ORIGINAL ARTICLE

Bone Mineral Densities and Hip Axis Lengths of Normal Singapore Women

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Summary

This study aims to evaluate the bone mineral densities and hip axis lengths of women in the local population. 227 normal Singapore women of ages 20 to 70 years had evaluation of their bone mineral densities (BMDs) by means of dual Xray absorptiometry (DXA). The trend of BMDs at the left femoral neck and the lumbar spine remains fairly constant with increasing age until the 45-49 years age-band, beyond which there is a consistent decline. The mean hip axis length is 10.3cm with a standard deviation of 0.6cm. In general, the bone mineral densities in the femoral neck and lumbar spine as measured by DXA and the hip axis length of the local population is lower than corresponding figures reported in the Western population.

Key Words: Osteoporosis, Osteopenia, Fracture

Introduction

Osteoporosis is a condition characterised by low bone density and disordered bone microarchitecture. Its main clinical significance lies in the predisposition to fracture, particularly of the wrist, vertebrae and the femoral neck. Worldwide, these fractures constitute a major medical burden for the elderly and a public health burden for the community. Several studies have shown that the estimation of bone mineral density can predict future fracture risk among women[1,2]. Our study involved 227 normal Singaporean females with the aim of determining the trend of the local population's bone mineral densities at the lumbar spine and the femoral necks, as well as the mean hip axis length.

Materials and Methods

Female subjects were recruited from among hospital staff, their relatives and friends. Exclusion criteria were endocrine diseases (including use of exogenous thyroxine) renal, hepatic or rheumatic diseases (including metabolic bone diseases), use of hormone replacement or steroids, hysterectomy or oophorectomy, and presence of malignancy and a history of hip or vertebral fractures.

Bone mineral density measurements were made using the latest dual-energy X-ray absorptiometry scanner (Hologic QDR4000A) employing a fan-beam. Calibration was performed at regular intervals. The regions scanned were the left femoral neck (generally the non-dominant leg), the lumbar spine at the L1 to L4 region (in the anterior posterior view) and L2 to L4 region (in the lateral view). The subject is scanned supine, according to recommended protocol, with the legs internally rotated and the first toes opposing each other during the hip scanning, with the hips flexed at 90 degrees when the spine is being scanned. The hip axis length was measured along a line through the centre of the femoral neck, with one end at the inner edge of the acetabulum and the other at the outer border of the greater trochanter (Figure 1). A questionnaire was administered (in English or with

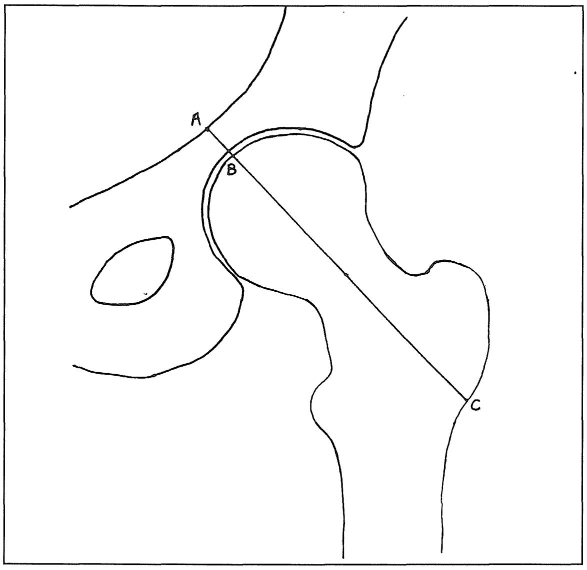

Fig. 1: Diagram of the hip showing the geometric measurement of the hip axis length. (AC=hip axis length, BC=femur axis length)

translation and explanation by the radiographer) which recorded several particulars (name, gender, age, weight, height, race, use of medications, concurrent medical illness, pre and postmenopausal status). Weight was measured on a standing scale in kilograms and height in centimetres by tape measure just before the commencement of the bone mineral density measurements.

