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Spinal Bone Mineral Density of Normal and Osteoporotic Women in Korea

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In order to define osteoporosis on the basis of bone mineral measurements, one must define an acceptable normal range or fracture threshold. It is clear that the normal range cannot be compared between different ethnic groups. We have measured spinal bone mineral density (BMD) by dual photon absorptiometry in 277 women without spinal fracture, aged 30-91 years, and in 53 women with asymptomatic spinal fracture to provide such a database for normal Korean women. Peak bone mass at the 3rd decade was 1.24 g/cm^2. BMD from age 40-69 was strongly correlated with age ($r = -0.7$) and the annual decrease averaged 0.018gm/cm^2. The rate of annual loss slowed by 50% in women after 70% years of age.

Fracture threshold was evaluated at the 90th percentile for spinal BMD in patients with vertebral fractures. The fracture threshold of the vertebra was 0.94 g/cm^2. Approximately 50% of normal women over 50 years of age had values below this threshold. These findings suggest that the way of developing low bone mass in Korean women is to peak high and lose fast.

Key Words: *Osteoporosis, Bone Mineral Density, Spinal Fracture*

INTRODUCTION

Osteoporosis, the most common metabolic bone disorder, is characterized by a reduction in bone mass that compromises the biochemical integrity of the skeleton and leads to an increased risk of fractures. Because the risk of fracture increases with decreasing bone mineral density (BMD) (Melton et al., 1990; Riggs and Melton, 1986; Melton et al., 1986), predicting fracture risk may be done with several bone mass measurement techniques. In order to define osteoporosis on the basis of bone mineral measurements, one must define an acceptable normal range and one must consider osteoporotic patients as those in whom measurements fall below the range for the young adult population or for age-and sex-matched healthy individuals (Nordin, 1987; Ott et al., 1987). Another approach has been to characterize the osteoporotic population to derive a fracture threshold based on the range of density measurements found in the population with fractures (Odvina et al, 1988). It is clear that normal range cannot be compared between different ethnic groups. The racial differences in BMD have been recognized between black and white women (Cohn et al., 1977; DeSimone et al., 1989) and between white and Japanese women (Yano et al., 1984). It is nevertheless worthwhile to study the BMD of Korean women to clarify the racial, nutritional and environmental factors influencing the development of osteoporosis. In this study we have collected data to provide such a database for Korean women and compare it with that of American and Japanese women even though the data was not randomly selected.

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MATERIALS AND METHODS

A total of 330 normal Korean women, aged 30-91 years, agreed to participate in the study from May 1988 to May 1991. All normal subjects were recruited from volunteers by word of mouth. Screened by medical history and physical examination, women free of disease or drugs known to influence bone and calcium metabolism were selected. Women with premature menopause and postmenopausal women who were on estrogen replacement therapy were excluded. All women had no past or current history of smoking or alcoholism. Height and weight were measured on the scanning day and all subjects under 40 Kg or over 100 Kg were excluded. Women over the age of 50 years routinely had lateral radiographs of the spine and 53 women have been detected to have more than one unrecognized compression fracture. These asymptomatic fracture patients were excluded from the normal database. Fracture threshold was evaluated at the 90th percentile for BMD of the lumbar spine (L2-4) in 53 patients with asymptomatic fracture. The distribution of BMD of normal subjects older than 50 years of age was investigated on the curves for analysis of fracture threshold.

The lumbar spinal BMD was measured using 153 Gd dual-photon absorptiometry (LUNAR DP4, Madison, Wisconsin). The results were expressed as BMD and as percentiles of controls matched for age, sex, weight, and ethnic background. Asian normal values are considered to be the same as white values by LUNAR software. Gadolinium sources were replaced annually. Measurements of the lumbar spine were made by one observer using the L2-L4 region of interest. The bone scanner used was properly calibrated according to the three-chamber standard provided with the instrument. Measurements on this standard phantom gave values within 1% of those expected. In 8 control subjects, the variation between two separate scans at 2 weeks interval was 2.4%. Statistical analysis was done with STATGRAPHICS (Stagraphics, STSC, Inc., Rockville, MD) on a personal computer. Data distribution was expressed as mean and standard deviation. Body mass index (BMI) was calculated as kg/m^2. A linear regression of BMD on age was obtained for middle-aged (40-69 years) and older normal subjects (over 70 years). Linear regressions were used to characterize the interrelationships of BMD, age, and body weight.

RESULTS

The average height, weight, and BMI are given in table 1. There were significant changes in height (P=0.0001), wight (P=0.03), and BMI (P=0.001) with age. The mean BMD values and age-matched percentiles for each decade group were significantly different (table 2). The BMD at the 3rd decade was 1.24 g/cm^2. There was a 5% decrease of BMD in th 4th decade. Mean age-matched percentile decreased below 100 after their fifties. Spinal BMD from age 40-69 was strongly correlated with age (r= −0.7, p=0.000) and the annual decrease averaged 0.018gm/cm^2. In older normal subjects, BMD was not significantly correlated with age. Height and weight had an influence on BMD (Table 3).

