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Evaluation of the Relationships Between Bone Mineral Density and Anthropometric Measurements in Women with Postmenopausal Osteoporosis

Postmenopozal Osteoporozu Olan Kadınlarda Kemik Mineral Yoğunluğu ile Antropometrik Ölçümler Arasındaki İlişkilerin Değerlendirilmesi

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Abstract

Objective: There are various factors that affect bone mineral density (BMD) in postmenopausal women. The aim of this study was to evaluate the relationships between anthropometric characteristics and BMD in women with postmenopausal osteoporosis (PMO).

Materials and Methods: Demographic features of the participants including age, menopause age, smoking habits, comorbidities, educational and marital status were recorded. Anthropometric characteristics such as height, weight, body mass index (BMI), waist-to-hip ratio (WHR), digit ratio of dominant hand (2D:4D), skeletal muscle mass index (SMI), hand and thigh circumferences were measured. In addition to L1-L4, femur neck (FN), femur total (FT) T-scores, serum calcium and 25(OH) vitamin D levels were noted.

Results: This study included a total of 181 women with PMO (mean age 62.78±7.81 years, menopause age 45.69±5.58 years and BMI 27.24±4.87 kg/m²). 64.6% of the participants had at least one systemic disease and 71.8% were non-smokers. The mean values of serum calcium and 25(OH) vitamin D were 9.71±0.73 mg/dL and 26.22±15.34 ng/mL, respectively. Weight and BMI showed significant positive correlations with T-scores at L1-L4 total, FN and FT. While thigh circumference and SMI significantly correlated with T-scores at FN and FT, hand circumference only correlated with T-score at FN. On the other hand, no correlations were found between T-scores and other anthropometric measurements (height, WHR, 2D:4D).

Conclusion: These findings have shown that the patients with lower weight and BMI have lower T-scores at lumbar spine and femur. Additionally, thigh circumference and SMI correlated positively with femur T-scores. Further studies are warranted to reveal the role of these anthropometric measurements in determining the risk of osteoporosis in postmenopausal women.

Keywords: Anthropometric measurements, bone mineral density, postmenopausal osteoporosis

Öz

Amaç: Postmenopozal kadınlarda kemik mineral yoğunluğunu (KMY) etkileyen çeşitli faktörler vardır. Bu çalışmanın amacı, postmenopozal osteoporozu (PMO) olan kadınlarda antropometrik özellikler ile KMY arasındaki ilişkileri değerlendirmektir.

Gereç ve Yöntem: Katılımcıların yaş, menopoz yaşı, sigara içme alışkanlığı, ek hastalıkları, eğitim durumu ve medeni durumu gibi demografik özellikleri kaydedildi. Boy, kilo, vücut kitle indeksi (VKİ), bel kalça oranı (BKO), dominant elin parmak oranı (2P:4P), iskelet kası kütle indeksi (İKKİ), el ve uyluk çevreleri gibi antropometrik özellikler ölçüldü. L1-L4'e ek olarak femur boyun (FB), femur total (FT) T-skorları, serum kalsiyum ve 25(OH) D vitamini seviyeleri not edildi.

Bulgular: Bu çalışmaya PMO'lu toplam 181 kadın dahil edildi (ortalama yaş 62,78±7,81 yıl, menopoz yaşı 45,69±5,58 yıl ve VKİ 27,24±4,87 kg/m²). Katılımcıların %64,6'sının en az bir sistemik hastalığı vardı ve %71,8'i sigara kullanmıyordu. Serum kalsiyum ve 25(OH) D vitamini ortalama değerleri sırasıyla 9,71±0,73 mg/dL ve 26,22±15,34 ng/mL idi. Ağırlık ve VKİ, L1-L4 total, FB ve FT'deki T-skorları ile anlamlı pozitif korelasyon gösterdi. Uyluk çevresi ve İKKİ, FB ve FT'de T-skorları ile anlamlı korelasyon gösterirken, el çevresi sadece FB'de T-skoru ile koreleydi. Öte yandan, T-skorları ile diğer antropometrik ölçümler (boy, BKO, 2P:4P) arasında bir korelasyon bulunmadı.

