The Relationship between Anthropometric Parameters and Bone Mineral Density in an Iranian Referral Population

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Abstract- Osteoporosis is a common health concern in both developed and developing countries. In this study the association between anthropometric measures and osteoporosis was investigated in 3630 males and females visiting BMD clinic of Shariati Hospital, Tehran, Iran, a teaching hospital and referral center for osteoporosis affiliated to the Tehran University of Medical Sciences. Anthropometric measurements obtained and also Bone Mineral Density (BMD) measurement was done using a Lunar DPXMD densitometer. Data were analyzed using SPSS with Chi-square and ANOVA with post-hoc tests. Results showed that the weight, BMI and age had the strongest correlation with the BMD values in the studied people. While age is negatively correlated with BMD in all the studied people, a positive association was noted between weight, height and BMI and BMD parameters (P<0,01). It was concluded that certain anthropometric parameters (BMI and weight) can considerably affect one's risk of developing osteoporosis. Further research on the effect of these variables on the association of weight and BMD is needed.

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Keywords: Osteoporosis; Anthropometric parameters; BMD; BMI; Weight; Age

Introduction

Osteoporosis is a common, major public health and growing problem recognized in both developed and developing countries (1,2). Fractures in hip and spine are known to be the most important complication of the disease which leads mortality and serious morbidity (3). There are some researches about related factors of osteoporosis and loss of Bone mineral density (BMD). They consist of advancing age (4), sex (5), smoking (6), menopause (3), low weight/weight loss, obesity (7), fat mass (8), weakness for physical activity, alcohol consumption, calcium intake, muscle strength, family history of fracture/osteoporosis, and height/weight loss. (9).

BMD is a significant determinant of fracture risk (10). BMD testing is used to diagnose osteoporosis (11). Body mass index (BMI) is the weight in kilograms divided by height in meters squared (12-14). It was previously believed that obesity and osteoporosis were two unrelated diseases (8,15) but the relationship between obesity and osteoporosis has been widely studied, and epidemiological evidence shows that the obesity is correlated with increased bone mass and fractures (8,16).

Based on Luo *et al*., results BMI is a risk factor of osteoporosis in male, and it may be related to body fat distribution (17). Morin *et al.,* found that low weight and BMI predict osteoporosis and are associated with increased fracture risk in younger women (18). Akdeniz *et al.,* determined the effects of the anthropometric measurements on osteoporosis from higher to lower influence as follows: weight, age of menopause, age, BMI and height. Weight and menopause age of the patients were the major determinants for osteoporosis (19).

Identification of probable relations between anthropometric measures like weight and height, and bone mineral density based on sex and age has not been investigated in an Iranian referral population. Identifying persons at risk of sustaining osteoporotic fractures is crucial to their prevention, and bone-active treatments may be useful for fracture prevention. Several osteoporosis risk assessment instruments have

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been proposed to identify people of different ages who are likely to have osteoporosis and should therefore undergo bone densitometry.

Hence, it is important to determine what is the best clinical strategy to identify osteoporotic people who are considered to be at high risk of fracture and for whom treatment is recommended? So, for osteoporosis prevention and timely treatment this research was done.

Materials and Methods

Study population

The study population consisted of 3630 males and females visiting BMD clinic of Shariati Hospital, a teaching hospital and referral center for osteoporosis affiliated to Tehran University of Medical Sciences, between 2006 and 2010. The mean age of the males (347) participating in the study was 53 ± 16 years. As for the females (3283), the value was 54 ± 11 years.

Anthropometric Measurements

Anthropometric measurements including weight and height were measured with light clothing and without shoes by trained technicians following international guidelines (11). Each anthropometric measurement was done by a similar instrument, and with the same technique.

Quality control for all measurements was regularly monitored. The height (to the nearest 0.1 cm) and the weight (to the nearest 0.1 kg) were measured using a wall-mounted stadiometer (Seca) and mobile digital scale (Seca, Hamburg, Germany), respectively. The BMI was calculated as the body weight divided by the height squared (kg/m^2).

