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Original Article

Bone Mineral Density of the Spine and Femur in Healthy Moroccan Women

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Abstract

Bone mineral density (BMD) measurements using dual-energy X-ray absorptiometry (DXA) are widely used to diagnose osteoporosis and assess its severity. Previous studies show the necessity to establish reference data for bone mass measurements for each particular population. Such data are lacking for the Moroccan population. The aim of this study was to determine spine and femur BMD reference values for the Moroccan female population and to compare them with values from western and other Arab countries. A cross-sectional study of 569 Moroccan women, (randomly selected in the area of Rabat, the capital of Morocco, aged between 20 and 79 yr) was carried out to establish reference values of BMD. Measurements were taken at the lumbar spine and proximal femurs using DXA (Lunar Prodigy Vision, GE). The data were compared with published normative data taken by United States (U.S.), European, Kuwaiti, Lebanese, and Saudi women over 6 decades of age. The percentage of osteoporosis in postmenopausal women using our reference curve was compared to that observed when the other curves (US, European and Arab) implemented in the Lunar machine was used. Our results showed that the Moroccan women showed the expected decline in BMD at both sites with age after peaking at 20–29 years of age. Moroccan females have lower BMD at the spine than U.S., Europeans, and Kuwaitis (approximately 10–12% for patients older than 50 yr). The BMD values of the total femur in Moroccan females were close to western (European and American), and Kuwaitis, but higher than Lebanese and Saudis. Using our reference database, 37.9% of postmenopausal women had spine osteoporosis vs. 39.6% and 23.4% using US/European and Arabic Lunar reference values respectively. At the femurs, 6.7% had osteoporosis vs. 2.5% using the Arabic Lunar reference values. In conclusion, our study emphasizes the importance of using population-specific reference values for BMD measurements to avoid over or underdiagnosis of osteoporosis.

Key Words: Bone mineral density; DXA; healthy population; Morocco; osteoporosis.

Introduction

Osteoporosis is a worldwide public health problem. Bone densitometry has become the ''gold standard'' in its diagnosis, treatment evaluation, and research. The World Health Organization (WHO) has established dual X-ray absorptiometry (DXA) as the best densitometric technique for assessing bone mineral density (BMD) in postmenopausal women, and based the definitions of osteopenia and osteoporosis on its results *(1–3)*. In clinical practice, BMD measurements are widely used to diagnose osteoporosis and to assess its severity, and changes in bone mass are commonly used as a surrogate for fracture risk. The BMD values (in g/cm^2) are not used for diagnosing osteoporosis. Instead, experts convened by the WHO proposed to define osteoporosis on the basis of

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the T-score, which is the difference between the measured BMD and the mean value of young adults expressed in standard deviations (SDs) for a normative population of the same ethnicity *(4)*. Despite its limitations *(5)*, this definition is currently applied worldwide. Thus, the WHO diagnostic criteria for osteoporosis define osteoporosis in terms of a T-score below −2.5. However, the interpretation of the BMD data generated by DXA systems raises many problems in clinical practice *(6–9)*. There may be an apparent discrepancy in the proportion of patients diagnosed to have osteoporosis by 6% to 15% when examinations are performed by different DXA manufacturers *(10)*. Moreover, manufacturers use reference values based on a United States (U.S.) and/or northern European adult population, which will influence the interpretation of BMD data in other populations with different genetic, geographic, and socioeconomic characteristics *(11–14)*. It has been well recognized that there are racial/ethnic differences in BMD values. If the reference values are not correct, there will be obvious consequences on the classification of subjects. These data show the necessity to establish reference data for bone mass measurements and also patterns of bone loss for each particular population.

Recently, several studies on Middle-Eastern Arab populations were conducted, and they showed important differences with western BMD values *(15–19)*. Studies of a BMD reference curve have never been done in Morocco nor have they been done in the adjacent countries of the South bank of the Mediterranean Sea. As no Moroccan reference data exists, clinical practice in Morocco has been to use data for Caucasian females to assess T-scores and Z-scores, even though commercial DXA systems now offer the option of comparison with an Arab reference population based on studies from the Middle East. Osteoporotic hip fracture incidence, which is frequently used as an indicator of the prevalence of osteoporosis, has been shown in a previous study to be lower among Moroccans than in the U.S./Western European populations and Middle-Eastern Arab populations, and is slightly higher than that reported for sub-Saharan countries *(20)*.

Thus, we aimed in this study to establish reference values for the healthy Moroccan female population and to compare them with those for occidental and Arab females, and look for the impact on the diagnosis of osteoporosis when different reference data are used.