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Öz

Sonuç: Bu bulgular, kilosu ve VKİ'si düşük olan hastaların lomber omurga ve femurda daha düşük T-skorlarına sahip olduğunu göstermiştir. Ek olarak, uyluk çevresi ve İKKİ, femur T-skorları ile pozitif korelasyon gösterdi. Postmenopozal kadınlarda osteoporoz riskini belirlemede bu antropometrik ölçümlerin rolünü ortaya çıkarmak için daha ileri araştırmalar gereklidir.
Anahtar kelimeler: Antropometrik ölçümler, kemik mineral yoğunluğu, postmenopozal osteoporoz

Introduction

The hallmarks of osteoporosis (OP), a systemic disease, are low bone mass and deterioration in the microarchitecture of bone tissue in addition, these result in bone fragility and an increase in the risk of fracture (1-5). It is a preventable, underdiagnosed, under-treated, and silent disease until complicated by fractures (2,5-10). As a public health issue, osteoporotic fractures may have fatal or severe disabling effects (1,5-7). All risk factors for OP and fractures with an impact on quality of life that crosses medical, social, and economic lines, should be considered and addressed thoroughly when managing a patient with suspected or diagnosed bone loss (1,5).

The factors affecting bone mineral density (BMD) vary widely in postmenopausal osteoporosis (PMO). Body composition, weight, alcohol consumption, smoking, exposure to sunlight, nutritional status, eating habits and physical activities are known to have a significant impact on BMD (11-13). Tools for population screening and early illness identification, the anthropometric measurements are straightforward, non-invasive, affordable, and useful (14,15). Some studies have been carried out to assess the relationships between anthropometric traits and BMD in PMO (10,13,16-22). It has been reported that weight, height and body mass index (BMI) were found to be positively associated with BMD parameters (16-22). On the other hand, there are conflicting results regarding the relationships between waist circumference (WC) and BMD as well as waist-to-hip (WHR) and BMD in PMO (10,13,16-19). There are very few studies evaluating the relationships between BMD and other anthropometric measurements including skeletal-muscle-mass-index (SMI), digit ratio of dominant hand (2D:4D), and hand circumference (10,18). This study sought to assess the associations between anthropometric parameters and BMD in PMO.

Materials and Methods

This cross-sectional research was conducted with 181 consecutive patients. Inclusion criteria were as follows: Aged over 50 years, being postmenopausal and having OP in accordance with World Health Organization (WHO) recommendations. The following were the exclusion criteria: The presence of conditions and/or drug usage that could lead to secondary OP, neurological disorders, vestibular diseases, malignancy, cardiac disorder, instrumentation in the spine and/or joints in the lower extremities.

Written informed consent was obtained prior to the study from all subjects. Approval for the study was granted by Hacettepe University Non-invasive Clinical Research Ethics Committee (decision no: GO 16/209-02, date: 12.04.2016). The study was carried out according to the principles of the Declaration of Helsinki.

Age, menopause age, smoking habits, comorbidities, educational and marital status were recorded as participant demographic characteristics. After then anthropometric characteristics such as height, weight, BMI, WC, hip circumference (HC), WHR, SMI, 2D:4D, hand and thigh circumferences were measured. WHR was calculated by dividing the standing-position measured WC by HC. Skeletal muscle mass (SM) was first computed to calculate SMI using the following formula (15):

$$SM=0.244\times weight+7.80\times height +6.6\times sex-0.98\times age+race-3.3$$

(sex =1 for male and 0 for female, race =-1.2 for Asian, 1.4 for African American, and 0 for white and Hispanic). SM (kilogram) was divided by squared height (square meter) to determine SMI. The 2D:4D ratio was determined by dividing the length of the second finger by the length of the fourth finger. Hand circumference measurement was measured using tape at the widest part of the palm and wrapping it around the palms. Lastly, thigh circumference was measured from the largest part of the dominant leg in the standing position.

