}
Spine T-score	-1.80 (1.8) -1.66±1.47 (-6.1-8.3)	-2.20 (1.9) -1.93±1.53 (-6.0-5.1)	-2.20 (1.9) -2.03±1.60 (-6.1-4.5)	0.001^{AvsB} 0.001^{AvsC} 0.438^{BvsC}
Spine				
Normal	202 (27.2)	92 (23.6)	30 (20.6)	0.002^{AvsB}
Osteopenia	318 (42.8)	140 (35.9)	51 (34.9)	0.003^{AvsC}
Osteoporosis	223 (30.1)	158 (40.5)	65 (44.5)	0.647^{BvsC}
Femur neck T-score	-0.40 (1.40) -0.37±1.15 (-7.1-2.8)	-0.90 (1.40) -0.87±1.11 (-5.9-3.0)	-1.30 (1.35) -1.39±1.21 (-5.0-2.0)	0.001^{AvsB} 0.001^{AvsC} 0.001^{BvsC}
Femur neck				
Normal	554 (74.6)	226 (57.9)	56 (38.4)	0.001^{AvsB}
Osteopenia	168 (22.6)	137 (35.1)	60 (41.1)	0.001^{AvsC}
Osteoporosis	21 (2.8)	27 (6.9)	30 (20.5)	0.001^{BvsC}

Data are presented as median (IQR) mean±SD (min-max) or n (%).

Pre-elderly: 50-64 years; young old: 65-74 years; middle old: 75-84 years.

Table III shows comparison of BMI categories for age, T-scores, and osteoporosis rates. The underweight (BMI <18.5) group (n=5) was excluded from Table III due to concerns that the relatively low number of cases could reduce the power and reliability of the statistical comparisons. Since the Independent Samples Kruskal-Wallis test exhibited significant differences across samples (p=0.001), significance values were adjusted by the Bonferroni correction for multiple tests.

When considering age scores in the Table III, normal weight group was similar to overweight group (p=0.944), and overweight group was similar to obesity group (p=0.106). However, normal weight group exhibited significantly higher scores than obesity group for age (p=0.026). When considering spine T-scores, normal weight group had significantly lower spine T-scores and higher osteoporosis rates than overweight group (p=0.005) and obesity group (p=0.001). Also, overweight group had significantly lower spine T-scores and higher osteoporosis rates than obesity group (p=0.001). When considering hip T-scores, normal weight group had significantly lower hip T-scores and higher osteoporosis rates than overweight group (p=0.001) and obesity group (p=0.001). Also, overweight group had significantly lower hip T-scores and higher osteoporosis rates than obesity group (p=0.001) (Table III).

Table III: Comparison of BMI categories for age, T-scores, and osteoporosis rates

	Normal weight (n=139)^{A}	**Overweight (n=354)^{B}**	**Obesity (n=810)^{C}**	**p**
Age, years	64.0 (16.0) 65.06±9.98 (50-93)	64.0 (15.25) 65.08±10.06 (50-99)	63.0 (12.0) 63.39±8.25 (50-95)	0.944^{AvsB} 0.026^{AvsC} 0.106^{BvsC}
Spine T-score	-2.8 (2.1) -2.42±1.66 (-6.1-4.5)	-2.2 (1.7) -2.04±1.39 (-4.6-3.7)	-1.7 (1.8) -1.58±1.48 (-6.1-8.3)	0.005^{AvsB} 0.001^{AvsC} 0.001^{BvsC}
Spine Normal Osteopenia Osteoporosis	 27 (19.4) 33 (23.7) 79 (56.8)	 62 (17.5) 142 (40.1) 150 (42.4)	 237 (29.3) 346 (42.7) 227 (28.0)	 0.002^{AvsB} 0.001^{AvsC} 0.001^{BvsC}
Femur neck T-score	-1.5 (1.6) -1.45±1.21 (-4.4-1.9)	-1.0 (1.4) -0.98±1.1 (-5.0-2.0)	-0.4 (1.4) -0.38±1.16 (-7.1-1.4)	0.001^{AvsB} 0.001^{AvsC} 0.001^{BvsC}
Femur neck Normal Osteopenia Osteoporosis	 54 (38.8) 57 (41.0) 28 (20.1)	 184 (52.0) 141 (39.8) 29 (8.2)	 605 (74.7) 178 (22.0) 27 (3.3)	 0.001^{AvsB} 0.001^{AvsC} 0.001^{BvsC}

Data are presented as median (IQR) mean±SD (min-max) or n (%).

Normal weight: BMI ≥18.5 and <25.0; Overweight: BMI ≥25.0 and <30.0; Obesity: BMI ≥30.0.