Bone Mineral Density (BMD) Measurement

Patients underwent L1–L4 anteroposterior lumbar spine, hip and its sub-regions DXA study with a Lunar DPXMD densitometer (Lunar 7164, GE, Madison, WI) by a trained operator according to the manufacturer's instruction. Quality control procedures were carried out in accordance with the manufacturer's recommendations. Instrument variation was regularly determined by a weekly calibration procedure using a phantom supplied by the manufacturer. Precision error for BMD measurements was 1– 1.5% in the lumbar and 2–3% in the femoral regions.

Data analysis

Data were entered to Microsoft Access Databank, and analyzed using SPSS 13.0 for Windows (SPSS, Chicago, IL) based on a Pair-Wise approach. *P* values lower than 0.01 were considered statistically significant. Means ± SD were used to express standard descriptive statistics. Categorical variables were expressed as percentages and compared using *Chi*-square. Differences among means were investigated by analysis of variance (ANOVA) with Post-Hoc test.

Results

Table 1 outlines a summary of the demographic and anthropometric features of the 3630 patients recruited in this study. Except for age, the other studied anthropometric parameters (L_1-L_4, femoral neck and total hip) had a significant positive correlation with BMD values measured at the three sites (Table 2). Age, on the other hand, was negatively correlated with the reported BMD values. The effect of weight, BMI and age was stronger than height on BMD values at the studied sites.

Table 1. Anthropometric parameters (Mean ± SD) in 3630 studied patients

Anthropometric Variables	Sex	
	Female Mean±SD	Male Mean±SD
Age (yrs)	54±11	53±16
BMD L1_L4 (g/cm^2)	1.011±.171	1.041±0.182
BMD Femoral Neck (g/cm^2)	0.840±0.138	0.861±0.154
BMD Total hip (g/cm^2)	0.901±0.147	0.921±0.161
Height (cm)	157±7	170±7
Weight (kg)	68±12	71±12
BMI (kg/m^2)	13.32±4.80554	13.54±3.98591

Table 2. Pearson correlation (2-tailed) between the anthropometric parameters and BMD values of the studied population

Parameters	BMD L1-L4	BMD Femoral Neck	BMD Total Hip
Age	-0.308**	-0.375**	-0.287**
Weight	0.348**	0.411**	0.450**
Height	0.249**	0.246**	0.165**
BMI	0.224**	0.290**	0.376**

** Correlation is significant at the 0.01 level (2-tailed)
BMD=Bone mineral density, BMI=body mass index

While age, height, weight and BMI had significant effects on BMD values at both lumbar spine and total hip, gender failed to show such an influence on total hip (Table 3).

Table 3. Univariate analysis of the effects of the studied anthropometric variables on BMD values at L1-L4 and total hip

BMD	Anthropometric variables	F value	P value*
L1-L4	Weight	494.556	<0.0001
	Height	237.435	<0.0001
	Age	379.496	<0.0001
	sex	9.622	0.002
Total hip	Weight	911.284	<0.0001
	Height	100.035	<0.0001
	Age	322.328	<0.0001
	sex	5.427	0.020

* ANOVA

Weight was considered as a major factor affecting BMD values at both sites (L1-L4 and total hip). Forward Multiple Regression Analysis yielded a model for predicting BMD values at L1-L4 and total hip using weight as the strongest predictor. The model accounted for 22% of the variance of BMD at L1-L4, and 28% of the variance of total hip. The ratio of standardized coefficients of weight to age showed a twofold greater effect of weight on BMD at L1-L4 and total hip compared with age (Table 4).

