Bone density estimates and risk factors for osteoporosis in young women

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التقديرات المتعلقة بكثافة العظام وعوامل اختطار تخلخل العظام في صفوف الشابات

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الخلاصة: قدرت الكثافة المعدنية العظمية لعظم العقب في 185 شابة من شابات الإمارات العربية المتحدة. باستخدام طريقة SAHARA فوق الصوتية. وقد قامت جميع المشتركات باستيفاء استبيان حول العوامل التي يمكن أن تكون مرتبطة بتخلخل العظام. وقد تم تصنيف 29 امرأة (15.7%) من مجموع النساء اللائي شملهن الاستبيان باعتبارهن مصابات بقلة التعظم ولم يتم تصنيف أي منهن على أنها مصابة بتخلخل العظام. وكانت المشاركات في الاستبيان اللاتي يعانين من قلة التعظم أكثر احتمالاً للإصابة بتأخر بدء الإحاضة، وعدم انتظام دورات الحيض، وانخفاض منسب كتلة الجسم، وسوابق إصابة أفراد الأسرة بتخلخل العظام. على أن تأخر بدء الإحاضة وانخفاض منسب كتلة الجسم، كانا وحدهما نذيرين مستقلين مُنبئين بالإصابة بقلة التعظم.

ABSTRACT The bone mineral density (BMD) of the calcaneus was estimated in 185 young women from the United Arab Emirates, using SAHARA ultrasound. All participants completed a questionnaire on factors potentially associated with osteoporosis. In all, 29 (15.7%) of the women were classified as having osteopenia and none as having osteoporosis. Participants with osteopenia were more likely to have had a later onset of menarche, irregular periods, lower body mass index, and a positive family history of osteoporosis. Only late menarche and low body mass index, however, were independent predictors of osteopenia.

Estimations de la densité osseuse et facteurs de risque d'ostéoporose chez les jeunes femmes

RESUME On a estimé la densité minérale du calcanéum chez 185 jeunes femmes des Emirats arabes unis, en utilisant les ultrasons SAHARA. Toutes les participantes ont rempli un questionnaire sur les facteurs potentiellement associés à l'ostéoporose. En tout, on a classé 29 (15,7 %) des femmes comme ayant une ostéopénie et aucune comme ayant une ostéoporose. Les participantes atteintes d'ostéopénie connaissaient davantage de probabilités d'avoir une menstruation tardive, des irrégularités menstruelles, un indice de masse corporelle inférieur et des antécédents familiaux positifs d'ostéoporose. Toutefois, seuls les menstruations tardives et le faible indice de masse corporelle étaient des facteurs prédictifs indépendants d'ostéopénie.

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Introduction

The attainment of a higher peak bone density has an important role in the prevention of osteoporosis later in life [1–3]. Genetic factors and race/ethnicity have a strong influence on peak bone density [4–6]. Physiological, environmental, and modifiable lifestyle factors can also play a significant role [5,7]. These factors include adequate nutrition and body weight [8,9], exposure to sex hormones at puberty [10,11] and level of physical activity [12,13], and are not only important for the acquisition of maximal bone mass but also for its maintenance throughout life [5,14–16]. The primary objective of this study was to determine the correlation between bone mineral density (BMD) and potential risk factors for osteoporosis in a population of young healthy United Arab Emirates (UAE) women. A second objective was to compare the BMD of UAE women with that of other ethnic groups.

Methods

Paticipants

Two hundred young UAE female nationals were invited by local advertisement and site visits to participate in this cross-sectional study. Of those enrolled, 84 (42%) were medical students, 82 (41%) college and university students, 20 (10%) members of a women's social club and 14 (7%) employees of a health department; 15 women with a history of chronic illnesses and/or use of thyroid or glucocorticoid medications were excluded from the analysis. Ethical approval was obtained from the Ethics Committee of the Faculty of Medicine and Health Sciences, United Arab Emirates University.

