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Original

Relationship between body mass index and bone mineral density in Mashhad, Iran; a cross-sectional Study

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Abstract

Introduction: There is controversy regarding the effect of body weight on bone mineral density (BMD).

Objectives: The aim of this study was to assess the relationship between body mass index (BMI) and BMD among a sample of Iranian citizens.

Patients and Methods: This cross-sectional study was conducted on Iranian citizens who referred to Ghaem Hospital, Mashhad, Iran for bone densitometry. Measurements included weight, height, BMI and dual X-ray absorptiometry (DEXA) parameters including femoral T-score (FT) and Z-score (FZ) and lumbar spine T-score (LT) and Z-score (LZ). Data were analyzed using the statistical package for social sciences (SPSS) software version 22.

Results: A total of 302 subjects (15.2% male and 84.8% female) with the mean age of 55.15 ± 12.03 years participated in the study. The prevalence of osteopenia based on TF and TL was 2.3% and 3.0% respectively. The prevalence of osteoporosis based on TF and TL was 1.0% and 3.0% respectively. Age was significantly correlated with TL and ZL (r = -0.17, $P = 0.002$ and r = -0.12, $P = 0.037$ respectively). BMI was significantly interrelated with TF (r = 0.17, $P = 0.009$) and ZF (r = 0.20, $P = 0.02$). FT was significantly correlated with age (r = -0.12, $P = 0.045$). TL was significantly higher in <40 years group compared to >55 years group ($P = 0.003$).TF was significantly higher in <40 years group compared to >55 years group ($P = 0.030$). BMI was significantly correlated with FZ among post-menopausal women (r = 0.34, $P < 0.001$).

Conclusion: This study showed that higher BMI was associated with higher FT and FZ while only FZ was correlated with BMI among post-menopausal women.

Keywords: Bone mineral density; Body mass index; Osteoporosis; Osteopenia

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Introduction

Osteoporosis is identified by reduced bone mass, deteriorated bone structure and reduced bone strength, which increases the risk for bone fracture (1). Osteoporosis is the most common metabolic disease in the elderly, which is correlated with increased morbidity and mortality (2). The prevalence of osteoporosis was reported to range from 13% to 34% in the developed countries (3–7). The prevalence of osteoporosis is increasing (8). The estimated prevalence of osteoporosis in Iran was reported to range from 4% to 17% (9–11). The disability adjusted life year (DALY) for hip fracture among Iranian men and women was previously reported to be 16495 and 15880 years respectively while the DALY indicator for spine and forearm fractures in men and women in Iran were reported to be 2225 and 1269 years for spine and 37 and 121 years for forearm fractures respectively (12).

Various risk factors have been proposed that increase the risk for osteoporosis, including older age, menopause, sedentary lifestyle, smoking, hyperthyroidism and body mass index (BMI) (13-16). Although controversial findings have been reported regarding the relationship between BMI and osteoporosis, while some studies reported higher incidence of osteoporosis among subjects with low BMI and increased bone density in subjects with high BMI (overweight/obese), other studies reported reduced bone density in obese subjects (17-19).

Regarding the burden of osteoporosis and its growing incidence, preventive strategies are recommended for osteoporosis. In order to be able to tackle osteoporosis, the risk factors should be well identified. Obesity is a growing pandemic that affects various aspects of human life (20). The prevalence of obesity is increasing worldwide (20). In Iran, the prevalence of obesity among adults has reached 21.7% in 2015 from 18.8% in 2006 (21,22).

Objectives

Due to the equivocal reported effects for the effect of

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Implication for health policy/practice/research/medical education

There is controversy regarding the effect of body weight on bone mineral density. We found a lower prevalence of osteoporosis compared to regional and national data. Furthermore, there was a significant correlation between age and BMD in both genders. There was also a significant positive correlation between BMI and BMD especially among post-menopausal women.

BMI on BMD, this study was conducted to assess the relationship between BMD and BMI among a sample of Iranian community dueling Iranian men and women who live in Mashhad, Iran.

Patients and Methods

Study design

This cross-sectional study was conducted on Iranian men and women who were referred to Ghaem Hospital, Mashhad, Iran for bone densitometry. All subjects were approached by the researchers and were informed regarding the aims and objectives of the study. Subjects who were willing to participate in the study were asked to sign a written consent form.

All subjects who were Iranian citizens and were older than 18 years were included in the study. Subjects were excluded if they were pregnant or lactating, smoker, had chronic diseases or consumed medications that affect BMD, as well as positive family history for osteoporosis.

Anthropometric measurements including weight, height and BMI as well as dual X-ray absorptiometry were measured for all subjects. Weight was measured using a single weighing scale. Subjects were measured with minimal clothing in standing position. The measurements were taken to the nearest 0.1 kg twice and the mean measurement was recorded as the subject's weight. The weighing scale was calibrated daily. Height was measured to the nearest 0.1 cm using a stadiometer in standing position with the head in Frankfurt plane. BMI (kg/m^2) was calculated by dividing the weight (kg) by the square of height (m).