Table 4. The confounding effects of the studied anthropometric variables on BMD values at L1-L4 and total hip

BMD	Anthropometric variables	B- Standardized coefficient *	r^2
L_1-L_4	**Weight**	0.303	0.216
	Height	0.116	
	Age	-0.265	
	sex	-0.032	
Total hip	**Weight**	0.456	0.278
	Height	-0.055	
	Age	-0.284	
	sex	0.030	

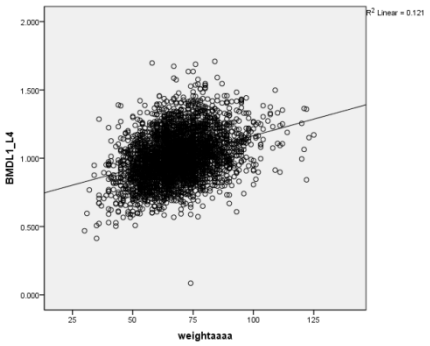
* ANCOVA

Assessing the results for adjusted data for sex and age revealed that the weight has the most partial correlation with BMD at total hip and femoral neck (Table 5).

Table 5. Partial correlation of age and sex-adjusted anthropometric parameters and BMD values

	BMD		
Control Variables	**L1-L4**	**Femoral Neck**	**Total hip**
Weight	0.351	0.429	0.458
Height	0.203	0.193	0.108
BMI	0.282	0.366	0.436

Partial correlation adjusted for sex and age



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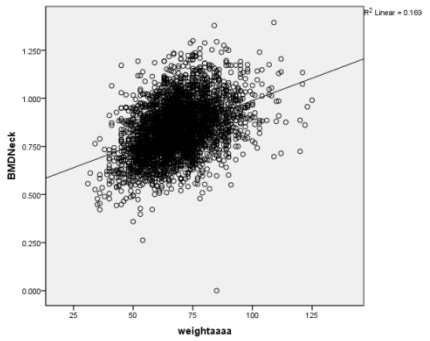

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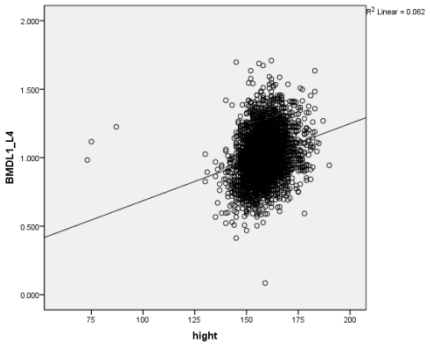

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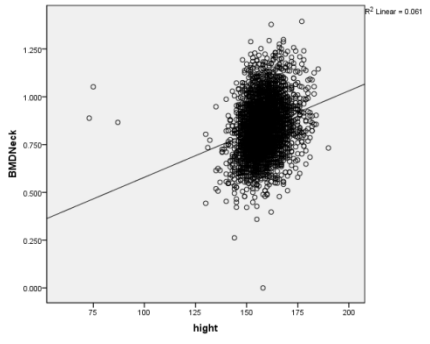

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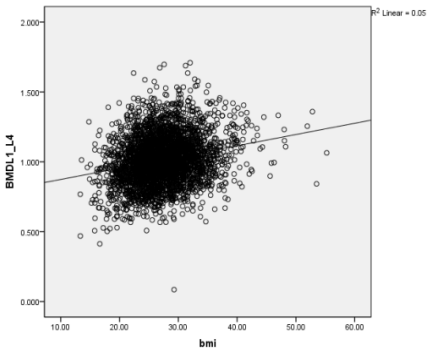

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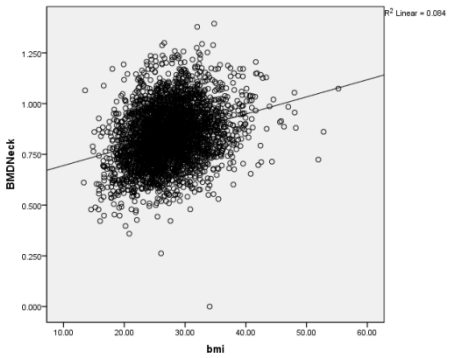

F

Figure 1. Showing correlation between some studied anthropometric parameters (A. weight and BMD L1-L4, B. weight and BMD Neck, C. height and BMD L1-L4, D. height and BMD Neck, E. BMI and BMD L1-L4, F.BMI and BMD Neck) in 3630 referent patients (3283 female and 347 male)

Scatter plots (bivariate) for weight, height and BMI have been separately showed in Figure 1 (A-F). It seems that body weight is the best determinant of BMD at L1-L4, femoral neck and total hip. Age has a substantially smaller effect and gender and height having the minimal effect.