Using a dual-energy X-ray absorptiometry system from Hologic, BMD was calculated, and OP was identified in accordance with WHO standards. T-scores were recorded at the femur neck (FN), femur total (FT), and lumbar spine (LS, L1-L4 total).

Statistical Analysis

The IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA) was used to conduct the statistical analysis. The mean and standard deviation or median (minimum-maximum) were used for continuous variables, whereas percentages and numbers were used for categorical variables. The Kolmogorov-Smirnov test revealed that the data were normal distribution, and the Pearson correlation was performed to ascertain the relationship between parametric variables. A p-value of 0.05 was taken into account.

Results

The study comprised a total of 181 postmenopausal women with a mean age of 62.78±7.81 years. Table 1 displays the patients' demographic details, clinical traits, and anthropometric characteristics. The average values of calcium and 25-hydroxyvitamin D levels were 9.7±0.73 mg/dL and 26.2±15.34 ng/mL, respectively. The correlations between BMD and anthropometric measurements are shown in Table 2. With respect to the L1-L4 total, FN and FT T-scores, weight and BMI significantly correlated positively. While the thigh circumference and SMI were significantly correlated with both the femoral neck and total T-scores, hand circumferences showed significant correlation only with FN T-score. No correlation was found between height, WHR, 2D:4D ratio and T-scores of all regions.

Discussion

Anthropometric measurements are usually chosen for population screening because they are affordable and simple to implement in clinics. The relationships between anthropometric traits and BMD in postmenopausal women have not been thoroughly investigated in many research (10,13,16-22). In most of the previous studies, it has been found that weight, height, and BMI positively correlate with BMD parameters (16-22). In line with earlier findings, we reported that LS and femur BMD were positively associated with weight and BMI in postmenopausal women. The associations between WC and BMD, as well as WHR and BMD, in PMO are contradictory (10,13,16-19). In a cross-sectional population-based study, Hasani-Ranjbar et al. (16) showed that BMI and WC were positively associated with BMD in three different bone areas, while WHR had a negative correlation with BMD in postmenopausal women. According to Kim et al. (17), body weight was favorably correlated with all regions of BMD, while WC was adversely correlated with all regions of BMD in a study with 907 postmenopausal healthy female participants aged 60 to 79 years. According to a population-based study with 4,445 subjects by Aghaei Meybodi et al. (13), it has been shown that BMD was significantly correlated to weight, height, BMI and WHR. Unlike prior inquiries, we found that there was no relationship between WHR and LS or femur T-scores. There exists very little research that investigates the connections between BMD and other anthropometric parameters such as SMI, digit ratio of the dominant hand (2D:4D), and hand circumference (10,18). In a cross-sectional study consisting of 482 patients who attended the geriatric outpatient clinic, Murat et al. (18) established that LS and FN T scores were considerably associated with weight, BMI, WC, and SMI. It has been demonstrated that SMI provides the most contribution to predicting FN and LS T-scores in multiple regression analysis (18). Arazi et al. (10) reported that 97 postmenopausal women's anthropometric characteristics, including WHR, SMI, 2D:4D, and calf circumference, were associated with BMD. In the scope of the same study, no relationship was found between hand circumference and BMD. Consistent with previous reports, our results have shown that some anthropometric characteristics (weight, BMI, SMI, thigh and hand circumference) were associated with T-scores in PMO. Similar to the results of other studies, we found LS and femur BMD positively correlated with weight and BMI in postmenopausal women, as well as positive correlations between femur T-scores (both neck and total) and thigh circumference and SMI in postmenopausal women. Moreover, we also determined that hand circumference was only related to the FN T-score. Contrary to the previous results, we could not find a correlation between WHR, 2D:4D ratio and T-scores.

