Bone xxx (2009) xxx–xxx

Contents lists available at ScienceDirect

Bone

journal homepage: www.elsevier.com/locate/bone

# Bone mineral density of the spine and femur in a group of healthy Moroccan men

A. El Maghraoui [a,*], M. Ghazi [a], S. Gassim [a], A. Mounach [a], I. Ghozlani [a], A. Nouijai [a], L. Achemlal [a], A. Bezza [a], M. Dehhaoui [b]

[a] Rheumatology and Physical Rehabilitation Department, Military Hospital Mohammed V, Rabat, Morocco
[b] Statistics Department, Agronomic and veterinary institute Hassan II, Rabat, Morocco

ARTICLE INFO

*Article history:*
Received 1 September 2008
Revised 19 November 2008
Accepted 29 December 2008
Available online xxxx

Edited by: H. Genant

*Keywords:*
Bone mineral density
DXA
Osteoporosis
Healthy population
Morocco

ABSTRACT

*Background:* Bone mineral density (BMD) measurements using dual-energy X-rays absorptiometry (DXA) are widely used to diagnose osteoporosis and to 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 male Moroccan population.

*Aim:* To establish reference values for the healthy Moroccan male population and to compare them with those for Caucasian and Arab males, and to study the impact of different curves implemented in the DXA system on the diagnosis of osteoporosis.

*Methods:* A cross-sectional study of 592 Moroccan men, recruited from the area of Rabat, the capital of Morocco, aged between 20 and 79 years was carried to establish reference values of bone mineral density. Measurements were taken at the lumbar spine and proximal femurs using DXA (Lunar Prodigy Vision, GE). The data were compared with published normative taken by US, European, Iranian, Lebanese, and Saudi men over six decades of age. Impact on osteoporosis diagnosis according to the WHO criteria using the personalized curve and US (NHANES), European and Middle-East reference curves (as implemented in the Lunar densitometers) was studied.

*Results:* Our results showed that the Moroccan men showed the expected decline in BMD at both sites with age after peaking at 20–29 years age group. Every anatomical region has a different rate of bone loss: lumbar spine (0.3% per year) femoral neck (0.6%), trochanter (0.3%), and total hip (0.4%). The lumbar spine and femoral subregions BMD exhibited increases from 0.3 to 0.5% per kilogram of body weight. In the spine, the US/European Lunar reference values classified a larger proportion of men as osteoporotic (18.1% vs. 7.4%) while using the Arabic Lunar reference values, only 7.8% were classified as osteoporotic. However, using Arabic curve for the femurs resulted in underdiagnosis of osteoporosis (1.8% vs. 6.0%), whereas the US/European Lunar reference values classified men as osteoporotic in 3.9% and 5.3% respectively.

*Discussion:* In comparison with the other Countries, the spine BMD of Moroccan men were slightly lower than Iranian's, Europeans and Brazilians but higher than the Saudi and Lebanese males. We found BMD values taken at the lumbar spine to be around 4% lower than European values between ages 50 and 59 years, and 10% lower for older subjects. These values were 4–6% higher than Saudis/Lebanese values between ages 20–39. For older subjects, Moroccan values were more than 10% higher than Saudis and almost similar to Lebanese. Femoral neck BMD values were 8% higher in young adults (age 20–39 years) to US/Saudis/Lebanese values, but about 10% lower in ages over 60 to US values whereas it was similar to Saudis and Lebanese values.

*Conclusion:* Our study emphasises the importance of using population-specific reference values for BMD measurements to avoid over or underdiagnosis of osteoporosis.



## Introduction

Men account for 33–50% of all vertebral fractures, 20–35% of all femoral fractures and 15% of all distal forearm fractures [1,2]. Especially femoral fractures are associated with increased morbidity and mortality rate [3]. In Morocco, the incidence of hip fractures in men has been estimated to 58/100,000 inhabitant over 50 [4].

Although osteoporosis had historically been recognized only when clinical fractures occurred, the development of techniques for measuring bone mass has allowed osteoporosis to be detected by the study of bone mineral density (BMD). In clinical practice, the diagnosis of osteoporosis is based on the evaluation of bone mass and/or the presence of fragility fractures. The WHO densitometric criteria for the diagnosis of osteoporosis when the patient presented a BMD

* Corresponding author. Rheumatology and Physical Rehabilitation Department, Military Hospital Mohammed V, PO Box: 1018, Rabat, Morocco.
*E-mail address:* aelmaghraoui@gmail.com (A. El Maghraoui).