Results

A total of 278 female subjects between ages 20 to 80 were initially included in this study. Those outside the age range were excluded. Of the 278 selected, 233 met the exclusion criteria. In view of the small numbers of subjects between 70 to 80 years of age, this age group was excluded as well. For the final analysis, a total of 227 female subjects were involved. Of the racial breakdown, 79% were Chinese, 4% were Malays, 12% were Indians and 4% of other races. The bone mineral densities were analysed in 5 years age bands as shown in Table I and graphically displayed in Figure 2. There is a distinct decline in bone mineral densities of both the

Table I
Trend of bone mineral densities according to age-bands in 227 normal Singapore females

Age-band (years)	N	Bone Mineral Densities Femoral neck (g/cm2)	Lumbar spine (ap) (g/cm2)	Lumbar spine (lat) (g/cm2)
20-24	8	0.79	0.99	0.80
25-29	31	0.78	0.93	0.73
30-34	25	0.77	0.97	0.77
35-39	26	0.77	1.00	0.76
40-44	33	0.77	1.01	0.77
45-49	34	0.80	1.01	0.77
50-54	20	0.80	0.92	0.68
55-59	17	0.73	0.91	0.64
60-64	18	0.63	0.78	0.55
65-69	15	0.60	0.74	0.54

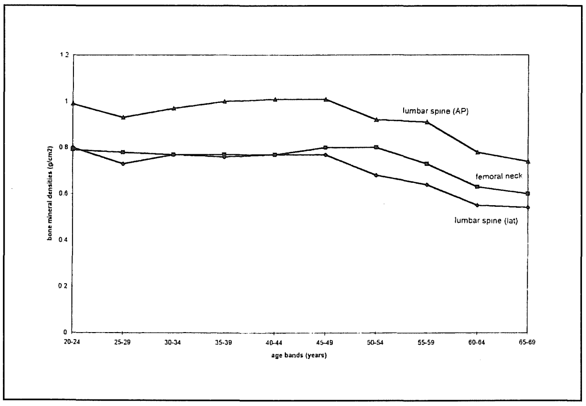

Fig. 2: Trend of bone mineral densities in age bands.

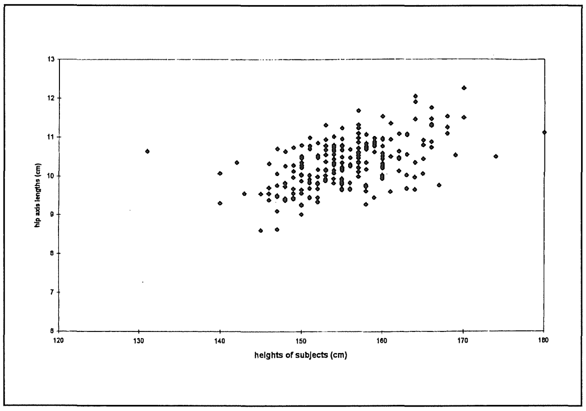

Fig. 3: Scatter diagram of the hip axis lengths and heights of subjects.

femoral necks and the lumbar spine, beginning at 45 - 49 years age-band in normal female subjects. The mean hip axis length was 10.31cm (103.1mm) with a maximum of 12.25cm, a minimum of 8.60cm and a standard deviation of 0.62cm. Further statistical analysis of the hip axis lengths in terms of race and age was deemed inappropriate due to small numbers in each group. However, hip axis lengths were correlated with the heights of the subjects. This gave a moderate correlation $r=0.51$ ($p<0.01$) (Figure 3).

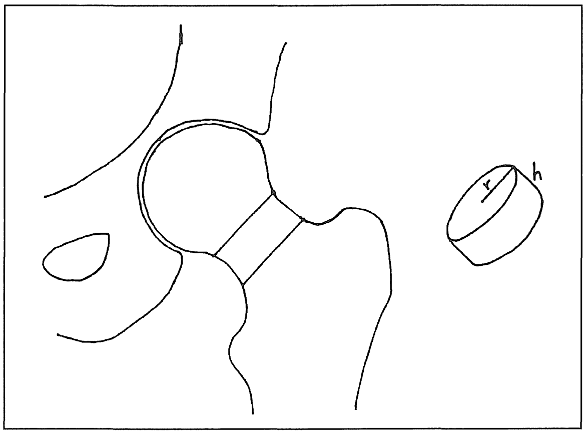

Fig. 4: A simple model of the femoral neck and the relationship between areal density and femoral neck radius.

let the bone density be p. Assume that it is constant.

therefore, bone mass=volume x p,

areal density=bone mass/cross-sectional area=volume x p/cross-sectional area

$=\pi r^2hp/2rh=\pi rp/2$

$\therefore$ areal density $\propto$ r

Thus, it may be proposed that bone mineral densities at the femoral neck be standardised or normalised by dividing it with femoral neck radius and corrected to a standard radius, for comparisons with the results of other investigations.

