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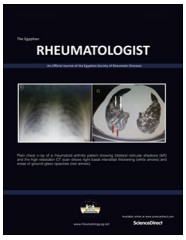

ORIGINAL ARTICLE

Association of bone mineral density and body mass index in a cohort of Pakistanis: Relation to gender, menopause and ethnicity

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KEYWORDS

Bone mineral density;
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Abstract *Aim of the work:* To assess association of body mass index (BMI) with bone mineral density (BMD) in a sample of Pakistanis and explore their relation with age, gender, menopausal status and ethnicity.

Patients and methods: A cross-sectional study at a tertiary care rehabilitation medicine center included apparently healthy individuals referred for an assessment of BMD through dual energy X-ray absorptiometry (DXA). Subjects with any associated disorder, history of malignancy, intake of steroids, or under osteoporosis treatment were excluded. Patients were sub-grouped according to the age ($\leqslant$50 and $>$50 years) and menopausal status. The ethnicity was based on the provinces the patients came from.

Results: Out of 600 people, 253 (42.2%) were males with a mean age of 65 $\pm$ 10 years (range: 28–100 years) and 347 (57.8%) were females (56 $\pm$ 10 years; range: 18–92 years). The majority of males had normal BMI and osteopenia while majority of females were overweight and had osteopenia. Most individuals among sub-groups based on age and menopausal status had their BMI in the overweight range. The mainstream of the subjects $\leqslant$50 years and premenopausal women had a normal BMD and those $>$50 years had osteopenia. The majority of postmenopausal women had osteoporosis. The ethnicity (based on provinces) did not affect BMI or BMD. In both genders, the underweight individuals were more likely to develop osteoporosis than individuals who were overweight or had normal BMI.

Conclusions: Majority of Pakistani women were overweight while men had a normal BMI. Younger age and premenopausal status was directly associated with a normal BMD. Both genders were significantly prone to have a low BMD if they had a lower BMI.

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1. Introduction

Osteoporotic fractures are a serious health problem all over the world. Worldwide, osteoporosis causes more than 8.9 million fractures annually. In other words, it means an osteoporotic fracture every three seconds [1]. The combined lifetime risk for hip, forearm and vertebral fractures coming to clinical attention is around 40%, equivalent to the risk for cardiovascular diseases [2]. Of interest, the knowledge of osteoporosis among Alexandrian women was moderate as regards its risk factors, preventive measures and consequences [3].

Osteoporotic fractures are directly related to the bone strength. Bone strength is measured through bone mineral density (BMD), which refers to the amount of mineral per unit of space or mass per volume of the bones. There are many factors influencing BMD and the probability of osteoporotic fractures. Among these, age, gender, race, height, weight, and body mass index (BMI) are considered independent predictors of osteoporotic fractures [4]. It has been reported that the fat mass has a role in bone metabolism [5] and osteoarthritis does not prevent the occurrence of osteoporosis [6] in postmenopausal women.

So far, the research on osteoporosis and osteoporotic fractures in Pakistan is limited. With this study, we intended to add additional information to the current data with an aim to improve country-level preventive strategies. It would also supplement important information to the global statistics especially focused on developing countries. The study was aimed at assessment of the association of BMI with BMD in a sample of Pakistani men and women. Exploring association of BMI and BMD with age, gender, menopausal status, and ethnicity based on provinces were secondary goals.

2. Patients and methods

The cross-sectional study was done at Armed Forces Institute of Rehabilitation Medicine, Rawalpindi, Pakistan, which is a tertiary-care rehabilitation center, from January 2010 to 2014. Before commencing the study, the permission was acquired from hospital committee on research ethics. All included subjects gave an informed consent.

Apparently healthy individuals referred for an assessment of BMD through dual energy X-ray absorptiometry (DXA) scan were included. Subjects with rheumatoid arthritis, thyroid, parathyroid, adrenal, hepatic or renal disorders, history of malignancy, history of intake of steroids, thyroxin or anticonvulsants or under osteoporosis treatment were excluded. Height and weight were recorded in centimeters and kilograms respectively and the body mass index (BMI) was calculated. The subjects were submitted to DXA examination using Discovery BMD analysis machine (Discovery A; Hologic, Bedford, MA) according to the manufacturer's guidelines. To ensure that the measurement is reliable, a standard phantom was scanned daily before starting the tests and the machine was recalibrated to adjust for potential changes. DXA measurements were taken at the lumbar spine (L2 → L4) and at both femoral necks. The lowest BMD was noted and expressed in the form of T-score.