8756-3282/$ – see front matter © 2009 Elsevier Inc. All rights reserved.
doi:10.1016/j.bone.2008.12.025

T-score value lower than −2.5 standard deviations were described as being for use in post-menopausal Caucasian women only [5]. Thus, the use of this definition for the diagnosis of osteoporosis in men is controversial. For this reason, there are discrepancies in the use of WHO criteria in men and there is no consensus about which reference values should be used: those coming from the peak bone mass of men or those already accepted for women [6,7].

Commercial DXA systems contain sets of BMD reference data for different populations, although even these databases may not be appropriate. These reference data allow a patient's BMD measurement to be compared to the expected peak bone mass of a young normal of the same sex and ethnicity (to deliver a T-score), and to the mean age-matched value for the normative population (the so-called "Z-score"). It has been well recognized that geographic, ethnic, and socio-economic factors affect bone mass significantly [8–10].

The aim of this study was to establish reference values for the healthy Moroccan male population and to compare them with those for Caucasian and Arab males, and to study the impact of different curves implemented in the DXA system on the diagnosis of osteoporosis.

## Materials and methods

### *Subjects*

A total of 592 healthy Moroccan men (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 (49.8% male).

The subjects were volunteers aged between 20 and 79 years. The recruitment was made in part among hospital staff, university students and lay people contacted by word of mouth. Though the sample was not a true probability sample, care was taken to ensure representativeness of the general population, enrolling nearly ten subjects per year of age and with a particular regard to the inclusion of a wide range of body sizes and activities.

The BMD of the lumbar spine and proximal right femur of these male volunteers with no previous history of bone disease was measured after they gave informed consent. The study was approved by the local Ethics Committee. All subjects were fully ambulatory. Screening was done by physical examination and questionnaires. Men using medications affecting calcium metabolism and those with medical conditions known to affect bone metabolism or with a history of any fracture or major systemic disorder were excluded. Thus, we excluded subjects with non-Caucasian origin, gastrectomy, intestinal resection, recent hyperthyroidism or hyperparathyroidism, treatment with corticosteroids for more than 6 months, or recent severe immobilization. We did not exclude individuals using inhalation steroids or 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.

Each subject completed a standardized questionnaire designed to document putative risk factors of osteoporosis. 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. 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.

In total, 678 men were screened. Among them 186 individuals were excluded from the study according to predetermined exclusion criteria, whereas 592 met all inclusion criteria and were invited to participate in the BMD measurement. The age range of the subjects was 20–79 years (mean ± SD 49.1 ± 17.2). The age distribution and some other basic parameters are shown in Table 1.

### *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 by the same 2 technicians in clinical practice and showed a smallest detectable difference of 0.04 g/cm$^2$ (spine) and 0.02 (hips) [4]. 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, 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

**Table 1**
characteristics of the study population

| | | Minimum | Maximum |
|---|---|---|---|
| Age (yrs): mean (SD) | 49.1 (17.2) | 20 | 79 |
| Weight (Kg): mean (SD) | 73.7 (12.6) | 40 | 116 |
| Height (cm): mean (SD) | 171 (7.2) | 150 | 196 |
| BMI (Kg/m2): mean (SD) | 25.0 (3.9) | 14.5 | 37.5 |
| Tobacco consumption | | | |
| Never smokers: *n*(%) | 393 (66.4) | | |
| Ex-smokers: *n*(%) | 93 (15.7) | | |
| Current smokers: *n*(%) | 106 (17.9) | | |
| Low calcium intake: *n*(%) | 310 (52.4) | | |
| Low physical activity: *n*(%) | 330 (55.7) | | |