Discussion

Our findings are essentially similar to that of Leong and Feng[3] which showed a fairly constant bone mineral density at the femoral neck and lumbar spine until 40 - 44 years of age and subsequent distinct decline, using the Hologic QDR2000 machine. As Leong has highlighted in their paper, the bone mineral densities of our local Asian population is in general 3 - 8% lower than our American counterparts. This is also suggested by the bone mineral densities determined in this study as well as in some local data presented by Lee and Bose in 1989 using a lunar DPX machine[4]. Surprisingly, despite the lower bone mineral densities among

Singapore females compared to the Americans, the age-adjusted incidence rates of hip fracture among women in Singapore has been reported as 75 per 100,000 while that of American whites in California as 559 per 100,000[5]. Similar observations had been made by Nakamura et al[6], who noted that Japanese subjects have a shorter femoral neck length and a lower incidence of hip fractures than white Americans subjects despite a lower bone density. The comparatively low rates of fractures in Asians, in spite of a lower bone mineral density, has been explained in various ways, but two of the more plausible explanations are related to the nature of bone mineral density measurement using DXA and the shorter hip axis length in Asians.

Firstly, this low bone density and low fracture rate pattern may be partly accounted for by the fact that bone mineral densities obtained by dual-energy X-ray absorptiometry are area densities, rather than volume densities, which implies that, even when the bone density is unchanged, a generalised proportional increase or decrease in the size of the bone will cause a hidden and implicit change in the third, and unmeasured, dimension and this will influence the density value. In fact, a straightforward calculation, based on a simple model of a cylindrical femoral neck, suggests that even when the actual bone density is kept constant, the apparent bone mineral density (area density) will increase proportionally with the radius of the bone. Thus, it is possible that with the small dimensions of the bones of Asians, the measured areal bone mineral densities appear lower than the Western counterparts. This is supported by some studies which have reported that bone mineral densities at both the hip and spine did not differ significantly between Chinese, Japanese and whites living in the United States after adjusting for weight and height[5,7].

The second plausible explanation of the observation may be the shorter hip axis length of Asians. The hip axis length of the female subjects in our study is 10.31cm, which is relatively shorter than that reported by Peacock, et at[8], in Caucasian women (12.96cm), and by Theobald, et al[9], in Caucasian women (12.93cm), African-American women (12.72cm) and Nigerian women (11.33cm). It appears that taller women have an increased risk of hip fracture which may be related to a longer hip axis length and increased mechanical impact, as pointed out by Theobald, et al[9]. In the study by Peacock et al[8], it was found that consideration of hip axis lengths together with bone mineral densities increased the discrimination of hip fractures, compared to that based on bone mineral densities alone. Moreover, in one study, a one SD increase in hip axis lengthwas associated with a 1.8 fold increase in the risk of hip fracture in elderly females[10]. Thus, it may be that the shorter hip axis length of our local female population 'protects' against a hip fracture.

One drawback of this present study is that the racial disposition of our study population is slightly different from the national racial distribution. Furthermore, the relatively small numbers of subjects belonging to certain races preclude us from analysing the data in greater detail. Larger cross-sectional studies involving the different races would be interesting and useful.

Locally, the incidence of hip fractures has increased from 0.7 per 1000 women who were 60 years of age and older in 1957 to 1962, to 1.5 per 1000 in women in 1985[5]. A worldwide projection of hip fractures in the elderly predicts that the incidence of hip fractures in Asia will increase dramatically to 3 times the figure for 1990 (giving a figure of more than 1.5 million cases) by the year 2025 as a result of differential population growth, while that of North Americans will increase at a slower rate[11]. This projection highlights the clinical significance of osteoporosis and should propel further efforts in the diagnosis and treatment of this condition in Asia.

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