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Taiwanese Journal of Obstetrics & Gynecology 52 (2013) 61−65

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Original Article

Longitudinal changes in bone mineral density of healthy elderly women in southern Taiwan

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Accepted 11 August 2012

Abstract

Objective: Longitudinal data on bone decline in ethnic Chinese elderly are sparse, especially in healthy, aged women. This study reviews the longitudinal change in bone mineral density (BMD) at the femoral neck, great trochanter, and Ward's triangle in healthy elderly Taiwanese women.
Materials and Methods: A prospective cohort study was conducted, with 1500 women aged $\geq$61 years. Fifty-four were eligible for hip evaluation and 52 underwent examination for hip BMD. Two years later, 50 women had a follow-up BMD examination. Linear regression was performed between age and bone density. The paired t test was used for BMD changes between examinations.
Results: In the initial study, there was a negative relationship between BMD and age using liner regression at all three sites ($p < 0.05$). Two years later, there was a significant decrease in BMD at all three sites ($p < 0.01$). In terms of age cohorts, both age groups showed a significant decrease in BMD at the three sites studied ($p < 0.01$). There was a peak loss of BMD as high as 2.74% annually at the Ward's triangle in those aged 61−70 years.
Conclusion: Our findings indicate that BMD is negatively correlated to aging in the healthy female. The loss of BMD at the Ward's triangle in those aged 61−70 years is faster than at other sites. Attention should be given to bone loss in ethnic Chinese females because their bone loss is more severe than that of Caucasians.

Keywords: bone loss; bone mineral density; elderly; female; longitudinal study

Introduction

Osteoporosis among the elderly is a major public health problem. The incidence of osteoporosis-related fracture increases with age. The elderly, especially women, are at particular risk for osteoporosis-related fractures as a result of falls and low bone mass. Among osteoporotic bone fractures, hip fractures result in functional dependency, socioeconomic problems, greater health care utilization, and the highest mortality rate than other fractures. The risk of mortality increases to 30−33% within 1 year after fracture [1−4].

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1028-4559/$ - see front matter
http://dx.doi.org/10.1016/j.tjog.2012.08.001

Bone strength reflects the integration of two main features: bone mineral density (BMD) and bone quality. Many studies have indicated that BMD is inversely associated with age and directly associated with fracture [5–7]. A longitudinal study showed that the incidence of hip fracture is associated with low femoral neck BMD [8].

Longitudinal data on bone decline in Taiwanese women are sparse. Studies of BMD in Taiwan are limited to cross-sectional designs and the participants were the general population, without stratification [9,10]. These limitations also appeared in other studies of ethnic Chinese populations [11–13]. Comprehensive assessment of bone loss over time is important in order to characterize the pattern of bone loss in relation to aging and identify the populations at risk for osteoporosis. To identify the leading factors of osteoporosis more precisely, a longitudinal study would be a better choice than a cross-sectional study. Bone loss underestimation was found in one cross-sectional study [14].

With the accurate delineation of bone mass in perimenopausal women, attention has shifted to BMD among adults in their later years. The rate of change in bone mass is related to fracture risk in the elderly, because this group is highly susceptible to relatively low energy fractures associated with bone fragility. The absolute levels of BMD may determine the susceptibility of the elderly to fractures as they age. Elderly persons who are active volunteers for studies and who have no other ongoing medical problems that might affect BMD are only a minority of the elderly population. We hypothesized that the bone loss rate in different areas of the proximal femur in different age groups differs in elderly women. Thus, we performed a prospective longitudinal cohort study of healthy participants aged $\geq$61 years, with a 2-year interval, to gather baseline information about the course of senile osteoporosis in elderly women in Kaohsiung, the biggest city in southern Taiwan. The primary goal of this study was to provide baseline BMD data of healthy, elderly women. The secondary goal was to ascertain the aging effect on the magnitude of BMD loss, and the third goal was to compare the difference in the BMD loss rate at different sites of the proximal femur among different age groups.

