Original article

Body weight is a Better Predictor of Bone Mineral Density than Body Mass Index in Postmenopausal Women

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Background: we aimed to evaluate the effect of body weight and Body Mass Index (BMI) on Bone Mineral Density (BMD) in healthy postmenopausal Iranian women.

Material and Methods: Two hundred postmenopausal women (age between 51 and 69 years) who had presented to the nuclear medicine center at Shariati Hospital in Tehran, Iran between April 2012 and August 2013 were included in this cross sectional study. Of these 46 healthy women who met the study criteria constituted for evaluation. After recording weight and height of individuals, Body Mass Index (BMI) (kg/m2) was calculated as weight (kg) divided by height square (m^2). Bone Mineral Density (BMD) in Femoral Neck (FN) and lumbar spine sites (L1-L4) were measured by dual-energy X-ray absorptiometry (DEXA).

Results: We observed statistically significant negative correlation between BMD measurements at femoral neck and lumbar$_{1-4}$ spine with age and significant positive correlation with weight and BMI. Stepwise multiple linear regression analysis showed that only weight and age, after adjustments to BMI determined lumbar$_{1-4}$ spine BMD *(R^2 = 23%)* and femoral neck BMD *(R^2 = 28.6%)*.

Conclusions: These results suggest that the relationship between body weights and BMD is Stronger than the relationship between BMI and BMD. Therefore, in comparison with body mass index, body weight alone is a better predictor of bone mineral density.

Keywords: Body Mass Index (BMI), Bone Mineral Density (BMD), Postmenopausal Women, Weight

Introduction

Osteoporosis is an age-related disease and characterized by low bone mass density and micro-architectural deterioration of bone tissues, leading to enhanced bone fragility and consequently increased fracture risk (Tuck & Francis, 2002, Pietschmann et al., 2009) which make it to a an important public health problem among old people (Burge et al., 2007). Population aging is a health problem worldwide. In 2010, an estimated of 524 million people were aged 65 or older that is about 8 percent of the world's population. By 2050, this number is expected to nearly triple to about 1.5 billion, representing about 16 percent of the world's population. Although more developed countries have the oldest population profiles, in which the vast majority of older people-and the most rapidly aging populations-are in less developed countries. Between 2010 and 2050, the number of older people in less developed countries is projected to increase more than 250 percent, compared with 71 percent increase in developed countries. This remarkable phenomenon is being accompanied with higher incidence of osteoporosis as well as increased osteoporotic fractures leading to substantial costly

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consequences of disability and mortality, (Jordan & Cooper, 2002; Srivastava & Deal, 2002; Baheiraei et al., 2005; Reginster & Burlet, 2006). It was well accepted that either Bone Mineral Density (BMD) or Bone Mineral Content (BMC) are most appropriate diagnostic criteria to identify low-trauma fracture risk among at risk people (Bener, Hammoudeh. & Zirie. 2005; Zhao et al., 2008). However, regardless BMD, low body weight or low BMI ($\leq$ 19 kg/m²) are clinical risk factors that could contribute to fracture risk. (Compston et al., 2009). It has been argued that hypothetical mechanisms such as gravitational effect of increased weight on muscle that stimulates bone formation secretion of bone-active hormones from the pancreatic beta cells (including insulin, amylin, and preptin) and secretion of bone-active hormones (e.g., oestrogens and leptin) from the adiposities of fat mass could be resulted in low fracture risk in obese postmenopausal women (Rosen & Bouxsein, 2006).

Many researchers believe that the BMI should be used as a predictor of BMD (Knoke & Barrett-Connor, 2003; De Laet et al., 2005; El Maghraoui et al., 2007). However, in literature it was indicated that BMI could not be a valid predictor of bone density. Furthermore, three large epidemiologic studies named as the Women's Health Initiative (WHI) among 11, 390 women (1998); the Cardiovascular Health Study (CHS) among 1, 578 men and women (Schott et al., 1998); and EPIDOS among 7, 598 women (Fried et al., 1991) showed that weight alone is a much better predictor of BMD in comparison with BMI. In Iran, population aging caused increased prevalence of older people in recent years. This notable event is being accompanied with high prevalence of osteoporosis that could be detected in early stages in order to be prevented. Since, in majority of health centers of this developing country, BMI measurement is not routine, this study aimed to investigate if body weight measuring could be a better predictor of bone mineral density compared with BMI among Iranian postmenopausal women.