In addition, correlation analyses were performed to investigate the relationship of T-scores with age and BMI scores in patients (n=1308). Age scores were found to be inversely correlated with spine (r: -0.159, p=0.001) and hip (r: -0.343, p=0.001) T-scores. In addition, there were significant positive correlations between BMI and T-scores in the spine (r: 0.244, p=0.001) and hip (r: 0.348, p=0.001).

DISCUSSION

This comparative and correlational study was conducted to evaluate and compare age groups and BMI categories in postmenopausal women in terms of osteoporosis. For this purpose, postmenopausal women were classified into age groups and BMI categories according to previously established classifications[6,7]. Then, comparisons were performed in terms of densitometry results considering these these

age groups and BMI categories. Additionally, the elderly groups were compared with a pre-elderly group, and correlation analyses were performed to determine the relationship of of T-scores with age and BMI scores in patients. The comparative results showed that pre-elderly group had significantly higher T-scores and lower osteoporosis rates than young old and middle old groups. Similarly, normal weight group had significantly higher T-scores and lower osteoporosis rates than overweight and obesity groups. Additionally, the correlational results demonstrated that T-scores were associated with age and BMI scores. All these findings highlight the relationship between aging, BMI, and osteoporosis, and indicate that younger and more obese postmenopausal women are less affected by osteoporosis. It is important to assess whether these findings are consistent with data reported in different societies.

In line with the findings of the current study, previous reports have demonstrated that older age[12], female gender[13], and underweight[14] are associated with osteoporosis development. Additionally, the burden of osteoporosis has been found to be highest in postmenopausal women aged 80 and older[1]. In fact, the mechanisms underlying the relationship between aging and osteoporosis are multifaceted in nature[12]. Therefore, the current findings should be considered from this perspective. In this context, it can be said that the findings indicating lower bone mineral density in older women observed in this study interact with weight status, as older groups exhibited lower BMI values. Similarly, lower weight and BMI values have been reported in the Russian population with osteoporosis[15]. Additionally, Hariri et al.16 have reported significant positive associations between BMI values and T-scores in elderly (age 50-90 years) diabetic patients from Saudi Arabia. Similarly, in Chinese society, low BMI has been reported as an independent risk factor for osteoporosis in elderly women[9].

Insufficient mechanical loading, malnutrition, hormonal imbalance, metabolic disturbance, cognitive diminish, inflammatory conditions, and circadian dysrhythmia have been suggested as responsible factors for the development of osteoporosis in the elderly groups[12]. The mechanisms underlying the interactions between obesity and osteoporosis and bone metabolism are complex and remain a subject of debate[17]. The positive effect of obesity on osteoporosis may be due to the constructive effects of high mechanical loading, various hormones and biochemical factors on bone metabolism[17,18]. On the other hand, obesity-related factors such as type 2 diabetes and central fatty deposition may be associated with osteoporosis, due to the disruption of bone microarchitecture[19].

Although previous studies have found increased osteoporosis in elderly women[1], the literature addressing and comparing elderly groups in terms of bone density is limited. Dudinskaya et al.[15] compared elderly groups in terms of bone density and found that the prevalence of osteoporosis was significantly different in the young old and middle old groups, at 22.9% and 26.2%, respectively. These rates are similar to the findings of the current study in older age groups, indicating that osteoporosis rates increase with age.

Bone fractures due to postmenopausal osteoporosis are increasing public health problems with an expected 50% increase by 2030[20]. However, there is still a need for more information about differences in elderly groups. Cao et al.[21] have compared clinical features and findings between elderly groups who underwent hip fracture surgery and found that the majority of these groups were female. Therefore, it is important to investigate elderly groups and postmenopausal women in terms of bone mineral density and osteoporosis. From

this perspective, our study is a valuable contribution to the literature. On the other hand, potential limitations of this study should be taken into consideration. First of all, it should be noted that this is a retrospective study and this design may limit the ability to obtain more detailed data. Additionally, this study contains data obtained from a single hospital and may reflect the characteristics of a limited population. Finally, there are limited studies in the literature comparing elderly groups in terms of bone density, and this may create inadequate in-depth discussion and presentation of comparative results.

In conclusion, there is limited literature on the differences in elderly groups and BMI categories in terms of osteoporosis. Elderly and thin women are more prone to osteoporosis than pre-elderly and obese women. The findings of the current study and the relevant literature in different societies indicate that as age increases and BMI decreases, osteoporosis rates increase.

Ethics Committee Approval: This study was approved by Gazi Yaşargil Hospital Clinical Researches Ethics Committee (decision number: 685; date: November 07, 2025).

Conflict of Interest: The author(s) declare that there is no financial conflict of interest related to this article.

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