Subjects and Methods

Subjects

A total of 569 healthy Moroccan women (age range: 20–79 yr) living in the Rabat area participated in the present study. Rabat is the capital of Morocco with a diverse population representing most Moroccans. Morocco has a population of 29,891,708 (2004 population Census), most of whom are Caucasians, and Rabat is a modern city of 627,932 inhabitants (50.2% female). It is divided in multiple census districts by the Census Department of the Ministry of Health. Originally, a total of 659 subjects were randomly selected using a cluster sampling method from 30 Census districts scattered around the city of Rabat from April until August 2005 to ensure that the average health status of the study group would reflect a normal adult population. Moreover, the sample was weighted to the Moroccan population pyramid of age. Subjects who agreed to participate in the survey were asked to visit our department to be enrolled in the present study. Each subject completed a standardized questionnaire designed to document putative risk factors of osteoporosis. The questionnaire was administered during the home visit together with an invitation to enter the study. The questionnaire collected information on life style, smoking habits, and level of physical activity in leisure time, along with calcium consumption and the use of vitamins and medications. Menstrual and reproductive histories were assessed. Premenopausal was defined as subjects having one or more menstrual bleedings during the last year. Postmenopausal was defined as those who had their last menstrual period >1 year prior in accordance with clinical definitions of the WHO. Height and weight were measured in our center before DXA measurement with light indoor clothes on, but without shoes. Body mass index (BMI) was calculated by dividing weight in kilograms by height in meters squared.

General exclusion criteria were non-Caucasian origin, diseases, drugs, and other major determinants known to affect bone metabolism. Thus, we excluded subjects with gastrectomy, intestinal resection, recent hyperthyroidism or hyperparathyroidism, treatment with corticosteroids, or recent severe immobilization. Subjects from the postmenopausal group who had taken estrogens earlier (at least during the 2 years after menopause) or who still were taking estrogens for more than 6 months were excluded, as well as those who had taken oral corticosteroids for more than 6 months. We did not exclude individuals using inhalation steroids. Women using medications affecting calcium metabolism and those with medical conditions known to affect bone metabolism (e.g., amenorrhea, anorexia nervosa, premature ovarian failure) or with a history of any fracture or major systemic disorder were excluded. Also excluded were women who had experienced an early menopause (i.e., before 40 yr of age). We did not exclude subjects with certain lifestyle habits, such as heavy smoking, being sedentary, being athletic, or having a high or low calcium intake, which are examples of voluntary factors that may have some impact on bone metabolism.

In total, 808 women were visited. Among them 178 individuals were excluded from the study according to predetermined exclusion criteria, whereas 630 met all inclusion criteria and were invited to participate in the BMD measurement. Finally, 569 individuals (90.3% of participating females) responded and entered the reference population sample (i.e., 210 premenopausal [36.9%] and 359 postmenopausal [63.1%] women). The BMD of their lumbar spine and proximal femurs were measured. All of them gave informed consent. All subjects were fully ambulatory. The age distribution, age at menarche, years since menopause, and some other basic parameters are shown in Table 1.

Table 1
Characteristics of the Study Population

Characteristic	Mean (SD)	Minimum	Maximum
Age (yr)	50.2 (14.3)	20	79
Weight (kg)	70.4 (12.5)	40	115
Height (cm)	157.6 (6.1)	141	178
BMI (kg/m^2)	28.3 (5.1)	16.8	48.8
Pregnancies	3.4 (3.0)	0	14
Age at menarche (yr)	13.0 (1.1)	9	17
Age at menopause (yr)	49.3 (5.1)	41	59
Years since menopause (yr)	6.3 (7.6)	1	35
	n (%)		
Low calcium intake	313 (55)		
Low physical activity	433 (76.1)		

Abbr: BMI, bone mass index; SD, standard deviation.

BMD Measurement

Bone mineral density was determined by a Lunar Prodigy Vision DXA system (Lunar Corp., Madison, WI). The DXA scans were obtained by standard procedures supplied by the manufacturer for scanning and analysis. All BMD measurements were carried out by 2 experienced technicians. Daily quality control was carried out by measurement of a Lunar phantom. At the time of the study, phantom measurements showed stable results. The phantom precision expressed as the coefficient of variation percentage was 0.08. Moreover, reproducibility has been assessed recently in clinical practice and showed a smallest detectable difference of 0.04 g/cm^2 (spine) and 0.02 (hips) *(21,22)*. Patient BMD was measured at the lumbar spine (anteroposterior projection at L1−L4 and L2−L4, but only L2−L4 results were presented to be compared with the published studies, which all used this site) and at the femurs (i.e., femoral neck, trochanter, ward, and total hip). The obtained reference curves were compared with studies that used a GE Lunar as in the present survey.

