ORIGINAL

Intergenerational comparison of total and regional bone mineral density and soft tissue composition in Japanese women without vertebral fractures

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Abstract : We measured total and regional bone mineral density (BMD) and soft tissue mass in 115 healthy Japanese women without vertebral fractures. The subjects, aged 20 to 75 years, were divided into four age groups : 20's to 40's group (n=33), 50's group (n=26), 60's group (n=26), and 70's group (n=30). BMD was measured by dual energy X-ray absorptiometry (DXA). The evaluated regions were the head, arms, legs, ribs, thoracic vertebrae, lumbar vertebrae and pelvis. The total and regional BMDs were the highest in the 20's to 40's group, and they decreased with age, and reached their respective lowest values in the 70's group. The decrease in BMDs of the spine and pelvis was the most prominent of all regional BMDs. Total and regional lean mass and fat mass were the highest in the 20's to 40's group, and they decreased to their respective lowest values in the 70's group. The results showed that the decrease in BMD of the spine and pelvis was the most prominent of all regional BMDs associated with a decrease in the total and regional lean mass and total and regional fat mass. J. Med. Invest. 49 : 142-146, 2002

Keywords : *bone mineral density, soft tissue, aging, dual energy X-ray absorptiometry*

INTRODUCTION

Aging is associated with estrogen deficiency (1, 2), low calcium absorption in the small intestines (3), low production of vitamin D3 (4), and low mechanical stress on bone as a result of a decrease in physical activity, and activation of interleukin (IL)-1, IL-6 and tumor necrosis factor (TNF) (5-7), all of which are risk factors for the development of osteoporosis. In women, the bone mineral density (BMD) of the lumbar spine reaches its maximum at between 20 and 30 years of age (8), and remains almost constant until the 40's. Thereafter, the BMD decreases rapidly with the onset of menopause, and thereafter continues to decline slowly with age (9, 10). Bone resorption is markedly accelerated in the first five or ten years following menopause. Over their lifetime, women lose approximately 50% of their peak trabecular bone and approximately 35% of their peak cortical bone (11).

Einhorn (12) reported that the relative content of trabecular bone varied among the different parts of the skeleton. The trabecular bone is approximately eight-fold as metabolically active as cortical bone, and the response to metabolic changes is faster in trabecular bone than in cortical bone (13). Based on these findings, the rate of bone loss should vary according to the region examined and the age of each individual.

The purpose of this study was to investigate the differences in the rates of regional BMD decrease and soft tissue mass variations using dual energy X-ray absorptiometry (DXA). In the present study, the subjects were divided according to age into four age-brackets : 20's to 40's group, 50's group, 60's group, and 70's group.

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MATERIALS AND METHODS

Subjects (Table 1)

This study comprised 115 Japanese women aged 21 to 79 years. These 115 subjects were out-patients undergoing examinations for osteoporosis. These healthy women were divided into four age-brackets : 20's to 40's group (n=33), 50's group (n=26), 60's group (n=26), and 70's (n=30) group. All subjects gave their informed written consent before DXA examination. None had received any treatment affecting bone metabolism or had fractures of the thoracic or lumbar vertebrae. Their physical characteristics (height, weight, and body mass index (BMI)) are shown in Table 1. The mean height and weight decreased with age. The height of the 20's to 40's group was significantly higher than that of the 60's group ($p<0.05$) and that of the 70's group ($p<0.05$). The body weight of the 70's group was significantly lower than that of the 20's to 40's group ($p<0.05$) and that of the 50's group ($p<0.05$). However, BMI did not vary markedly among the four groups.

Measurement of BMD and soft tissue composition

The mean BMD of the 2nd to 4th lumbar vertebrae (L2-4BMD), total body BMD and soft tissue mass were measured by DXA using a Hologic QDR 2000 (Waltham, MA, USA). The BMD (g/cm^2) of the head, arms, legs, ribs, thoracic vertebrae, lumbar vertebrae and pelvis were measured. The lean mass (g) and the fat mass (g) of head, arms, legs, and trunk were measured using a tissue bar (Figure 1) (14).