Questionnaire

After giving informed consent, each participant filled out a questionnaire in Arabic or English on factors thought to be associated with osteoporosis, such as reproductive history, dietary calcium intake, physical activity, exposure to sun, tobacco use, alcohol consumption, and family history of osteoporosis. Estimation of dietary calcium was based on a quantitative food frequency questionnaire in Arabic adapted to the local dietary customs. The questionnaire included local food items contributing significantly to calcium intake. Dietary calcium intake (g/day) was calculated from the participants' answers to the food frequency questionnaire using tables that define the calcium content of local foods [17]. Skin exposure to sunlight was determined from the participant's reported length of time (minutes/day) spent in the courtyard of her house. In this cultural group, this is where most exposure to sunlight occurs because in all other outdoor situations women generally wear dark clothes including head coverings and, in many cases, veils. Physical activity level was estimated from the answers to four questions related to exercise. These questions asked whether the participants walked carrying a load at least once per day, or walked for exercise, climbed stairs, or performed any other exercise activity at least once per week. Participants were defined as sedentary if they answered yes to one or fewer questions, mildly active if they answered yes to two questions, and moderately active if they answered yes to three to four questions.

Measurement of bone density

BMD (g/cm^2) of the right calcaneus was estimated in all participants using a SAHARA ultrasound bone densitometer (Hologic, Waltham, United States of America), which

measures the transmission of high frequency sound waves through the heel. From the measured signal, three ultrasound parameters are simultaneously determined: speed of sound (SOS), broadband ultrasound attenuation (BUA) and the quantitative ultrasound index (QUI). The SAHARA system software estimates BMD from the QUI and compares it to that of young, healthy, sex matched subjects to produce a T-score. The T-score is widely used to assist in the interpretation of BMD results. It measures the departure of the person's BMD value from the mean BMD for a young adult population in units of the population standard deviation. Estimated BMD measurements of the calcaneus for young healthy UAE women were compared with the manufacturer's reference for US Caucasian, European Caucasian and Chinese Asian young healthy women of the same age range [18]. In addition, dual-energy X-ray absorptiometry (DXA) scans (Lunar Expert XL, Madison, United States of America) of the lumbar spine and femurs were performed in 10 participants. Height in centimetres and weight in kilograms were also measured in all participants.

Statistical analysis

Data were processed using *SPSS*, version 10.0. Data were expressed as the mean and standard deviation (SD) unless otherwise stated. Bivariate analysis was performed using a *t*-test for continuous variables and chi-squared analysis for discontinuous variables. Subsequently, stepwise logistic regression was performed to determine a multivariate summary model of risk factors for the development of low BMD. Using clinically derived cut-off points for analysis, potential risk factors were assessed using chi-squared odds ratios. The subsequent analysis strategy involved the initial selection of all dichotomous variables

whose associated chi-squared statistics had *P*-values below 0.05. Stepwise regression was performed using forward selection, with a *P*-value of 0.10 for entry and 0.20 for removal. The final model included only those risk factors whose unique contribution, in the presence of all other variables, was significant at a level of alpha = 0.05.

Results

A total of 185 young healthy UAE women participated in the study. The median age was 22 years (range 18–36 years). Mean age at menarche was 13.1 ± 1.26 years, and mean BMI was 24.9 ± 5.0 kg/m². Only a few participants were taking calcium or vitamin D supplements (3.3%), multivitamins (11.9%), or had had previous BMD measurement (3.3%). None of the participants smoked cigarettes or consumed alcohol. Mean dietary calcium intake was 968.4 ± 707.6 mg/day and 44 participants (23.8%) consumed less than 500 mg calcium per day. Table 1 shows exercise, exposure to sunlight, reproductive history and family history of osteoporosis of the study participants.