**Table 2**
Height, weight and body mass index in normal Moroccan women by age groups

| | *n* | Height (cm) | Weight (kg) | BMI (kg/m$^2$) |
|---|---|---|---|---|
| | | mean (SD) | mean (SD) | mean (SD) |
| 20–29 | 100 | 175.9 (5.9) | 72.3 (11.7) | 23.3 (3.6) |
| 30–39 | 100 | 175.0 (6.7) | 76.6 (12.6) | 24.9 (3.7) |
| 40–49 | 100 | 172.2 (6.7) | 75.3 (13.4) | 25.3 (3.9) |
| 50–59 | 100 | 170.5 (5.7) | 74.5 (12.5) | 25.7 (3.9) |
| 60–69 | 100 | 168.2 (6.7) | 72.3 (11.3) | 25.6 (3.9) |
| 70–79 | 92 | 167.8 (6.9) | 70.6 (13.2) | 25.0 (4.1) |

**Table 3**
Age change in posteroanterior spine and femur bone mineral density (g/cm$^2$)

| Age group | *n* | L2-L4 | Femoral neck | Trochanter | Total hip |
|---|---|---|---|---|---|
| | | mean (SD) | mean (SD) | mean (SD) | mean (SD) |
| 20–29 | 100 | 1.205 (0.15) | 1.147 (0.16) | 0.959 (0.15) | 1.161 (0.16) |
| 30–39 | 100 | 1.165 (0.14) | 1.050 (0.15) | 0.897 (0.15) | 1.095 (0.16) |
| 40–49 | 100 | 1.140 (0.15) | 0.989 (0.13) | 0.962 (0.11) | 1.033 (0.11) |
| 50–59 | 100 | 1.116 (0.15) | 0.945 (0.12) | 0.850 (0.12) | 1.018 (0.14) |
| 60–69 | 100 | 1.076 (0.16) | 0.879 (0.11) | 0.813 (0.11) | 0.968 (0.12) |
| 70–79 | 92 | 1.047 (0.18) | 0.824 (0.11) | 0.767 (0.12) | 0.916 (0.14) |

Please cite this article as: El Maghraoui A, et al., Bone mineral density of the spine and femur in a group of healthy Moroccan men, Bone (2009), doi:10.1016/j.bone.2008.12.025

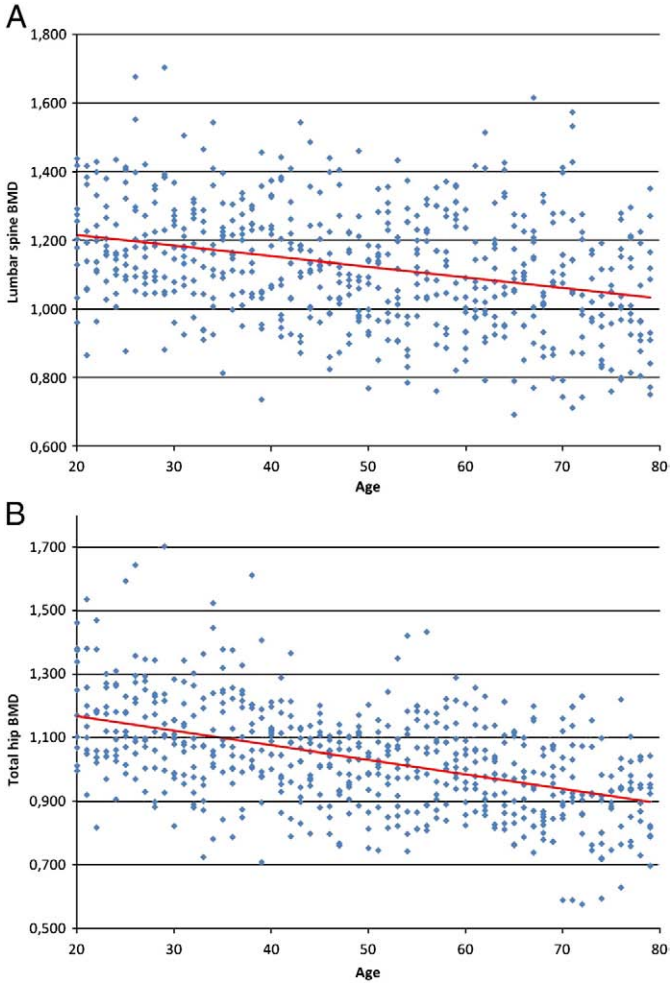


**Fig. 1.** Scatter-plot of lumbar spine (A) and total hip (B) BMD against age.

variables. The regression of BMD against age and weight was performed using linear regression. The level for significance was taken as $p \leq 0.05$. Excel 2007 and SPSS 15.0 were used for statistical analysis.