Statistics

Results were expressed as means±standard de-

Table 1. Characteristics of the subjects.

	20's to 40's	50's	60's	70's
No. of Subjects	33	26	26	30
Height (cm)	154.7±7.5[a, b]	152.6±5.7	149.6±6.2	149.9±5.1
Weight (kg)	53.9±9.0[b]	53.2±6.2[b]	52.2±11.0	47.7±8.1
BMI	22.6±3.6	22.9±2.5	23.4±5.2	21.2±3.5

Values are given as means±standard deviation.
[a]$p<0.05$ vs 60's group, [b]$p<0.05$ vs 70's group.

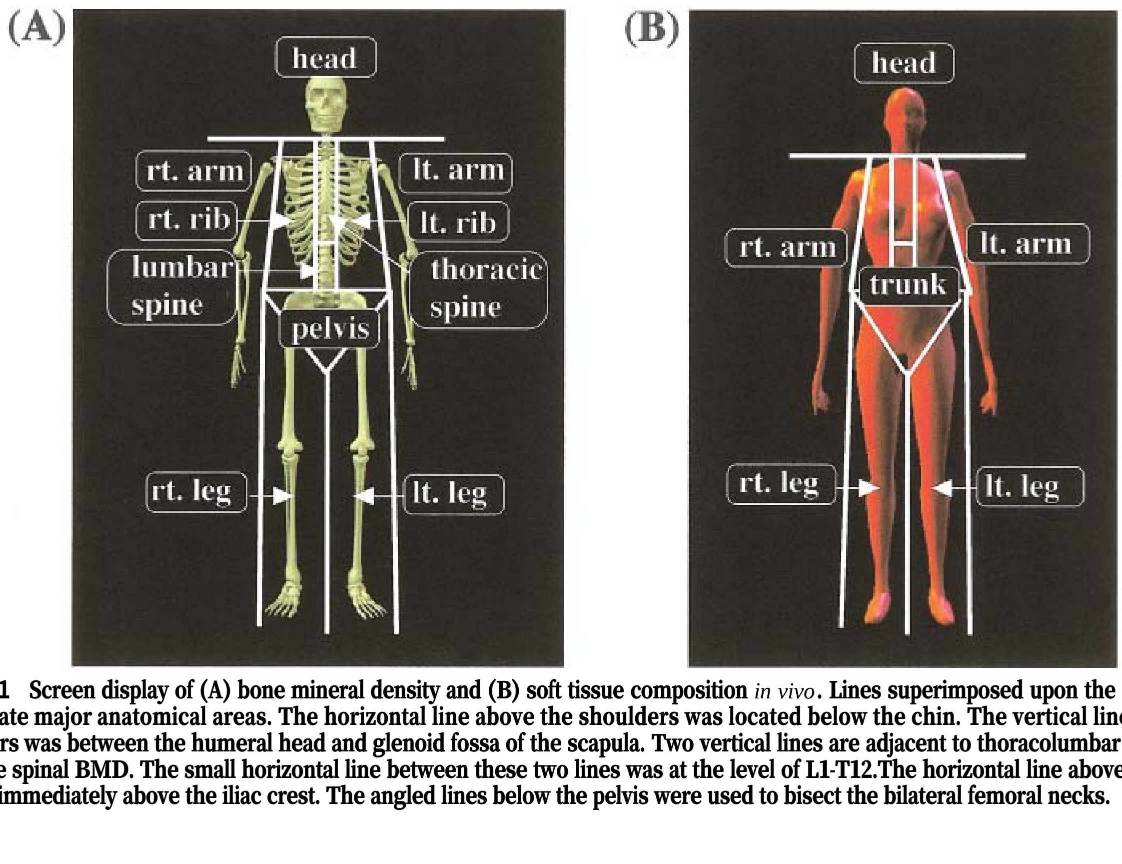

Figure 1 Screen display of (A) bone mineral density and (B) soft tissue composition *in vivo*. Lines superimposed upon the skeleton demarcate major anatomical areas. The horizontal line above the shoulders was located below the chin. The vertical lines at the shoulders was between the humeral head and glenoid fossa of the scapula. Two vertical lines are adjacent to thoracolumbar spine to measure spinal BMD. The small horizontal line between these two lines was at the level of L1-T12.The horizontal line above the pelvis was immediately above the iliac crest. The angled lines below the pelvis were used to bisect the bilateral femoral necks.