It has been demonstrated that the risk of bone fracture decreases with increasing BMI (17,23-26). Obesity is usually thought to be preventive against fractures by reducing the impact of falls owing to higher BMD and more soft tissue padding (23,27). In contrast, obese people may have an increased risk of falling due to their decreased physical mobility and muscle strength. Although it was previously believed that obesity guarded against OP, recently a high percentage of fat has been shown to negatively affect bone health (18). Premaor et al. (25) found that obesity was common among those who presented to the Fracture Liaison Service with a low-trauma fracture even though the majority of these postmenopausal women had BMDs that were within the normal range. Particularly, they reported that obese women had considerably more hip fractures than non-obese women. In a multinational, population-based cohort of postmenopausal women, Compston et al. (27) showed that the

Table 1. The demographic features, clinical properties and anthropometric characteristics of the patients

	n=181
Age (years) (mean ± SD)	62.78±7.81
Marital status	
Married	117 (64.6%)
Single	21 (11.6%)
Widow	43 (23.8%)
Education	
Illiterate	32 (17.7%)
Primary school	100 (55.3%)
High school	27 (14.9%)
University	22 (12.2%)
Height (cm) (mean ± SD)	156.20±5.95
Weight (kg) (mean ± SD)	66.20±11.61
Body mass index (kg/m²) (mean ± SD)	27.24±4.87
Age of menopause (years) (mean ± SD)	45.69±5.58
Waist-to-hip ratio (mean ± SD) (median)	0.88±0.90 0.88
Skeletal-muscle-mass-index (kg/m²) (mean ± SD)	9.06±1.31
Digit ratio (2D:4D)	0.99±0.07
Thigh circumference (cm) (mean ± SD)	52.29±9.59
Hand circumference (cm) (mean ± SD)	19.44±1.06
BMD in different bone areas (mean ± SD)	
Femoral neck T-score	-1.98±0.77
Total hip T-score	-1.66±0.85
Lumbar L1-L4 total T-score	-2.97±0.66

SD: Standard deviation, 2D:4D: Digit ratio of dominant hand

Table 2. The correlations between BMD and anthropometric measurements

	Lumbar L1-L4 total T-score	Femoral neck T-score	Total hip T-score
Height	r=0.102 p=0.176	r=0.015 p=0.840	r=-0.070 p=0.354
Weight	**r=0.203 p=0.007**	**r=0.310 p<0.001**	**r=0.256 p=0.001**
Body mass index	**r=0.164 p=0.029**	**r=0.324 p<0.001**	**r=0.288 p<0.001**
Waist-to-hip ratio	r=0.050 p=0.510	r=0.014 p=0.853	r=-0.023 p=0.766
Thigh circumference	r=0.038 p=0.616	**r=0.464 p<0.001**	**r=0.411 p<0.001**
Skeletal-muscle-mass-index	r=0.125 p=0.098	**r=0.308 p<0.001**	**r=0.290 p<0.001**
Digit ratio (2D:4D)	r=0.071 p=0.345	r=0.021 p=0.775	r=-0.002 p=0.984
Hand circumference	r=0.074 p=0.325	**r=0.148 p=0.048**	r=0.061 p=0.425

BMD: Bone mineral density, 2D:4D: Digit ratio of dominant hand

risk of fractures in the ankle and upper leg was considerably higher in obese women compared to non-obese females. They emphasized that obesity is related to an increased risk of ankle and upper leg fractures and does not protect against fractures in postmenopausal females. Gnudi et al. (28) reported that increased BMI and wrist or ankle fractures were not correlated in a study of postmenopausal women with fractures but increased BMI was linked to a considerably higher risk of humerus fracture and a lower risk of hip fracture.

The gynecoid fat distribution model with a low WHR provides significant advantages for women. It is stated that high WHR is associated with high androgen and cortisol levels and low estrogen (29). WC increases significantly during menopause due to the drop in estrogen levels (30). Estrogen may directly reduce WHR by enhancing the accumulation of fat in the hips and thighs and the accelerated lipolysis of abdominal fat. It appears likely that there is a strong correlation between WHR and bone density given the link between WHR and androgen and estrogen (29). Aghaei Meybodi et al. (13) found a correlation between WHR and BMD. In the study of Kim et al. (17), WC was demonstrated to be significantly larger in the postmenopausal group with fractures than in the postmenopausal group without fractures. It was also emphasized that WC was related to BMD and osteoporotic vertebral fractures (17). Arazi et al. (10) revealed a negative correlation between WHR and LS and hip BMD. In the study of Abbasi et al. (31), it has been demonstrated that osteoporotic females have a smaller WC and WHR than non-osteoporotic females. However, we could not find a relationship between WHR and T-scores.