The estimated mean BMD was 0.56 ± 0.13 g/cm². The frequency of distribution of estimated BMD values is shown in Figure 1. The distribution is approximately normal (skewness = 0.440, standard error of the mean = 0.179; kurtosis = −0.171, standard error of the mean = 0.355). Using the World Health Organization criteria and the mean BMD value of 0.56 ± 0.13 g/cm² as a reference, 29 (15.7%) participants were classified as having osteopenia (T-score between −1 and −2.4, or BMD < 0.43 g/cm²) and none as having osteoporosis (T-score ≤ −2.5). When reference data for American Caucasian women (mean age 25 years) were used, however, 50 (27%) and

Table 1 **Exercise, exposure to sunlight, reproductive history and family history of osteoporosis in study participants**

Category [a]	No.	%
Exercise status		
Sedentary	19	10.3
Mildly active	57	30.8
Moderately active	87	47.0
Missing	22	11.9
Exposure to sunlight (minutes/day)		
< 30	55	29.7
30–60	69	37.3
> 60	61	33.0
Reproductive history		
Irregular menstrual periods	36	19.5
Late menarche (onset > 15 years)	27	14.6
Parity	29	15.7
History of oral contraceptive use	23	12.4
Family history of osteoporosis	24	13.0

[a]For definition of categories see text.

2 (1.1%) of study subjects were classified as having osteopenia and osteoporosis respectively. Table 2 shows the characteristics of the participants according to their BMD category: normal mean BMD of 0.59 ± 0.11 g/cm^2 versus osteopenic mean BMD of 0.38 ± 0.04 g/cm^2. Participants with osteopenia were more likely to have had a later onset of menarche ($P = 0.011$), irregular periods ($P = 0.077$), lower BMI ($P = 0.037$) and positive family history of osteoporosis ($P = 0.053$) than those with normal BMD. When these four risk factors were entered into a stepwise multiple logistic regression analysis model, only late menarche and low BMI were independent predictors of osteopenia (odds ratio = 2.99, 95% confidence interval: 1.08–8.30 and odds ratio = 1.15, 95% confidence interval: 1.03–1.29 respectively) (Table 3). The correlation between calcaneus BMD measured by SAHARA ultrasound and hip BMD measured by Lunar DXA was determined in 10 participants. The correlation coefficient
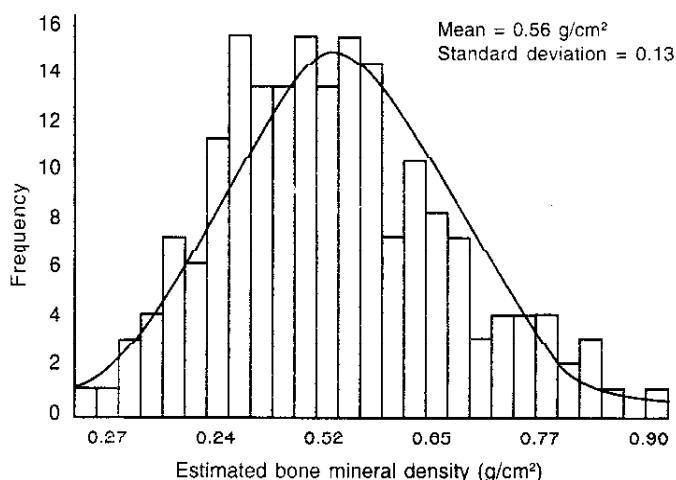

Figure 1 **Frequency of bone mineral density distribution in the 185 participants**

Table 2 **Characteristics of the study participants according to bone mineral density (BMD) category**

Characteristic	Participants with normal BMD (n = 156)	Participants with osteopenia (n = 29)
Age ± s (years)	22.7 ± 3.6	22.8 ± 4.5
Body mass index ± s (kg/m²)	25.2 ± 5.0	23.1 ± 4.1*
Calcium intake ± s (mg/day)	976.3 ± 755.4	703.2 ± 352.4
Exposure to sunlight ± s (minutes/day)	55.8 ± 47.6	65.5 ± 52.0
Exercise (% sedentary)	11.3	15.4
Age at menarche ± s (years)	13.0 ± 1.2	13.7 ± 1.4*
Late menarche (%)	13.5	29.6*
Irregular menstrual periods (%)	17.6	32.1
Parity (%)	13.5	13.8
Oral contraceptive use (%)	13.2	16.0
Family history of osteoporosis (%)	11.0	24.1

*Significant at $P < 0.05$.
s = standard deviation.

was statistically significant ($r = 0.7$, $P < 0.05$).