Discussion

Osteoporosis is an important public health problem particularly in older adults. It is more common in postmenopausal women and not only gives rise to morbidity but also markedly diminishes the quality of life in this population. Many factors have so far been linked with osteoporosis and bone loss. Aging is considered as the strongest factor contributing to bone loss and osteoporosis (14). Nutritional factors, lifestyle habits, including the daily diet and physical activity, as well as anthropometric factors are other parameters ranking first in the long list of osteoporosis-related risk factors (16-19). Liu *et al., in* 2008 reviewed 167 studies

evaluated the risk factors linked with lower fracture risk in men and women. Increased age (>70 years), low body weight (20 < body mass index < 25 kg/m2), weight loss (>10%), physical inactivity, prolonged corticosteroid use and previous osteoporotic fracture were among the factors mentioned in this study. Relatively little is known about how weight or weight changes may cause clinically significant change in the precision error (20). The present study, which was conducted on the data gathered from a referral center, revealed that weight, BMI and age have the strongest correlation with BMD values at the studied sites. While age is negatively correlated with BMD values at all the studied sites, a positive association was noted between weight, height and BMI and these BMD parameters (P<0.01). This finding was also supported in several earlier studies that linked aging, which is accompanied with loss of fat-free mass or body muscle protein, with lower bone mineral density (21-23). Morin *et al*., also reported that higher weight is accompanied with increased bone mineral density and lower risk of fracture in women aged between 40 and 59 years (18). Sadatsafavi *et al*., and Welsman *et al*., reported that body weight and weight changes theoretically affect the precision of spine and hip density in DXA measurements (24,25). Saarelainen *et al.,* also reported that obesity (BMI of 30 kg/m2) delays the incidence of osteopenia by 5 years (at the spine) and 9 years (at the femoral neck). They suggested that high baseline BMD of the obese or the fact that higher fat mass in the obese alters X-ray attenuation can explain the finding (26). Zhao *et al.,* on the contrary revealed an inverse correlation between fat mass and bone mass when the mechanical loading effects of body weight on bone mass were controlled (27). Ozeraitiene *et al*., similarly, reported that women with osteoporosis were older and overweight, had lower height and body weight, indicating that fat reserves are significantly related to low bone mineral density (28). Dargent-Molina *et al*., concluded that selecting women for BMD testing based on their weight is the simplest, but most effective screening method for identifying osteoporotic women as well as those at high risk of fracture (29). Bhupathiraju *et al*., likewise, concluded that efforts to reduce abdominal obesity will not only reduce the risk of chronic disease but may also improve bone health (30). Similar to other studies, the present research is limited due to the nature of its cross-sectional design. Causal correlations should not be assessed based upon cross-sectional data, regardless of the sample size and accuracy. Despite the size and the strength of the correlations found between the studied clinical risk factors and BMD values, it is not possible to use these variables in practice until more robust evidence is provided by longitudinal data.

It could therefore be concluded that certain anthropometric parameters (BMI and weight) can considerably affect one's risk of developing osteoporosis. Weight, therefore, can be used as to screen those at risk of developing osteoporosis and its related complication; further research, however, are needed to assess the efficacy of weight in this regard. Moreover, considering the fact that fat mass as well as body fat and abdominal fat distribution can also influence bone mineral density (31), the effect of these variables on the association of weight and BMD should be studied in future research.

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