Statistical Analysis

Results are presented as means (±SD) and categorical variables are expressed as frequencies. Associations between continuous variables were examined by Pearson correlation coefficient. Analysis of variance was used to examine differences among the groups for different variables. The regression of BMD against age was performed using linear regression. The level for significance was taken as $p < 0.05$. Excel 2003 and SPSS 13.0 were used for statistical analysis.

Results

The basic anthropometric characteristics of the 569 females studied are presented in Table 1. Their mean weight was 72.3 ± 12.5 kg, their mean height was 157.6 ± 6.3 cm, and their mean body mass index 28.3 ± 5.2 kg/m^2. The body weight and BMI increased with age; the weight difference of 20−79 yr olds was 7.7 kg ($p < 0.0001$) with a corresponding BMI difference of 6.3 ($p < 0.0001$) (Table 2). Height declined with age: the height difference 20−79 was 9.2 cm ($p < 0.0001$).

Subjects were divided into six decade subgroups for cross-sectional analysis. The number of Moroccan subjects was highest in the 50−59 yr age group. The data showed that mean BMD value of the spine of Moroccan females was declining with age, especially in their menopausal period with accelerated decline after age 50 yr. The peak BMD of the spine and proximal femurs was reached in the third decade of life. Table 3 shows the BMD of the normal Moroccan females in five skeletal sites. Moroccan women exhibited a similar pattern of decrease in BMD that was also described for U.S., European, Lebanese, Saudi, and Kuwaiti reference values (Fig. 1).

The influence of age on the BMD results was examined by regression analysis (Table 4). In females of 50 to 79 yr of age, significant decreases (% per year) in L2−L4 BMD (0.7%) and femoral BMD subregions were observed (i.e., the neck [0.7%], Ward's triangle [0.9%], and the trochanter [0.5%], respectively.

Age-Related Changes: Lumbar Spine

The spine BMD values between 20−29 yr were defined as the peak bone mass values. Between 40 and 59 yr, there was a linear decline of BMD (equivalent to a decrease of approximately 13% or 0.6% per yr). The apparent decrease was slightly less between 60 and 79 yr (-0.35% per yr).

In Fig. 1A, the spine BMD of the Moroccan females is compared with the Kuwaiti, Saudi, and Lebanese women data for the Arab countries and with the U.S. and Europeans for occidental countries. In general, Moroccan females have lower BMD at the spine than the U.S. and Northern Europeans and Kuwaitis (about 2% at age 20−29 yr and 10−12% for patients older than age 50 yr). Compared with Lebanese women, Moroccans had higher BMD values at age 20−29 yr (6%) but lower values after 50 yr old

Table 2
Height, Weight, and Body Mass Index in Normal Moroccan Women by Age Groups

Age group (yr)	*N*	Height (cm) (mean ± SD)	Weight (kg) (mean ± SD)	BMI (kg/m^2) (mean ± SD)
20−29	71	162.2 ± 5.0	64.0 ± 10.5	24.3 ± 4.1
30−39	72	159.6 ± 5.6	68.6 ± 12.2	27.0 ± 4.7
40−49	89	158.4 ± 5.6	71.1 ± 12.1	28.1 ± 4.7
50−59	175	156.9 ± 5.9	72.9 ± 12.8	29.5 ± 4.9
60−69	119	155.4 ± 6.1	70.5 ± 12.5	29.1 ± 5.0
70−79	43	153.4 ± 5.8	71.7 ± 14.2	30.6 ± 5.7

Abbr: BMI, bone mass index; SD, standard deviation.

Table 3
Age Change in Posteroanterior Spine and Femur Bone Mineral Density (g/cm^2)

Age group (yr)	*N*	L2−L4 (mean ± SD)	Femoral neck (mean ± SD)	Trochanter (mean ± SD)	Ward (mean ± SD)	Total hip (mean ± SD)
20−29	71	1.156 ± 0.12	1.026 ± 0.12	0.815 ± 0.11	0.915 ± 0.15	1.029 ± 0.11
30−39	72	1.134 ± 0.12	0.983 ± 0.14	0.792 ± 0.12	0.849 ± 0.13	1.003 ± 0.12
40−49	89	1.100 ± 0.13	0.939 ± 0.13	0.789 ± 0.11	0.781 ± 0.15	0.991 ± 0.13
50−59	175	0.974 ± 0.13	0.866 ± 0.12	0.731 ± 0.08	0.688 ± 0.13	0.918 ± 0.13
60−69	119	0.922 ± 0.15	0.802 ± 0.09	0.696 ± 0.08	0.624 ± 0.10	0.867 ± 0.11
70−79	43	0.863 ± 0.16	0.723 ± 0.14	0.637 ± 0.16	0.528 ± 0.10	0.790 ± 0.12

Abbr: SD, standard deviation.