All subjects underwent fual-energy X-ray absorptiometry (DEXA) scan using the Osteocore II Osteodensitometer (MEDILINK, France). The DEXA assessment is considered as the gold standard for the measurement of BMD (23). The femoral T-score (FT) and Z-score (FZ) as well as lumbar spine T-score (LT) and Z-score (LZ) were recorded for each subject.

Ethical issues

The research followed the tenets of the Declaration of Helsinki.

Statistical analysis

Data were analyzed using the statistical package for social sciences (SPSS) software version 22. The normality of continuous variables was assessed using the Kolmogorov-Smirnov test. Variables with normal distribution were presented as mean and standard deviation (SD). Categorical variables were presented using frequency and percentage. Comparison of the continuous variables between groups was performed using the independent student t-test and one-way analysis of variance (ANOVA) with Bonferroni post hoc test. The distribution pattern of categorical variables was compared between group using the chi-square test. The Pearson correlation coefficient was used to assess the correlation between BMI and BMD parameters. Relationship between BMD and other study parameters was assessed using linear logistic regression. The level of significance was considered as $P<0.05$.

Results

A total of 302 subjects (46, 15.2% male and 256, 84.0% female) participated in the study. The mean age of subjects was 55.15 ± 12.04 years. The characteristics of study subjects are presented in Table 1.

Prevalence of osteopenia was 2.3% based on TF (femoral T-score) and 3.0% based on TL (lumbar T-score). Prevalence of osteoporosis was 1.0% based on TF and 3.0% based on TL. There was no significant difference in BMD parameters between genders ($P>0.05$) (Table 2). There was a significant but week correlation between age and TL (r=-0.17, $P=0.002$), ZL (lumbar Z-score) (r=-0.12, $P=0.037$) and TF (r=-0.12, $P=0.045$). There was a significant difference in TL and TF between age groups ($P=0.003$ and $P=0.014$ respectively). TL was significantly higher in <40 years age group compared to >55 years group ($P=0.003$) while TF was significantly higher in 40-55 years age group compared to >55 years group ($P=0.003$) (Table 3).

The Pearson correlation coefficient revealed a significant but week correlation between BMI and TF (r=0.17, $P=0.009$) and ZF (femoral Z-score) (r=0.20, $P=0.002$) (Table 4). There was only a significant correlation between BMI and ZF among the post-menopausal women (r=0.341, $P<0.001$) (Table 4).

Table 1. Demographic and BMD characteristics of study subjects

Variable	Mean	SD
Age (y)	55.15	12.04
Weight (kg)	70.01	7.99
Height (cm)	157.30	5.47
BMI (kg/m$^{2)}$	28.53	3.31
TL	-1.035	2.04
ZL	0.245	1.70
TF	-1.420	1.41
ZF	-0.630	1.37

SD, standard deviation; TL, lumbar T-score; ZL, lumbar Z-score; TF, femoral T-score; ZF, femoral Z-score.

Table 2. Comparison of BMD parameters between genders

Variable	Gender group	Mean ± SD	*t*	*P*
TL	Male	-0.934 ± 1.52	0.436	0.663
	Female	-1.047 ± 1.62		
ZL	Male	-0.096 ± 2.51	0.276	0.783
	Female	-1.169 ± 1.47		
TF	Male	-1.267 ± 1.51	1.236	0.217
	Female	-1.537 ± 1.33		
ZF	Male	-1.271 ± 2.85	-1.972	0.050
	Female	-0.791 ± 1.14		

TL, lumbar T-score; ZL, lumbar Z-score; TF, femoral T-score; ZF, femoral Z-score.

Table 3. Comparison of BMD parameters between age groups

Variable	Age grou (y)	Mean ± SD	*F*	*P*
TL	<40	-0.223 ± 1.62[a]	5.775	0.003**
	40-55	-0.927 ± 1.54		
	>55	-1.239 ± 1.60[a]		
ZL	<40	0.306 ± 1.51	2.156	0.118
	40-55	-0.045 ± 1.30		
	>55	-0.311 ± 1.86		
TF	<40	-1.451 ± 1.14	4.354	0.014*
	40-55	-1.188 ± 1.25[b]		
	>55	-1.687 ± 1.44[b]		
ZF	<40	-0.900 ± 1.02	0.295	0.745
	40-55	-0.769 ± 2.10		
	>55	-0.915 ± 1.16		

TL, lumbar T-score; ZL, lumbar Z-score; TF, femoral T-score; ZF, femoral Z-score.