Table 1. Physical Characteristics of Normal Women

Age	n	Height (cm)*	Weight (kg)**	BMI***
30 - 39	23	158.8±6.2	54.8±7.6	21.7±3.1
40 - 49	65	157.6±5.1	55.8±6.4	22.4±2.5
50 - 59	101	156.2±5.2	57.0±6.6	23.6±2.7
60 - 69	58	152.9±5.1	55.4±8.8	23.7±3.5
70 - 79	22	153.2±5.8	51.4±8.6	22.0±3.2
>80	8	150.7±6.2	53.3±8.5	23.2±3.3

Data are presented as mean±standard deviation
BMI=body mass index
* P=.001 by ANOVA
** P=.03 by ANOVA
*** P=.001 by ANOVA

Table 2. Spinal Bone Mineral Density and Age- Matched Percentiles in Normal Women by Age in Decades

Age	n	BMD (g/cm^2)*	Percent matched**
30 - 39	23	1.24±0.12	105.4± 8.8
40 - 49	65	1.18±0.13	104.9±11.2
50 - 59	101	1.05±0.13	99.5±12.5
60 - 69	58	0.84±0.16	87.0±15.4
70 - 79	22	0.80±0.12	86.9±11.8
>80	8	0.69±0.13	76.0±13.1

Data are presented as mean±standard diviation
BMD=bone mineral density
* P=.00000 by ANOVA
** P=.00000 by ANOVA

Table 3. Regression of Spinal Bone Mineral Density on Age, Body Weight, and Height

Age group	n	Age	r	SEE	P
40 - 69	224	2.013 − 0.018 × age	−0.69	0.14	0.0000
> 70	30	1.418 − 0.086 × age	−0.37	0.13	0.0547
overall	284	1.850 − 0.015 × age	−0.72	0.14	0.0000
		Weight			
40 - 69	224	0.753 + 0.005 × Weight	0.19	0.19	0.005
> 70	30	0.391 + 0.007 × Weight	0.46	0.12	0.017
overall	284	0.605 + 0.007 × Weight	0.26	0.19	0.003
		Height			
40 - 69	224	−0.635 + 0.011 × Height	0.31	0.18	0.000
> 70	30	−0.214 + 0.006 × Height	0.28	0.13	0.16
overall	284	−0.961 + 0.013 × Height	0.35	0.19	0.000

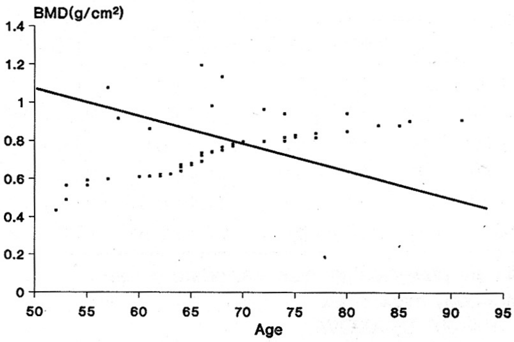

Fig. 1. Individual values of BMD in women with fractures. The center line denotes the age regression of normal women.

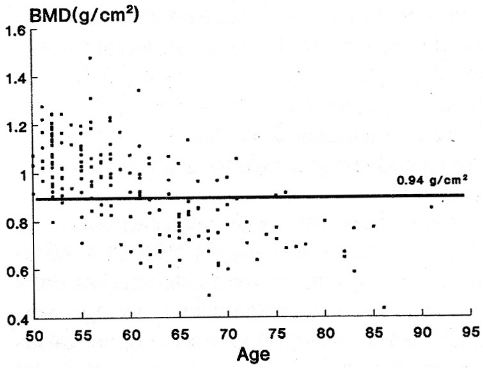

Fig. 2. Individual values of BMD in normal women after 50 years of age on the line of fracture threshold.

The fracture threshold of the vertebra was 0.94 g/cm^2. Individual values of BMD in women with fractures are shown in figure 1. Women before 70 years were in the lower part of the normal range or below it, but women after 70 years were within the normal range (± 2 standard deviation of control regression line). Figure 2 shows the individual values of BMD in control women over the age of 50 on the line for the calculation of fracture threshold. Approximately 50% of the control individuals were located below the line of fracture threshold.

DISCUSSION

The present cross-sectional study of age-related bone loss of the lumbar vertebra in Korean women has confirmed a clear trend of decrease in age-specific mean values of BMD and a good correlation with weight, and height. It is important to establish the normal ranges for age-related decreases of BMD for the diagnosis of metabolic bone diseases and the prevention of primary osteoporosis in Korea. These normal ranges are also useful for the evaluation of racial, nutritional and other environmental differences of BMD in trabecular bone.