Material and methods

The study was designed as a cross-sectional investigation, in which 200 postmenopausal women aged between 51-69 years were convenience sampled. All women were recruited from the nuclear medicine centre at Shariati Hospital in Tehran, Iran. Medical history was obtained fromall participants. In this study the women who aged > 55, being menopause for 1years and being satisfied to participate in the research were entered into the study. However, the women who suffering from diseases affected on osteoporosis such as hyperthyroidism, hyperparathyroidism, renal failure, mal absorption syndrome, alcoholism, chronic colitis, multiple myeloma, leukemia, chronic arthritis or previous use of therapies that interfere with bone metabolism e.g., glucocorticoids, heparin, warfarin, thyroxin, estrogen) as well as selective estrogen receptor modulator (SERM), bisphosphonate, or calcitonin for at least in past year were excluded from the study. Simultaneously, diabetes type 1 and 2 were also considered as exclusion criterion. According the inclusion/exclusion criteria, 46 eligible women were assessed in this study. All participants were first awarded about the aim and procedure of the study and then signed informed consent. The study protocol and procedures were approved by the ethical committee of Tarbiat Modares University.

Weight was measured in light indoor clothing without shoes, by using an electronic balance (precision 0.1 kg). Height was measured without shoes in erect standing position (precision 0.5 kg). BMI was calculated as weight (kg) divided by height square (m²). Lumbar $_{1-4}$ spine BMD and femoral neck (FN). BMD were measured by using dual-energy X-ray (DEXA) absorptiometry. The densitometer was calibrated using a standard phantom every time before measurement. According to the WHO classification, "osteoporosis" was defined as a BMD T-score $\leq$ 2.5, "osteopenia" (or "low bone mass") as a T-score between -1 and -2.5 and "normal" BMD is defined as a T-score-1.0 or greater.

Statistical analysis used: Statistical analyses were performed using SPSS software for Windows (version 16). All variables were distributed normally. Mean, Standard Deviation, and minimum and maximum values were used to describe the data. The Pearson's linear Correlation Coefficient were used to determine relationship between quantitative variables. The stepwise multiple linear regression analysis was utilized to evaluate the impact of body weight and BMI on femoral neck and L_1-L_4. P-value < 0.05 were considered significant in both analyses.

Results

Totally, 46 healthy post menopausal woman with mean age of 55.7 ± 4.2 years (range: 51-65) and mean BMI of 28.35 ± 4.5 kg/m^2 (range: 20-41/74) took part in the study. Table 1 presents the anthropometric and densitometry data of the studied women. According to the WHO classification for BMI, 9women (19.56%) had normal weight, 25 women (54.34%) were overweight, and 12 women (26.08%) were obese. Of all participants, (N = 56) 28.26% had normal BMD in spine site, (N = 88) 43.47% were suffering from osteopenia, and (N = 56) 28.26% were suffering from osteoporosis. Moreover, the frequency of normal BMD, osteopenia and osteoporosis in the femoral neck site were (N = 95) 47.84%, (N = 83) 41.30% and (N = 22) 10.86% respectively.

Table 1. Clinical, anthropometric and densitometry characteristics of studied postmenopausal women.

Variable	Mean ± S.D	Range
Age (years)	55 ± 4.2	51-65
Weight (kg)	70.5 ± 1.8	45-99
Height (kg)	157.7 ± 5.5	148-170
BMI (kg/m²)*	28.35 ± 4.5	20-41.74
Lumbar spine BMD (g/cm²)**	0.871 ± 0.159	0.607-1.404
Lumbar spine (T-score)	-1.60 ± 1.46	-4.00-3.20
Femoral neck BMD (g/cm²)	0.718 ± 0.109	0.486-0.977
Femoral neck (T-score)	-1.17 ± 0.98	-3.30-1.20

* BMI Body Mass Index; **BMD: Bone Mineral Density.

Table 2 presents the result of the Pearson's correlation analysis. Statistically, we observed significant negative correlation between BMD measurements at femoral neck and lumbar$_{1-4}$ spine with age and significant positive correlation with weight and BMI.

Table 2. Correlation between anthropometric Variable and BMD.

Variable	Femoral neck BMD**		Lumbar spine BMD**	
	r	P$_{value}$	r	p$_{value}$
Age (years)	-0.32	0.028	-0.29	0.047
Weight (kg)	0.46	0.001	0.42	0.004
Height (cm)	0.27	0.068	0.17	0.246
BMI (kg/m²)*	0.35	0.016	0.34	0.018

*BMI: Body Mass Index; **BMD: Bone Mineral Density.

Based on the result of the multiple regression analysis only weight and age, after adjustment to height and BMI were able to predict femoral neck BMD *(R² = 28.6%)* and lumbar$_{1-4}$ spine BMD *(R² = 23%)* (Table 3).