Discussion

The findings of this study revealed that the prevalence of osteoporosis was 1.0% based on femoral T-score and 3.0% based on lumbar T-score. It was previously reported that the prevalence of osteoporosis in Iran was between 4% to 17% (9–11). In a meta-analysis in 2018, the overall prevalence of osteoporosis in the East Mediterranean Region was reported to be 24.4% and 16.8% based on femoral spine with a higher prevalence among women (24.4% in women vs. 20.5% in men) (24). In a meta-analysis in 2013 the prevalence of osteoporosis was reported to be 17% in Iran based on lumbar spine with higher prevalence among post-menopausal women (40%) compared to pre-menopausal women (19%) and men (3%) (11). These findings indicated a higher prevalence of osteoporosis in previous studies compared to the current study findings. This finding might be due to the smaller sample size in the current compared to the previous meta-analyses.

The current study also found a significant correlation between age and BMD. The lumbar T-score was significantly higher in subjects younger than 40 years old compared to subjects who were older than 55 years old and femoral T-score was significantly higher in subjects who were between 40 and 55 years old compared to subjects who were older than 55 years old. This finding was in line with the findings of the aforementioned meta-analyses that revealed higher BMD in younger subjects (<55 to 59 years old) compared to older subjects (>55 to 60 years old) (11,25-27). Furthermore, the findings of the current study revealed no gender differences in terms of BMD neither in femoral nor lumbar spine. This finding was in line with the findings of previous studies conducted in South Korea and Iran (26,28) while the findings of previous studies revealed higher BMD measurement especially in femoral area in men compared to their age adjusted females (11,24,27).

This study also observed a significant and positive correlation between BMI and femoral T-score and Z-score in total population while only a significant correlation was observed between BMI and femoral Z-score among post-menopausal subjects. This finding was in line with the findings of a study conducted in Isfahan, Iran, that reported a significant positive correlation between BMI and BMD (in hip and lumbar spine) in men, pre-menopausal and post-menopausal women (28). Similarly, in a study conducted on Indian women using heel ultrasound for measurement of BMD, leaner women were found to be significantly more prone to develop osteoporosis (29). These findings indicate a protective effect for BMI on the development of osteoporosis mainly due to the effect of increased body weight on hip and lumbar spine. In contrast, some studies revealed different results (30,31). For instance in a study on middle-age Australian citizens the relation between lean and fat mass and BMD became weaker or absent in second and third BMI tertile (30). The reason for the difference in findings of previous study regarding the different effects of BMI on BMD might be in part related to the differences in sample size, study population, regional BMD measurement and more importantly to the distribution pattern of fat in the body as well as the relation between lean mass and BMD.

Table 4. Correlation between BMI and BMD parameters

Group			TL	ZL	TF	ZF
BMI (kg/m^2)	Total population (N=302)	r	-0.012	0.071	0.171	0.202
		P	0.862	0.287	0.009**	0.002**
	Post-menopausal (n=140)	r	-0.008	0.035	0.138	0.341
		P	0.934	0.721	0.159	<0.001**

BMI, body mass index; TL, lumbar T-score; ZL, lumbar Z-score; TF, femoral T-score; ZF, femoral Z-score.

The current study did not assess body composition of the subjects. It was previously shown that android obesity and abdominal obesity were related to higher BMD due to increased weight and BMI (32, 33). The exact mechanism for the protective effect of obesity against osteoporosis is not yet determined but a number of hypotheses exist for this effect including the biomechanical stimulation due to the excess fat mass, pancreatic secretion of insulin, amylin which may affect bone remodeling, in response to increased fat mass and secretion of estrogen and other bone-active hormones from adipocytes (31). The findings of this study add to the previous literature regarding the protective effect of obesity against osteoporosis.

One of the limitations of the current study was the small sample size compared to previous epidemiological studies. As this study was based in one center, recruitment of larger sample size required longer duration, which was no applicable. It is recommended that further researches be conducted on multiple centers and on larger samples in order to be able to infer the results to the whole population. It is also suggested that further studies look into the effect of body composition (lean and fat mass) as well as the assessment of obesity related hormones that affect bone metabolism in order to better understand the underlying mechanism of effect for BMI on BMD.

Conclusion

The findings of this study revealed a lower prevalence of osteoporosis compared to regional and national data. Furthermore, there was a significant correlation between age and BMD in both genders. There was also a significant positive correlation between BMI and BMD especially among post-menopausal women.

Limitations of the study

The most important was the small number of patients.

Author's contribution

NS and MM were the principal investigators of the study. NS and MM were included in preparing the concept and design. MM revised the manuscript and critically evaluated the intellectual contents. All authors participated in preparing the final draft of the manuscript, revised the manuscript and critically evaluated the intellectual contents. All authors have read and approved the content of the manuscript and confirmed the accuracy or integrity of any part of the work.

Conflicts of interest

The authors declare that they have no competing interests.

Ethical considerations

Ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

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