The Racial differences in bone density have been reported between black and white women (Cohn et al., 1977; Desimone et al., 1989). Lumbar and radial BMD is lower in Japan than in the United States (Yano et al., 1984; Hagiwara et al., 1989; Norimatsu et al.,1989). The values of BMD in our study and those in Mazess (Mazess et al., 1987) for white women and in Norimatsu (Norimatsu et al., 1989) for Japanese women by DP3 are comparable, because the same model densitometer is used and that instrument calibration and bone mineral measurements are performed according to a standardized procedure. In the most widely accepted model for age-related bone loss, bone mass increases until peak bone mass is attained. This probably occurs during the third decade of life and may be followed by a period of relative stability until the point at which age-related bone loss begins, in the fourth decade or early in the fifth decade (Compston, 1990). It is of interest that the observed range of spinal BMD values in korean women until their Sixties were similar to those of Japanese and American women. It has been reported that calcium intake, daily activity, and birth-control pills which are different between Korean and American women, had no effects on the BMD of premenopausal women but that smokers had a significantly lower spinal BMD (Mazess and Barden, 1991). In Korea, social morality does not allow young women to smoke. So, only a few older Korean women smoke and most premenopausal women do not smoke. This may partly account for the similarity in BMD between Korean and American women until their sixties, although body weight was not considered. But, in their sixties, Korean women have a greater decrease in BMD (0.84 g/cm^2) than American (0.98g/cm^2) (Mazess et al., 1987) and Japanese women (0.93 g/cm^2) (Norimatsu et al., 1989). Annual loss rate in middle aged Korean women was 1.5 and 2 times greater than in Japanese (Norimatsu et al., 1989) and American women (Mazess et al., 1987), respectively. After 70 years of age, there was a relative stabilization of the BMD values with an apparent annual decrease of about 0.002 g/cm^2 in American (Mazess et al., 1987) and 0.0007 g/cm^2 in Japanese women (Norimatsu et al., 1989), but a continuous decrease at the rate of 0.0086 g/cm^2 was seen after 70 years in our study.

The mechanisms of ethnic difference in bone mass are not known. Theoretically, the lower peak bone mass and increased rate of loss at the menopause results in a considerably lower bone mass and higher fracture risk in later life (Compston, 1990). Peak bone mass in Korean women is no different but age related bone loss is 2 times greater than that of Americans. Christiansen (Christiansen et al., 1987), has suggested on the basis of biochemical data, that some women lose bone more rapidly than others during menopause (so-called fast losers). According to this concept, the way of developing low bone mass in Korean women is to peak high and lose fast and the process of rapid loss starts not from a high peak bone mass but relatively later. The reason why Korean women experience rapid bone loss after the age of 60 compared to white and Japanese women is not clear. Although the mean menopausal age was not calculated in our study, it has been reported that the mean menopausal age in Korean women was 47.6 years (Min and Ku, 1985) and this age is 3 years earlier than that of white women. Since the menopause has a greater effect on bone loss than does chronological age (Nilas and christiansen, 1987), earlier menopause in Korean women may account for the difference. Other possibilities are the low calcium intake and sedentary life style of Korean elderly women. Although the role for calcium deficiency in age-related bone loss remains to be frimly established, a quantitative review of the evidence suggest that calcium had a preventitve effect and that this effect was greatest when the baseline calcium was low (Cumming, 1990). Calcium intake is quite different between nations (Hegsted, 1986) and mean dietary calcium intake in Korean women is 403.6 mg/day and is lower in older women (Tchai, 1990). Although Korea has been developing socially or economically very rapidly, most elderly women are sedentary and do not participate in regular weight-bearing exercise.

Fracture thresholds from our study were 0.94 g/cm^2. The corresponding values of white (Riggs et al., 1981) and Japanese women (Norimatsu et al., 1989) were 0.97 g/cm^2. From these two reports, the fracture threshold was slightly lower in Korean women. Approximately 50% of normal Korean and Japanese women after 50 years had values below threshold, but by age 65, half of the normal white women had BMD values below threshold. These data suggest that bone loss may not be a sufficient factor to induce a spinal fracture, as Melton has suggested (Melton et al., 1986). In fact, the Japanese women had lower BMD than white women, but the femoral neck fracture rate was 1/2 or 1/3 lower than in white women (Gallagher et al., 1980). The reason for the low incidence of fracture has been regarded as smaller body size (Norimatsu et al., 1989) since the stress on the bone is smaller when women fall from a lower standing height. Mean body weight over 50 years in our study and in Japanese women was 54.3 Kg, 53.6 Kg (Norimatsu et al., 1989), respectively, but in white women it was 65Kg (De-Simone et al., 1989).

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