## Results

The basic anthropometric characteristics of the 592 males studied are presented in Table 1. Their mean weight was 73.7±12.5 kg, their mean height was 171.6±7.2 cm, and their mean body mass index 25.0±3.9 kg/m$^2$. The body weight and height among individuals grouped by age were higher at 20–29 years vs. more aged groups while BMI was lower. The weight difference of 20–79 yr olds was 1.7 kg ($p$=0.34) with a corresponding height and BMI difference of 8.2 cm ($p$= 0.002) and 1.7 Kg/m$^2$ ($p \leq 0.0001$) respectively (Table 2).

**Table 4**
Pearson correlation coefficient of bone mineral density (BMD) at different skeletal sites with age, weight, height and BMI in males studied

| | Age | Weight | Height | BMI | LS BMD | FN BMD | Tr BMD |
|---|---|---|---|---|---|---|---|
| Weight | −0.06 | | | | | | |
| Height | −0.44(**) | 0.39(**) | | | | | |
| BMI | 0.15(**) | 0.87(**) | | | | | |
| LS BMD | −0.31(**) | 0.29(**) | 0.28(**) | 0.18(**) | | | |
| FN BMD | −0.61(**) | 0.30(**) | 0.38(**) | 0.12(**) | 0.65(**) | | |
| Tr BMD | −0.41(**) | 0.31(**) | 0.28(**) | 0.19(**) | 0.66(**) | | |
| TH BMD | −0.47(**) | 0.32(**) | 0.28(**) | 0.20(**) | 0.68(**) | 0.90(**) | 0.93(**) |

LS: lumbar spine, FN: femoral neck, Tr: trochanter, TH: total hip.
** Correlation is significant at the 0.01 level (2-tailed).

**Table 5**
Regression of BMD for spine and femur regions on age and weight in men age 20–79 years

| Region | Regression equation | $R$ | $p$ | Percentage of loss per year |
|---|---|---|---|---|
| Spine L2-L4 | 1.277−0.003 age+0.004 weight | 0.417 | <0.0001 | 0.3 |
| Femoral neck | 1.005−0.006 age+0.004 weight | 0.668 | <0.0001 | 0.6 |
| Trochanter | 0.777−0.003 age+0.003 weight | 0.503 | <0.0001 | 0.3 |
| Total hip | 0.968−0.004 age+0.004 weight | 0.561 | <0.0001 | 0.4 |

*Age-related changes of BMD*

Subjects were divided into six decade subgroups for cross-sectional analysis. The mean BMD values are grouped according to age and are given in Table 3. The BMD values between 20–29 were defined as the peak bone mass values. Every anatomical region has a different rate of bone loss. Significant changes were also evident in the lumbar spine (0.3% per year) and femur BMD subregions (% per year): neck (0.6%), trochanter (0.3%), and total hip (0.4%) in males between 20 and 79 years of age, respectively. According to WHO criteria, osteoporosis of the lumbar spine and femoral neck exists in Moroccan men at BMD<0.814 and 0.737 respectively. Osteopenia of the lumbar spine exists between 1.051 and 0.814; for femoral neck, osteopenia is defined as a BMD between 0.983 and 0.737 g/cm$^2$.