The findings of Arazi et al. (10) demonstrated a significant positive association between SMI and BMD. Similarly, Murat et al. (18) showed that LS and FN T-scores were significantly related to SMI. In addition, they emphasized the importance of SMI in predicting FN and LS T-scores (18). Similarly, we found a positive correlation between SMI and femoral neck and total T-scores.

It is known that women's second fingers are typically equal to or longer than their fourth fingers, whereas men's second fingers are typically shorter than their fourth digit. It has been proposed that 2D:4D has an adverse relationship with prenatal testosterone and a positive relationship with prenatal estrogen (10,32). Zheng and Cohn (32) showed that the 2D:4D ratio was related to the equilibrium of the androgen and estrogen receptors. These receptors are more determinative of the length of the fourth finger than the second finger. The androgen receptor inactivation decreases the ring finger's growth rate, whereas the estrogen receptor inactivation increases the ring finger's growth rate, decreasing the 2D:4D ratio. The 2D:4D ratio is thought to reverberate circulating androgen and estrogen levels. Genetic studies have shown that certain genes regulated by sex steroids play significant roles in finger growth. Wnt5a has been demonstrated to organize the rate of growth and maturation of chondrocytes in long bones. It is also known that aging-related bone loss is caused by a decrease in estrogen (10,32). In a previous study, it was reported that 2D:4D was associated with LS and hip BMD in postmenopausal women (10). On the contrary, we found no relationship between the 2D:4D ratio and T-scores in our study.

Many studies have indicated that BMD and handgrip strength (HGS) have a positive association (10,33-36). It is thought that hand circumference and HGS have a strong favorable association (37). Accordingly, it is assumed that hand circumference can be utilized as an anthropometric measurement to estimate BMD. Nevertheless, Arazi et al. (10) reported that the hand circumference was not related to LS and hip BMD. We found that hand circumference was related to FN T-scores but not lumbar and FT T-scores.

Study Limitations

Our study's limitations include a small sample size and the fact that we did not document the patients' fracture histories. If we had examined the relationship between fracture and anthropometric characteristics, the data could have enriched our research. Our study's strength is that a sample of postmenopausal osteoporotic women was examined using a variety of anthropometric characteristics. More study is needed to investigate the relationships between BMD and other anthropometric characteristics such as SMI, 2D:4D, and hand circumference. We contributed to the restricted literature by finding that there was no correlation between WHR and LS or femur T-scores, nor between 2D:4D ratio and T-scores.

Conclusion

In conclusion, we found that anthropometric measurements including weight, BMI, SMI, thigh and hand circumference significantly correlated with T-scores at LS and or femur. BMD in PM women is a complex issue, and a comprehensive evaluation that includes the anthropometric element will be beneficial in terms of clinical practical applications. Further research is needed to reveal the act of anthropometric measurements in determining the OP risk in postmenopausal women.

Ethics

Ethics Committee Approval: Approval for the study was granted by Hacettepe University Non-invasive Clinical Research Ethics Committee (decision no: GO 16/209-02, date: 12.04.2016).

Informed Consent: Written informed consent was obtained prior to the study from all subjects.

Authorship Contributions

Concept: A.Y., O.Ö., Ş.G., Y.G.K., Design: A.Y., O.Ö., Ş.G., Y.G.K., Data Collection or Processing: A.Y., O.Ö., Ş.G., Analysis or Interpretation: A.Y., O.Ö., S.K., Y.G.K., Literature Search: A.Y., O.Ö., Ş.G., S.K., Y.G.K., Writing: A.Y., O.Ö., Ş.G., S.K., Y.G.K.

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