Table 3. Stepwise multiple linear regression model* for BMD Measurements at femoral neck and lumbar$_{1-4}$ spine.

Variables	RC*	R²-adjusted	P$_{value}$
Dependent variable: femoral neck BMD			
Weight	0.462	0.286	**0.001**
Age	-0.325		**0.013**
Dependent variable: L1-L4 BMD			
Weight	0.422	0.230	**0.002**
Age	-0.295		**0.029**

*RC = Regression Coefficient

Discussion

Reduced bone mass and osteoporosis are important socioeconomic problems due to their high morbidity, especially vertebral and hip fractures in aging populations chiefly for women (De Laet et al., 2005). There are various detection methods for osteoporosis. DXA as a golden standard test for measuring bone mineral density is widely used because of its safety, accuracy (1994).

In this cross-sectional study the effects of bodyweight and BMI on bone mass measurements in healthy postmenopausal Iranian women were investigated. As the findings showed, there was a negative correlation between age and BMD of lumbar$_{1-4}$ spine and femoral neck. Moreover, there were positive relationships between weight /BMI and BMD measurements in both locations. However, after adjustments to BMI, only weight and age, could determine lumbar$_{1-4}$ spine and femoral neck BMD.

Our data is concur with the findings of the cross-sectional study that was done by Genaro et al. (Genaro et al., 2010) indicating that BMI did not predict total body BMC as well as total femur and femoral neck BMD. In another study that was conducted by Ooms et al in 1993 it was reported that body weight and years past menopause were the best determinants of BMD (Ooms et al., 1993). Also, Robbins in 2006 found that body weight alone is a much better predictor of BMD than BMI (Robbins et al., 2006). We support their theory that BMI cannot be an appropriate predictive model because a height squared phrase into the denominator result in underestimate the BMD of taller subjects and overestimate it for shorter subjects. They mentioned that taller thin subjects have greater actual BMDs than would be predicted using BMI as the predictor.

Furthermore, shorter heavier subjects are at a similar risk for low BMD like taller thinner subjects of the same weight.

In addition, numerous studies have shown that properties of organisms as phenotypic expression of human stature vary with l attitude. Furthermore existed evidence (Rensch, 1938), stated individuals living in colder climates have greater body sizes than individuals living in warmer climates. Previous researchers (Gustafsson & Lindenfors, 2009) suggested that both male and female mean stature increase with increasing distance from the equator. Also, Ruff in 2002 reported that mean body weight, height and breadth vary by 50% or more, about 10% and 20% respectively, within sex, in a worldwide sampling of populations but variation in height does not follow any particular geographic trend (Ruff, 2002). Moreover, it is generally accepted that blacks have a more tendency toward mesomorphy and, on average, have shorter trunks and longer extremities than whites (Malina, 1973; Himes, 1988, Malina RM, 1996). With these variations in body size and shape in different population, BMI cannot be an appropriate test to predicting osteoporosis. In the line of these evidences, our study found no association between height and BMD in both FN and L_1-L_4 locations. In addition, the present study confirmed Robbins' (Robbins et al., 2006) theory that concluded BMI is an incomplete test to be used for BMD screening.

Black et al. (Himes, 1988) developed an simple scoring system to predict fracture risk in postmenopausal women that was comprised of a set of seven criteria of which weight less than or equal to 125 pounds (75 kg) was one of the risk factors. These researchers recommended that body weight should be used as a BMD predictor instead of BMI.

Many studies have shown that BMI is a determinant factor of BMD. In these studies BMI are a better predictor of fracture than weight alone. Our study did not address fracture prediction, but only the intermediate endpoint of BMD. Body mass index is used in many studies as a proxy for body habit us, but body habit us may not be what is driving BMD. It is unclear why heavier individuals have higher BMD_s but there are at least two reasonable hypothesis that are not reciprocal exclusive. Increased tissue mass may affect hormonal levels, which play a role in bone turnover. More

simplistically, individuals who engage more in weight-bearing exercise cause increased bone growth and less risk of low BMD. Accordingly, height would be less likely to play a negative role in this mechanism, and thus should not be used as a de nominate or in the predictive model.

Conclusion

In conclusion, our data indicated that despite known positive relationship between BMI and BMD, BMI is not a good predictor for bone density. Thus, body weight should be used as an assessment tool for predicting BMD instead BMI in postmenopausal women.

Conflict of interests

The authors declare that they have no conflicts of interest.

Author contribution

SRP, SZ, AEA; Study Importation, Data collection and analysis, Writing the first draft of the Paper.

SRP, SZ, AEA: Study design and data analysis, editing and confirming the final draft of the paper.

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