After calculation of BMI and DXA estimation for BMD, the sample was sub-grouped into "underweight", "normal" and "overweight" based on the BMI (BMI <18.5, 18.5–24.9 and >24.9 respectively) and sub-grouped into "normal", "osteopenia" and "osteoporosis" based on the BMD (T-score >-1, -1.1 to 2.5 and <-2.5, respectively) according to the World Health Organization guidelines [7,8]. For identification of the effect of age on BMI and BMD, the sample was also sub-grouped into "$\leqslant 50$ years" and ">50 years". The age limit of 50 years was selected because there are more chances of having low BMD and increased fracture risk at age over 50 years [2,9]. The women in the sample were further grouped into pre- and postmenopausal based on their menopausal status. The provinces were used as markers of ethnicity because the ethnicity and ethnic conflicts in Pakistan are primarily determined by provinces that generally share common cultural and linguistic traits [10,11]. Thus, the sample was divided into people hailing from Punjab, Sindh, Khyber Pakhtunkhwa, Balochistan or Azad Jammu and Kashmir as in previous studies from the same center [12,13].

2.1. Statistical analysis

Using Statistical Package for Social Sciences version 20 (IBM Corp., Armonk, NY, USA), descriptive statistics were performed. Univariate analysis using general linear model was used to find the association between BMI and BMD, and of age, gender, menopausal status, and ethnicity based on provinces. During analysis of BMI and BMD with age, gender, menopausal status, and ethnicity based on provinces, the other variables were taken as covariates being potential cofounders. A p-value < 0.05 was considered significant.

3. Results

Out of 600 people, 253 (42.2%) were males with a mean age of 65 ± 10 years (range: 28–100 years) and 347 (57.8%) were females (mean age 56 ± 10 years; range: 18–92 years). One patient failed to get a measurement of BMI and BMD and was excluded while analyzing the association of BMI and BMD with other variables. Among 347 females, 195 had reached menopause, 72 were still having menstruation while 80 denied to comment on the question (Table 1).

Bulk of the sample was overweight, in the age-group of >50 years, that hailed from the Punjab province and had BMD in the osteopenia range (Table 1). Majority of males had a normal BMI and BMD in the osteopenia range (Table 2). Majority of females were "overweight" and had BMD in the osteopenia range. Most individuals among both age groups were having BMI in the "overweight" range. The mainstream in the age group $\leqslant 50$ years had a normal BMD while most individuals in the age group >50 years had a BMD in the osteopenia range. The relationship of BMI and BMD with menopausal status and ethnicity based on provinces is provided in Table 2.

Considering the relation of BMI with BMD, in males, the underweight individuals were more likely to develop osteoporosis than individuals who were overweight or had normal BMI ($p < 0.001$). In females too, the underweight individuals were more likely to develop osteoporosis than individuals who were overweight or had normal BMI ($p < 0.001$) (Table 3).

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Table 1 Demographic features (age, gender, ethnicity and body mass index) and bone mineral density in Pakistani individuals.

Variable		Pakistanis (n = 600) n (%)
Age	⩽50 years	124 (20.7)
	> 50 years	476 (79.3)
Gender	Male	253 (42.2)
	Female	347 (57.8)
Meno-pausal status	Reached menopause	195 (73)
	Continuing menstruation	72 (27)
Ethnicity		
Province	Punjab	422 (70.3)
	KP	81 (13.5)
	AJ & K	65 (10.8)
	Sindh	23 (3.8)
	Baluchistan	9 (1.5)
BMI	Underweight	31 (5.2)
	Normal	220 (36.7)
	Overweight	348 (58)
	Normal	189 (31.5)
BMD	Osteopenia	237 (39.5)
	Osteoporosis	173 (28.8)

BMI, body mass index; BMD, bone mineral density; KP, Khyber Pakhtunkhwa; AJ & K, Azad Jammu and Kashmir. Eighty women did not comment on their menopausal status. One patient was unable to submit his weight and height or his BMD.