viation (S.D.). One-way analysis of variance (ANOVA) was used to evaluate the significance of differences among the four groups. When ANOVA indicated significant differences among the four groups, the differences were evaluated using Fisher's protected least significant difference (PLSD). A *p* value of less than 0.05 was considered statistically significant.

RESULTS

L2-4BMD, total BMD and regional BMD (Table 2).

As shown in Table 2, L2-4BMD in the 20's to 40's group was the highest of all groups. L2-4BMD of the 50's group was approximately 80% of that of the 20's to 40's group. L2-4BMD of the 70's group was approximately 69% of that of the 20's to 40's group. The difference in L2-4BMD was the greatest between the 70's group and the 20's to 40's group. The decrease in the lumbar BMD as assessed by whole body-scanning was similar to that of L2-4BMD.

The difference in the thoracic BMD between the 70's group and the 20's to 40's group was the second greatest among the regional BMDs, and that regarding pelvis BMD was the third greatest. The tendency of pelvic BMD to decrease with age was similar to that of lumbar and thoracic BMD. In contrast, the decrease in BMD of the left and right arms, as non-weight-bearing bones, was small compared with that of weight-bearing bones such as the thoracic and lumbar spine, pelvis and legs.

Total and regional lean mass (Table 3).

Total lean mass of those in the 20's to 40's group was the highest among all generations. Total lean mass was significantly decreased in the 70's group ($p<0.05$), being 90.1% of the total lean mass of those in the 20's to 40's group. The lean mass of all re-

Table 2. Bone mineral density.

	20's to 40's	50's	60's	70's
No. of Subjects	33	26	26	30
L2-4BMD	1.02±0.15 [a, b, c]	0.83±0.16 [d, e]	0.74±0.16	0.71±0.14
total	1.05±0.08 [a, b, c]	0.91±0.11 [d, e]	0.85±0.08	0.83±0.07
left arm	0.66±0.04 [a, b, c]	0.59±0.06 [d, e]	0.55±0.05	0.54±0.05
right arm	0.70±0.05 [a, b, c]	0.61±0.06 [e]	0.59±0.06	0.57±0.04
left rib	0.58±0.06 [a, b, c]	0.51±0.06 [d, e]	0.47±0.05	0.44±0.04
right rib	0.60±0.06 [a, b, c]	0.53±0.05 [d, e]	0.50±0.05	0.46±0.04
thoracic spine	0.89±0.19 [a, b, c]	0.74±0.13 [d, e]	0.66±0.11	0.63±0.09
lumbar spine	1.05±0.20 [a, b, c]	0.84±0.19 [d, e]	0.75±0.17	0.72±0.14
pelvis	1.08±0.16 [a, b, c]	0.92±0.15 [d, e]	0.83±0.13	0.78±0.13
left leg	1.09±0.09 [a, b, c]	0.91±0.20	0.89±0.09	0.85±0.08
right leg	1.09±0.09 [a, b, c]	0.91±0.19	0.90±0.09	0.85±0.09
head	1.92±0.23 [a, b, c]	1.69±0.36 [e]	1.53±0.66	1.47±0.21

(g/cm^2)

Values are given as means±standard deviation.
[a]p<0.05 vs 50's, [b]p<0.05 vs 60's, [c]p<0.05 vs 70's, [d]p<0.05 vs 60, [e]p<0.05 vs 70's.

Table 3. Total and regional lean mass.