(3−6%). However, versus Saudis, Moroccans had higher BMD values (6% at 20−29 yr and 5−11% after 60 yr old).

Age-Related Changes: Proximal Femurs

The BMD of the femoral neck decreased progressively with age, with an increase in the rate of decline after the decade 40−49 yr, persisting up to 79 yr (Table 4; Fig. 1B). The peak BMD of the total femur and femoral neck of the Moroccan women was reached as the Caucasians' peak in the age group 20−29 yr. Between 20 and 40 yr there was a linear decline of BMD (equivalent to a decrease of approximately 2.5% or 0.12% per yr. The apparent decrease was steeper between 40 and 79 yr -0.73% per yr, with a total loss of 25.5%. The Moroccan females BMD values in all the femur regions were slightly higher than U.S./Europeans (3% in the age group 20−29 yr and 3−6% in 50−79 yr). The total femur BMD values for the Moroccans were also 6−13% higher than the values for Lebanese and Saudis values. However, the femur BMD values were slightly lower than Kuwaitis (about 0−2% at all age groups).

Impact on Subjects' Classification

We compared (Table 5) the postmenopausal women classification according to the WHO criteria using the personalized curve, the U.S. (National Health and Nutrition Examination Survey for the femur and manufacturer standards for the lumbar spine), European and Middle-Eastern (Maalouf et al. *[15]*) reference curves as implemented in the Lunar densitometers. The estimates using our reference curve were close in all sites to that given when the European curve was used. However, using Maalouf et al. *(15)* curve for the femurs resulted in underdiagnosis of osteoporosis (2.5% vs. 6.7%), whereas in the spine, the U.S./European Lunar reference values classified a larger proportion of women as osteoporotic (39.6% vs. 37.9%), whereas using the Arabic Lunar reference values, only 23.4% were classified as osteoporotic.

Discussion

It has been well recognized that there are racial/ethnic differences in BMD values *(23)*. Reference values have been shown to be virtually identical in different white populations *(24−28)*. The BMD values in black subjects were found to be about 8−12% higher than in Caucasians *(29)*, whereas Asian women have lower BMDs than Caucasians, this difference being partially attributed to smaller body size *(30,31)*.

There have been several recent BMD studies in Arabian populations *(15−19)*. A study of the BMD values in normal Lebanese subjects *(15)* found BMD values taken at the lumbar spine to be around 8% lower than U.S./European values between ages 20 and 59 yr, and 5−6% lower for older subjects. Femoral neck BMD values were 8% lower in young adults (age 20−39 yr), but only 2−3% lower in the postmenopausal years. Studies of Saudi females *(16)* found BMD values to be about 5% lower than the U.S./European women, despite that Saudi women having a higher average body

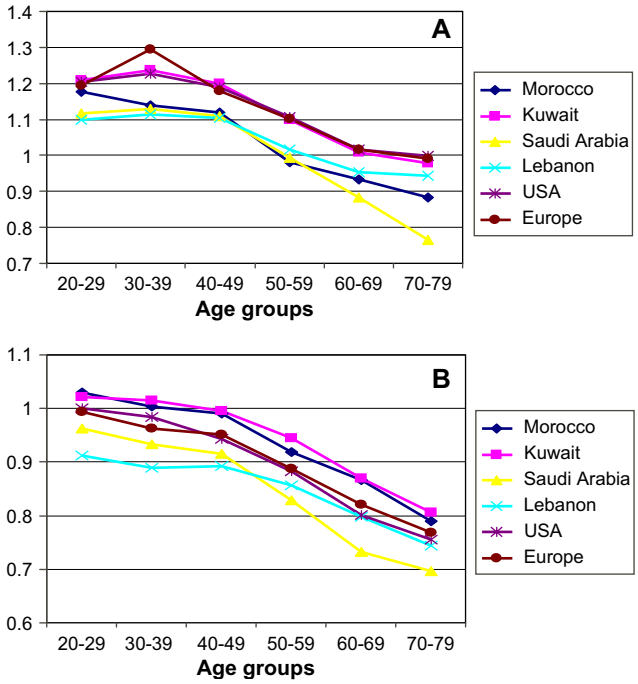

Fig. 1. Bone mineral density (g/cm^2) of Moroccan women at the (**A**) spine and (**B**) femur compared with United States, European, and other Arab women.