4. Discussion

In this study, it was found that the majority of men had a normal BMI while the majority of women were overweight. Previous studies carried out in Pakistan have generally shown a female predisposition for being ''overweight''. Nazli et al. discovered that 53.4% of women living in the rural areas of Peshawar were ''overweight'' [14]. Jafar et al. analyzed data for 8972 people aged 15 years or more from the National Health Survey of Pakistan (1990–1994) and noticed that being female was independently and significantly associated with being ''overweight'' or ''obese'' [15]. Khan et al. reported a double percentage of females having abdominal obesity than males with the same risk factors [16]. Globally, a review of gender disparities in obesity abstracted that, overall, more women are obese than men [17]. Nazli et al. attributed this predisposition to pregnancies that the women have, and social restrictions prevalent in our society that bind women to stay at home and abstain from going outside for walk or outdoor activities [14].

Nazli et al. also found a statistically strong association between obesity and age, which, according to the authors, could be credited to a decreased physical activity with increasing age [14]. Jafar et al. too, discovered that advancing age was independently and significantly associated with being overweight or obese [15]. No relation of age and menopausal status with BMI was found in this study as the majority among all sub-groups was having BMI in the ''overweight''

Table 2 Differences in age, gender and ethnicity (based on provinces) according to the body mass index and bone mineral density in Pakistani individuals.

Variables n (%)		BMI			p	BMD			p
		Under-weight	Normal weight	Over-weight		Normal	Osteo-penia	Osteo-porosis	
Age									
	⩽50 years	6 (4.8)	32 (25.8)	86 (69.4)	< 0.001	68 (54.8)	41 (33.1)	15 (12.1)	< 0.001
	> 50 years	25 (5.3)	188 (39.6)	262 (55.2)		121 (25.5)	196 (41.3)	158 (33.3)	
Gender									
	Males	13 (5.2)	127 (50.4)	112 (44.4)	< 0.001	79 (31.3)	105 (41.7)	68 (27)	< 0.001
	Females	18 (5.2)	93 (26.8)	236 (68)		110 (31.7)	132 (38)	105 (30.3)	
Menopausal status									
	Reached menopause	12 (6.2)	52 (26.7)	131 (67.2)	0.39	30 (15.4)	77 (39.5)	88 (45.1)	< 0.001
	Continuing menstruation	4 (5.6)	22 (30.6)	46 (63.9)		61 (84.7)	10(13.9)	1 (1.4)	
Ethnicity									
Province	Punjab	20 (4.8)	163 (38.7)	238 (56.5)	0.09	135 (32.1)	175 (41.6)	111 (26.4)	0.1
	KP	5 (6.2)	16 (19.8)	60 (74.1)		24 (29.6)	26 (32.1)	31 (38.3)	
	AJ & K	5 (7.7)	25 (38.5)	35 (53.8)		19 (29.2)	26 (40)	20 (30.8)	
	Sindh	1 (4.3)	11 (47.8)	11 (47.8)		9 (39.1)	6 (26.1)	8 (34.8)	
	Baluchistan	0 (0)	5 (55.6)	4 (44.4)		2 (22.2)	4 (44.4)	3 (33.3)	

BMI, body mass index; BMD, bone mineral density. KP, Khyber Pakhtunkhwa; AJ & K, Azad Jammu and Kashmir.

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Table 3 Relation of the bone mineral density (BMD) with the body mass index (BMI) according to the gender of the Pakistani individuals.

	Variables	Pakistani individuals (n = 600)							
		Men (n = 253)			p	Women (n = 347)			p
		BMI				BMI			
		Under-weight	Normal weight	Over-weight		Under-Weight	Normal weight	Over-weight	
BMD	Normal	–	27 (21.3)	52 (46.4)	< 0.001	2 (11.1)	21 (22.6)	87 (36.9)	< 0.001
	Osteopenia	6 (46.2)	65 (44.1)	43 (38.4)		2 (11.1)	33 (35.5)	97 (41.1)	
	Osteoporosis	7 (43.8)	44 (34.6)	17 (15.2)		14 (77.8)	39 (41.9)	52 (22)	

BMI, body mass index; BMD, bone mineral density.

range. Similarly, the BMI did not, statistically, appear to be influenced by ethnicity based on provinces.