	20's to 40's	50's	60's	70's
No. of Subjects	33	26	26	30
total	33.8±5.5 [a]	33.0±3.3 [b]	32.2±4.0	30.4±5.7
left arm	1.29±0.36	1.32±0.22	1.27±0.25	1.29±0.17
right arm	1.53±0.46	1.52±0.20	1.43±0.29	1.40±0.31
trunk	17.2±3.3	16.5±3.6	16.0±3.2	16.1±1.7
left leg	4.84±1.07	4.74±0.64	4.77±0.74	4.61±0.57
right leg	5.10±1.17	4.97±0.65	4.97±0.75	4.80±0.58
head	3.44±0.67	3.37±0.35	3.41±0.33	3.40±0.26

(kg)

Values are given as means±standard deviation.
[a]p<0.05 vs 70's, [b]p<0.05 vs 70's.

Table 4. Total and regional fat mass.

	20's to 40's	50's	60's	70's
No. of Subjects	33	26	26	30
total	17.9±7.5 [a]	18.3±4.8 [b]	16.8±8.0	14.4±6.8
left arm	1.25±0.53 [a]	1.31±0.33 [b]	1.12±0.58	0.94±0.54
right arm	1.35±0.62 [a]	1.27±0.45	1.26±0.90	0.94±0.58
trunk	7.94±4.21	8.61±3.16 [b]	7.64±4.30	6.16±3.91
left leg	3.31±1.29 [a]	3.08±0.66	2.94±1.18	2.60±1.11
right leg	3.45±1.15 [a]	3.11±0.64	2.96±1.22	2.54±1.23
head	0.94±0.13	0.87±0.12	0.89±0.20	0.90±0.09

(kg)

Values are given as means±standard deviation.
[a]p<0.05 vs 70's, [b]p<0.05 vs 70's.

gions, except for the lean mass of the left arm and head, decreased with age.

Total and regional fat mass (Table 4).

Total fat mass, left and right arms fat mass, left and right legs fat mass of those in the 20's to 40's group were significantly greater than those in the 70's group (p<0.05). In addition, total fat mass, left arm fat mass, and trunk fat mass of subjects in the 50's group were significantly greater than those of subjects in the 70's group (p<0.05). Total and regional fat mass of subjects in the 70's group, except for head fat mass, showed the lowest values. Total fat mass of women in the 70's group was 80.4% of that of those in the 20's to 40's group.

DISCUSSION

As shown in this study, the magnitude of the decrease in lumbar and thoracic BMD was high compared with other regional BMDs. Einhorn (12) showed that the relative content of trabecular bone varied among the different parts of the skeleton, and that the content of trabecular bone of vertebrae was 66-90%, that of the hip at the intertrochanteric region was 50%, that of the hip at the femoral neck was 25%, that of the distal radius was 25%, that of the mid-radius was 1%, and that of the femoral shaft was 5%. As for bone metabolism, the trabecular bone is approximately eight times as metabolically active as cortical bone, because the surface of trabecular bone is larger than that of cortical bone, and the response to metabolic changes in trabecular bone is faster than that of cortical bone (13). Therefore, the marked rate of decrease in lumbar, thoracic and pelvic BMD may be due to the high content of trabecular bone compared with other regional bones.

In addition, physical activity decreases with age, which may lead to trabecular bone resorption in postmenopausal women. Changes in trabecular bone resulting from low mechanical stress on bone are more prominent than those observed in cortical bone. The differences in the patterns of bone loss in different regions may be ascribable to the site-specific cortical to trabecular bone ratio. The lumbar and thoracic spines are rich in trabecular bone (12), and this may explain why the decrease in BMD was more marked in the spine compared with other regions, as shown in the present study.

In the present study, we also demonstrated that total lean mass declined with age to their respective minimal levels in women in their 70's. The tendency of a decrease in total lean mass was similar to that observed in L2-4BMD compared with total fat mass. Based on this finding, lean mass may become a predictor of L2-4BMD.

This study was a cross-sectional one. The divergent levels of dietary calcium intake and other environmental factors in addition to aging must have effects on BMD, which may account for the differences in BMD among these age-groups. Therefore, a longitudinal study is required to assess the effects of aging on total and regional BMD, and soft tissue composition.

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