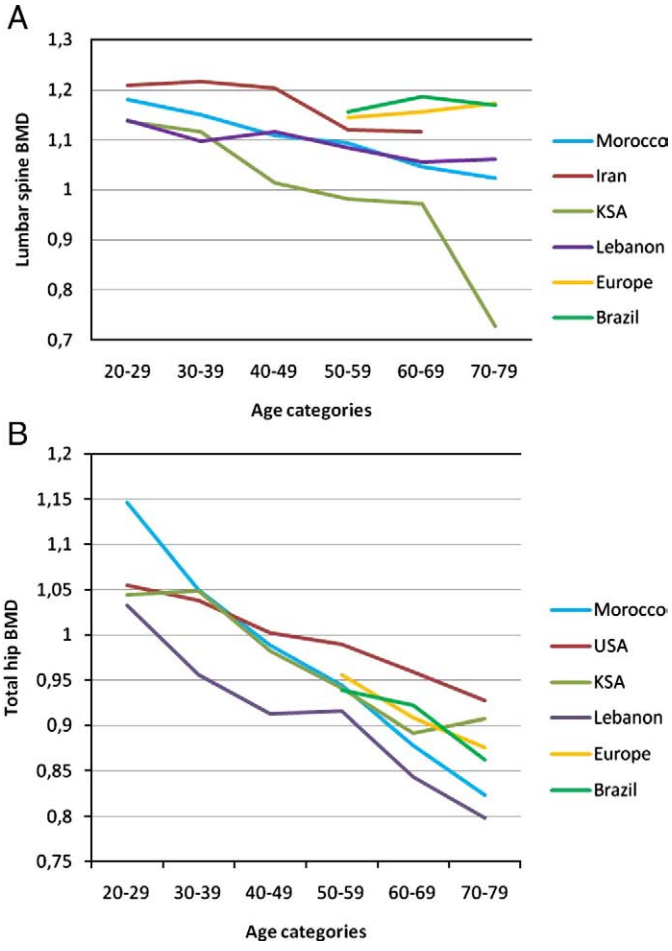


**Fig. 2.** BMD (g/cm$^2$) of Moroccan men at the spine (A) and femur (B) compared with other men from different countries.

**Table 6**
Classification of men over 50 according to WHO criteria using our normative curve or some manufacturer-provided reference values (results are expressed in percentage)

| | US Reference | European Reference | Middle-East Reference | Moroccan Reference |
|---|---|---|---|---|
| *(L2–L4)* | | | | |
| Normal BMD | 42.9 | 41.5 | 62.8 | 52.8 |
| Osteopenia | 38.7 | 40.4 | 29.4 | 39.7 |
| Osteoporosis | 18.4 | 18.1 | 7.8 | 7.4 |
| *(Total hip)* | | | | |
| Normal BMD | 58.2 | 58.9 | 66.0 | 41.1 |
| Osteopenia | 37.9 | 35.8 | 32.3 | 52.8 |
| Osteoporosis | 3.9 | 5.3 | 1.8 | 6.0 |

Age showed highly significant negative correlations with all skeletal sites examined (Fig. 1, Table 4). With respect to weight, height and BMI, there were positive correlations with BMD which were significant for all skeletal sites examined.

The influence of age, height, and body weight on the BMD results was examined by stepwise regression analysis (Table 5). The lumbar spine and femoral subregions BMD exhibited differences from 0.3 to 0.5% per kilogram of body weight.

*Impact on subjects' classification*

We compared (Table 6) the men classification according to the WHO criteria using the personalized curve, the US (NHANES for the femur and manufacturer standards for the lumbar spine), European and Middle-Eastern (Maalouf et al. [11]) reference curves as implemented in the Lunar densitometers. The prevalence of osteoporosis was consistently overestimated when using the Lunar-supplied Caucasian cutoffs as compared with the Moroccan cutoffs. In the spine, the US/European Lunar reference values classified a larger proportion of men as osteoporotic (18.1% vs. 7.4%) while using the Arabic Lunar reference values, only 7.8% were classified as osteoporotic. However, using Maalouf et al. curve for the femurs resulted in underdiagnosis of osteoporosis (1.8% vs. 6.0%), whereas the US/European Lunar reference values classified men as osteoporotic in 3.9% and 5.3% respectively.

## Discussion

This report provides spine and femur reference values for a large group of male subjects from Morocco, with exclusion of disorders and drugs known to affect bone metabolism. The purposes of the study were to determine the normal BMD of the Moroccan men and to determine whether the obtained BMD values were different enough from US, European or Arab reference values to warrant separate Moroccan reference data. A similar work has been done recently in women and showed particular risk factors of osteoporosis [12] and the necessity of a separate Moroccan reference curve [4].

Indeed, it has been well recognized that there are racial/ethnic differences in BMD values [13–15]. Reference values have been shown to be virtually identical in different white populations. In our population, peak bone mass was attained before the third decade as earlier described in a number of other studies. The changes in lumbar spine and femur BMD values with age in Moroccan men showed a similar pattern to that previously reported for US [16], European [17,18], Brazilian [19], Saudi [20], Iranian [21] and Lebanese [11] reference values.