Table 4
Simple Linear Regression Model of BMD Over Age and Percentage of Bone Loss Between 20 and 79 Years of Age (n = 569)

Region	Equation	r	*p*	Percentage of loss at 20–79 yr	
				Total	Per yr
Spine	$1260 - 0.063 \times$ age	−0.51	<0.0001	29	0.5
Femoral neck	$1103 - 0.061 \times$ age	−0.60	<0.0001	30	0.5
Trochanter	$1001 - 0.077 \times$ age	−0.41	<0.0001	18	0.3
Ward's triangle	$0.867 - 0.035 \times$ age	−0.65	<0.0001	38	0.6
Total hip	$1100 - 0.047 \times$ age	−0.47	<0.0001	25	0.4

Abbr: BMD, bone mineral density.

weight and body mass index than their Caucasian counterparts. The BMD values of Kuwaiti females were similar to their Caucasian counterparts and significantly higher than those for Lebanese and Saudi women, especially for premenopausal women *(18)*. In comparison with the other Arab countries, the spine BMD of Moroccan women were lower than the Kuwaitis, but higher than the Saudi and Lebanese females. The Saudi women were found to be heavier than the Kuwaiti women in all ages. The differences in BMD values between Kuwaiti and Saudi females were thought to be a result of the differences in exercise and lifestyle. Among factors influencing reference values, body weight and obesity are well known to correlate well positively with BMD *(32–35)*. Our population study had a mean BMI of 28.3 kg/m^2 which is higher than the values reported in Western populations (about 24 in most series). It was also higher than the BMI of the Lebanese *(15)*. The Moroccan females in all age groups weighed more than the Kuwaiti females, but were close to Saudi and Qatari females. Also, the Moroccan society as in all Arab countries, is conservative. Women wear heavy clothes and are rarely exposed to the sun despite sunshine most of the year. Furthermore, most females have a sedentary lifestyle with very little outdoor activities (76% of the population study), low calcium intake (55% in our study), multiparity (mean: 3.4 in our study), and lactation, which are well recognized as important osteoporosis risk factors.

Reference BMD values are now available for many populations. The results of the present study strongly support the notion that population-based variations in BMD values exist, which enforces the need to establish local reference BMD values for each population to allow correct interpretation of DXA measurements *(36)*. Even BMD values were close to European values (especially at the femurs); the results of the present study show the wide discrepancies in the percentage of Moroccan women classified with spine osteoporosis when data from the manufacturer's database or our current study are used.

The present study is the first large-scale report on reference values on the BMD of the lumbar spine and the femur (including subregions of trochanter, Ward's triangle, and neck) in randomly selected healthy ambulatory Moroccan women of various age groups (20–79 yr) with defined exclusion criteria.

The main limitation of our study lies in the study of the population of a single city to establish a reference database for the whole country. However, the procedures used to select

Table 5
Classification of the Postmenopausal Women According to WHO Criteria Using Our Normative Curve or Some Manufacturer-Provided Reference Values

	U.S. reference (%)	European reference (%)	Middle-East reference (%)	Moroccan reference (%)
L2–L4				
Normal BMD	22.8	22.8	36.8	26.2
Osteopenia	37.6	37.6	39.8	35.9
Osteoporosis	39.6	39.6	23.4	37.9
Total hip				
Normal BMD	45.7	46.8	66.0	46.8
Osteopenia	46.2	46.5	31.5	46.5
Osteoporosis	8.1	6.7	2.5	6.7

Abbr: BMD, bone mineral density; WHO, World Health Organization.

subjects, who were all randomly selected from the general population of this cosmopolite important city support the general conclusions of the study. Another limitation is the absence of the BMD-fracture risk relationship evaluation. Further studies are needed in this connection.

In conclusion, a Moroccan reference BMD for women has been established for the lumbar spine and proximal femur on a randomly selected sample of adequate size and weighted to the Moroccan population. We found that the reference curve for the lumbar spine is significantly different from the Caucasian normative data reported by the manufacturer, and this has a significant impact on subject classification according to the WHO criteria. For the femur, slight discrepancies in mean values and standard deviation were found.

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