Discussion

The distribution of estimated BMD values in this group of 185 young healthy UAE women was approximately normal. Hence, the mean BMD value could be compared with mean BMD values of healthy young women from different ethnic groups using the same ultrasound technology (Figure 2). Although UAE participants had the lowest mean BMD, the differences between UAE and United States Caucasian women and Chinese women were not statistically significant ($P = 0.09$ and 0.63 respectively). Hence the differences in fracture rates among these populations, if any, will more likely be determined by differences in the magnitude of bone loss that occurs after achieving peak bone mass.

Factors that are important in maintaining bone mass include adequate nutrition and body weight, exposure to sex hormones and physical activity [5,14–16]. In this study, participants with osteopenia were more likely to have a later onset of menarche, irregular menstrual periods, lower BMI and positive family history of osteoporosis than those with normal BMD. Only late menarche and low BMI, however, were independently predictive of osteope-

Table 3 **Multiple logistic regression analysis model for osteopenia risk factors**

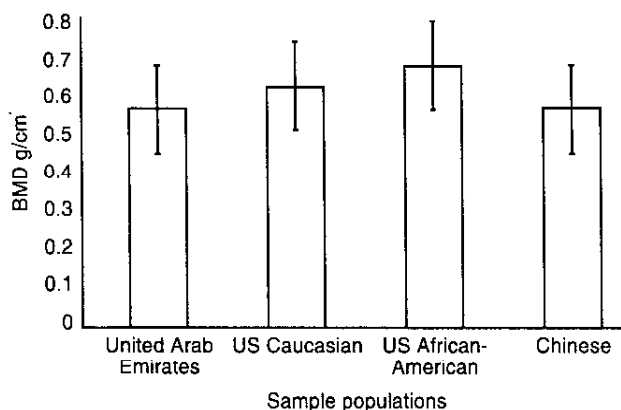| Risk factor	Odds ratio	95% confidence interval	P-value
Late menarche	2.99	1.08–8.30	0.035
Low body mass index	1.15	1.03–1.29	0.01

Figure 2 Estimated mean bone mineral density (BMD) of the heel in young women from different populations: Source: [18]

nia. These results are consistent with other studies in premenopausal women [19–21]. Although mean calcium intake was close to the recommended daily allowance for this age group, it is a cause for concern that a significant proportion of the participants consumed less than 500 mg/day. Increased dietary calcium intake is associated with increased bone mass [16] and reduced risk of hip fracture later in life [14,15].

Finally, as shown in this and in other studies, the normative data supplied by manufacturers may over- or underestimate the proportion of a tested population categorized as having osteopenia or osteoporosis [22,23]. Thus, the construction of reference ranges that accurately represent the local population is essential for the correct identification of osteoporosis from BMD measurement [24]. Although the young adult BMD values determined in our study could be used as a reference database, one should have about 100–200 subjects in each age decade from 20 years to 80 years if detailed comparisons are to be made [25].

Some limitations of this study deserve comment. We measured bone density at a peripheral site by a relatively new technique [26]. Although T-score thresholds for subject classification are site- and technique-dependent [27], device-specific T-score thresholds are being constructed by international bodies [28], and the young adult reference values determined in this study could provide the basis for accurate implementation of the revised thresholds for SAHARA ultrasound in the UAE. In the small subgroup of participants studied, the correlation coefficient between heel BMD measured by SAHARA ultrasound and hip BMD measured by Lunar DXA was significant ($r = 0.7$, $P < 0.05$) and representative of previously published results [29]. A second concern is that we studied mainly college and university students whose lifestyle may be quite different from the rest of the population. The vast majority of young women in the UAE, however, goes to college or university [30]. Therefore, studying mainly college and university students was appro-

priate in order to obtain a representative sample of women in this age group.

In conclusion, local reference data are essential for the correct identification of osteoporosis from BMD measurements. Normal timing of onset of puberty and BMI are important determinants of bone density in young healthy UAE women. Mean BMD of UAE women is slightly lower than United States Caucasian women and Chinese women, although these differences are not statistically significant. Strategies need to be developed to encourage modification of all risk factors for osteoporosis early in life. This will allow individuals to achieve their full genetic potential for acquiring skeletal mass and consequently lower their future risk of fractures.

Acknowledgements

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