In comparison with the other Countries (Fig. 2), the spine BMD of Moroccan men were slightly lower than Iranian's [21], Europeans and Brazilians but higher than the Saudi [20] and Lebanese males. We found BMD values taken at the lumbar spine to be around 4% lower than European values between ages 50 and 59 years, and 10% lower for older subjects. These values were 4–6% higher than Saudis/Lebanese values between ages 20–39. For older subjects, Moroccan values were more than 10% higher than Saudis and nearly similar to Lebanese. Femoral neck BMD values were 8% higher in young adults (age 20–39 years) to US/Saudis/Lebanese values, but about 10% lower in ages over 60 to US values whereas it was similar to Saudis and Lebanese values.

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. This is best illustrated by the results of the present study (see Table 6), which show the wide discrepancies in the percentage of Moroccan men over 50 classified with osteopenia or osteoporosis, when data from the manufacturer's database or our current Moroccan data were used for the calculation of T-scores. Indeed, we found more than a twofold difference in the prevalence of osteoporosis (8% vs 18%) as it was the case of Ahmed et al. [22] when they applied two different normative data sets to their study data and found a twofold difference in the prevalence of osteoporosis (6% vs 15%). Moreover, previous studies have reported an inappropriately high incidence of osteoporosis when the T-scores were based on the manufacturer's reference data in various populations examined [23,24], including Spanish [18], Turkish [25], British [16], Greek [26], and Lebanese [9] populations.

There are several limitations of this study. This data were cross-sectional in nature with no data specifically related to fracture risk providing a survey of current BMD values by age and only an estimate of mean BMD changes through time. The second limitation lies in the procedures used to select subjects, who were all volunteers and ambulatory, and presumably healthier than the general population. However, these limitations hold nearly for all DXA reference data and the similarity of our results (in particular of the femoral neck) with other reports that used different selection criteria support the general conclusions of the study.

In conclusion, a Moroccan reference BMD for men has been established for the lumbar spine and proximal femur on a sample of adequate size. The present study shows that Moroccan men exhibited similar trends in the rates of bone loss in the lumbar spine and femoral subregions to that observed in Caucasians and Arabs. However, Moroccans showed lower BMD values at the lumbar spine than the corresponding Caucasian reference values particularly in the older age group (50–79 years), but higher values than those reported for Arab males. For the proximal femur, although slight discrepancies in mean values and standard deviation were found, the difference was minimal. Body weight was a significant predictor of BMD at all skeletal sites examined and was more important than height in multiple regression analysis. The BMD values obtained in the present study resulted in lower prevalence of osteoporosis in males according to WHO criteria if the manufacturer's reference values rather than Moroccan reference values were used.

## References

[1] Vallarta-Ast N, Krueger D, Wrase C, Agrawal S, Binkley N. An evaluation of densitometric vertebral fracture assessment in men. Osteoporos Int 2007;18:1405–10.
[2] Szulc P, Montella A, Delmas PD. High bone turnover is associated with accelerated bone loss but not with increased fracture risk in men aged 50 and over-prospective MINOS study. Ann Rheum Dis 2007.
[3] Papaioannou A, Kennedy CC, Ioannidis G, et al. The osteoporosis care gap in men with fragility fractures: the Canadian Multicentre Osteoporosis Study. Osteoporos Int 2007.
[4] El Maghraoui A, Guerboub AA, Achemlal L, et al. Bone mineral density of the spine and femur in healthy Moroccan women. J Clin Densitom 2006;9:454–60.
[5] Kanis JA. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis: synopsis of a WHO report. WHO Study Group. Osteoporos Int 1994;4:368–81.
[6] Tan LJ, Lei SF, Chen XD, et al. Establishment of peak bone mineral density in Southern Chinese males and its comparisons with other males from different regions of China. J Bone Miner Metab 2007;25:114–21.