It was observed that most of the individuals in the age group $\leqslant$50 years had a normal BMD while most individuals in the age group $>$50 years had a BMD in the osteopenia range. The gender did not appear to affect BMD as both genders had BMD in the osteopenia range, however, postmenopausal women were significantly more in number to have osteoporosis than women still having menstruation. The ethnicity based on provinces had no significant association with the BMD. Age and menopause are unquestionably independent risk factors for osteoporosis and osteoporotic fractures. A Chinese study found that total hip and femoral neck BMD decreased with age [18]. An Iranian study confirmed that age $>$70 years and years that have elapsed since menopause were the most important risk factors for predicting osteoporosis even after adjusting for other variables [19]. Other studies have also suggested age and menopause as inevitable risk factors for osteoporosis [20,21].

From numerous study results that investigated factors affecting BMD in postmenopausal women, a positive association has been reported between BMD and BMI [12–24]. After adjustment of several factors, BMI was recently found to be positively related to BMD in a cohort of Korean women [20]. A study from the neighboring country India, concluded that high BMI or body weight significantly correlated with bone acceleration in both men and women while lower body weight was associated with a lower BMD [25]. A study from the other neighboring country Iran, concluded that BMI and weight were directly associated with BMD of hip and vertebrae and being ''overweight'' and ''obese'' decreased the risk for osteoporosis [26]. In Pakistan, the relevant data had been quite variable. A Pakistani study carried out in the suburbs of Karachi concluded that obese women had significantly higher BMD values over hip and femoral neck than non-obese women [27]. Another Pakistani study, on the other hand, failed to demonstrate a significant relationship between BMI and BMD of pre and postmenopausal women [28]. In this study, a positive relationship was discovered between BMI and BMD as the underweight males were more likely to develop osteoporosis than individuals who were overweight or had normal BMI. Likewise, in females, the underweight individuals were more likely to develop osteoporosis than individuals who were overweight or had normal BMI. In the literature, some studies are still inconclusive in this respect, and differ on opinion of considering low BMI a risk factor for reduced BMD and osteoporosis [23,29,30].

How obesity exerts positive effects on BMD, the mechanisms are still not entirely clear. It is presumed that the adipose tissue secretes many adipokines that produce bone remodeling through effect on bone formation and resorption. The bone, also works as an endocrine organ and affects glucose homoeostasis and body weight through the actions of bone-derived factors such as osteocalcin and osteopontin [30–33]. This positive feedback through bone-adipose tissue axis maintains both BMI and BMD [31–33]. Obesity is also associated with better BMD because of the conversion of androgen to estrogen in the adipose tissue [34], which improves bone mass in both men and women [35].

This study had a few limitations. First, the cross-sectional design did not permit verification of a causative relationship between BMI and bone characteristics. In addition, we did not collect history about lifestyle and dietary habits that might have acted as co-founding factors in our study. Lastly, we did not calculate association between BMI and fracture risk.

The results of this study are pertinent to Pakistan but can be applied to the people of the south Asian region, and other developing countries and would help in upgrading the preventive strategies against obesity and osteoporosis. Further research is needed to evaluate the reasons of unexpectedly high incidence of osteopenia in male Pakistani population. The association of fracture risk and BMI also needs to be studied in future studies.

In conclusion, majority of women in this study were overweight while the men had a normal BMI. Younger age and premenopausal status was directly associated with a normal BMD. The ethnicity based on provinces did not affect BMI or BMD. Both genders were significantly prone to have low BMD if they had a low BMI.

Disclosures

Part of the research has been presented as a poster presentation in 2nd International and 4th National Conference, Physical Medicine and Rehabilitation, held at Ayub Auditorium, Army Medical College, Rawalpindi, Pakistan; 10–12 April, 2015.

Conflict of interest

None.

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