Please cite this article as: El Maghraoui A, et al., Bone mineral density of the spine and femur in a group of healthy Moroccan men, Bone (2009), doi:10.1016/j.bone.2008.12.025

[7] Goemaere S, Vanderschueren D, Kaufman JM, et al. Dual energy x-ray absorptiometry-based assessment of male patients using standardized bone density values and a national reference database. J Clin Densitom 2007;10:25–33.
[8] Travison TG, Araujo AB, Esche GR, McKinlay JB. The relationship between body composition and bone mineral content: threshold effects in a racially and ethnically diverse group of men. Osteoporos Int 2008;19:29–38.
[9] Baddoura R, Arabi A, Haddad-Zebouni S, et al. Vertebral fracture risk and impact of database selection on identifying elderly Lebanese with osteoporosis. Bone 2007; 40:1066–72.
[10] Hoiberg M, Nielsen TL, Wraae K, et al. Population-based reference values for bone mineral density in young men. Osteoporos Int 2007;18:1507–14.
[11] Arabi A, Nabulsi M, Maalouf J, et al. Bone mineral density by age, gender, pubertal stages, and socioeconomic status in healthy Lebanese children and adolescents. Bone 2004;35:1169–79.
[12] El Maghraoui A, Guerboub AA, Mounach A, et al. Body mass index and gynecological factors as determinants of bone mass in healthy Moroccan women. Maturitas 2007;56:375–82.
[13] Tenenhouse A, Joseph L, Kreiger N, et al. Estimation of the prevalence of low bone density in Canadian women and men using a population-specific DXA reference standard: the Canadian Multicentre Osteoporosis Study (CaMos). Osteoporos Int 2000;11:897–904.
[14] Yang RS, Liu TK, Hang YS, Chieng PU, Tsai KS. Factor of risk for hip fracture in normal Chinese men and women in Taiwan. Calcif Tissue Int 1999;65:422–6.
[15] Lehmann R, Wapniarz M, Randerath O, et al. Dual-energy X-ray absorptiometry at the lumbar spine in German men and women: a cross-sectional study. Calcif Tissue Int 1995;56:350–4.
[16] Holt G, Khaw KT, Reid DM, et al. Prevalence of osteoporotic bone mineral density at the hip in Britain differs substantially from the US over 50 years of age: implications for clinical densitometry. Br J Radiol 2002;75:736–42.
[17] Lunt M, Felsenberg D, Adams J, et al. Population-based geographic variations in DXA bone density in Europe: the EVOS Study. European Vertebral Osteoporosis. Osteoporos Int 1997;7:175–89.
[18] Kroger H, Lunt M, Reeve J, et al. Bone density reduction in various measurement sites in men and women with osteoporotic fractures of spine and hip: the European quantitation of osteoporosis study. Calcif Tissue Int 1999;64:191–9.
[19] Zerbini CA, Latorre MR, Jaime PC, Tanaka T, Pippa MG. Bone mineral density in Brazilian men 50 years and older. Braz J Med Biol Res 2000;33:1429–35.
[20] Ardawi MS, Maimany AA, Bahksh TM, Nasrat HA, Milaat WA, Al-Raddadi RM. Bone mineral density of the spine and femur in healthy Saudis. Osteoporos Int 2005;16: 43–55.
[21] Larijani B, Hossein-Nezhad A, Mojtahedi A, et al. Normative data of bone Mineral Density in healthy population of Tehran, Iran: a cross sectional study. BMC Musculoskelet Disord 2005;6:38.
[22] Ahmed AI, Blake GM, Rymer JM, Fogelman I. Screening for osteopenia and osteoporosis: do the accepted normal ranges lead to overdiagnosis? Osteoporos Int 1997;7:432–8.
[23] Faulkner KG, Orwoll E. Implications in the use of T-scores for the diagnosis of osteoporosis in men. J Clin Densitom 2002;5:87–93.
[24] Simmons A, Simpson DE, O MJ, Doherty, Barrington S, Coakley AJ. The effects of standardization and reference values on patient classification for spine and femur dual-energy X-ray absorptiometry. Osteoporos Int 1997;7:200–6.
[25] Manisali M, Ozaksoy D, Yilmaz E, et al. Bone mineral density reference values in the normal female and male population of Izmir, Turkey. Eur Radiol 2003;13: 157–62.
[26] Hadjidakis D, Kokkinakis E, Giannopoulos G, Merakos G, Raptis SA. Bone mineral density of vertebrae, proximal femur and os calcis in normal Greek subjects as assessed by dual-energy X-ray absorptiometry: comparison with other populations. Eur J Clin Invest 1997;27:219–27.

Please cite this article as: El Maghraoui A, et al., Bone mineral density of the spine and femur in a group of healthy Moroccan men, Bone (2009), doi:10.1016/j.bone.2008.12.025