Materials and methods

Volunteer screening

All volunteers lived in Kaohsiung. The initial screening included 1500 women. The screening process included three phases. First, a junior nurse screened the potential candidates using a structured questionnaire. The exclusion criteria included: (1) history of established osteoporosis; (2) history of fracture or obvious metabolic bone disease; (3) history of malignancy; (4) history of endocrine diseases including thyroid, parathyroid, adrenal, pituitary, or gonadal diseases; (5) menopause before age 45 years; (6) history of drug abuse, psychosis, or alcoholism; (7) history of calcium or vitamin D supplementation, or thyroid, steroid, or gonadal hormone replacement or bisphosphonates or selective estrogen receptor modulator treatment for >2 months; (8) lower leg arthropathy leading to an inability to climb two flights of steps at one time, and the need to take a break during a walk of two blocks in length; and (9) spinal problems including spondylosis, sciatica, spondylolisthesis, kyphosis, or scoliosis. In all, 60 participants were qualified to enter the second phase of the study. The qualified women were invited to Kaohsiung Medical University Hospital for chest X-ray, laboratory tests, and pulmonary function examinations. Two senior physicians responsible for examining and reading the results made decisions on who would qualify for the third phase of the study, i.e., the BMD examination. Among 60 qualified women, 54 were eligible for hip evaluation and 52 (96.3% participation rate) completed the hip BMD examination. Two years after the initial examination, 50 elderly participants returned for the second hip BMD evaluation.

BMD measurement

Participants were invited to the same hospital for the second examination 2 years after the initial assessments. Norland 36R dual-energy X-ray absorptiometry (Fort Atkinson, WI, USA) was used to evaluate BMD in the femoral neck, the Ward's triangle, and the great trochanter. Only one specially trained technician performed the measurements to maintain minimal variance. The changes in BMD of the study participants between these two examinations were analyzed.

Statistical analysis

Data were analyzed by SPSS 14.0 for Windows. Univariate linear regression was perform to understand the relationship between age and hip BMD, using the baseline data. Two age cohorts (61–70 years and $\geq$71 years) were stratified to explore bone loss. The speed of bone loss was measured by percentage or rate. The paired t test was used to examine whether there were significant differences between the two examinations; $p < 0.05$ was considered significant.

Results

Cross-sectional analysis

Fifty participants, aged $\geq$61 years and from an urban area in Taiwan, completed the follow-up. All participants had experienced menopause for >7 years. The BMD and demographic characteristics of the elderly at baseline, such as age, body height, body weight, body mass index, and hip BMD are shown in Table 1. The participants were divided into two groups, those aged 61–70 years, and those aged $\geq$71 years. Baseline BMD at the femoral neck for these age groups were 0.699 ± 0.103 (mean $\pm$ standard deviation) g/cm^2 and 0.650 ± 0.097 cm^2; BMD at the Ward's triangle were 0.529 ± 0.079 g/cm^2 and 0.459 ± 0.092 g/cm^2; BMD at the great trochanter were 0.634 ± 0.079 g/cm^2 and 0.567 ± 0.092 g/cm^2, respectively. The distributions of BMD at all three examined sites were inversely related to age, using

Table 1
Bone mineral density (BMD) and population characteristics at baseline.

Age (y)	n	Height (cm)	Weight (kg)	Body mass index	Femoral neck BMD	Ward's triangle BMD	Great trochanter BMD
61–70	18	153.61 ± 5.57	58.61 ± 8.42	24.78 ± 2.84	0.699 ± 0.103	0.529 ± 0.079	0.634 ± 0.079
≥71	32	153.38 ± 4.95	54.75 ± 8.46	23.29 ± 3.63	0.650 ± 0.097	0.459 ± 0.092	0.567 ± 0.092
Total	50	153.46 ± 5.13	56.14 ± 8.57	23.83 ± 3.41	0.668 ± 0.101	0.484 ± 0.093	0.591 ± 0.093

linear regression at the initial examination (Fig. 1). The annual mean BMD loss rates at the femoral neck, the great trochanter, and the Ward's triangle were 0.007 g/cm^2, 0.01 g/cm^2 and 0.01 g/cm^2, respectively.

Longitudinal analysis

Longitudinal analyses revealed a significant loss of BMD at the femoral neck ($p < 0.01$), the great trochanter ($p < 0.001$), and the Ward's triangle ($p < 0.001$) in these 50 women (Table 2) 2 years later. Both age groups showed a significant decrease in BMD at the three studied sites. The annual mean losses of BMD for the 61–70 years and ≥70 years age groups, respectively, were 0.4 % and 0.68 % at the femoral neck; 2.74% and 0.71% at the Ward's triangle; and 0.56% and 0.72% at the great trochanter. In women aged 61–70 years, there was a significant peak loss of BMD as high as 2.74% every year at the Ward's triangle, higher than in the other groups.

Discussion

Our primary goal was to provide baseline data of BMD in healthy, elderly women. Using regression analysis, the baseline data of this study showed that BMD in the proximal femur

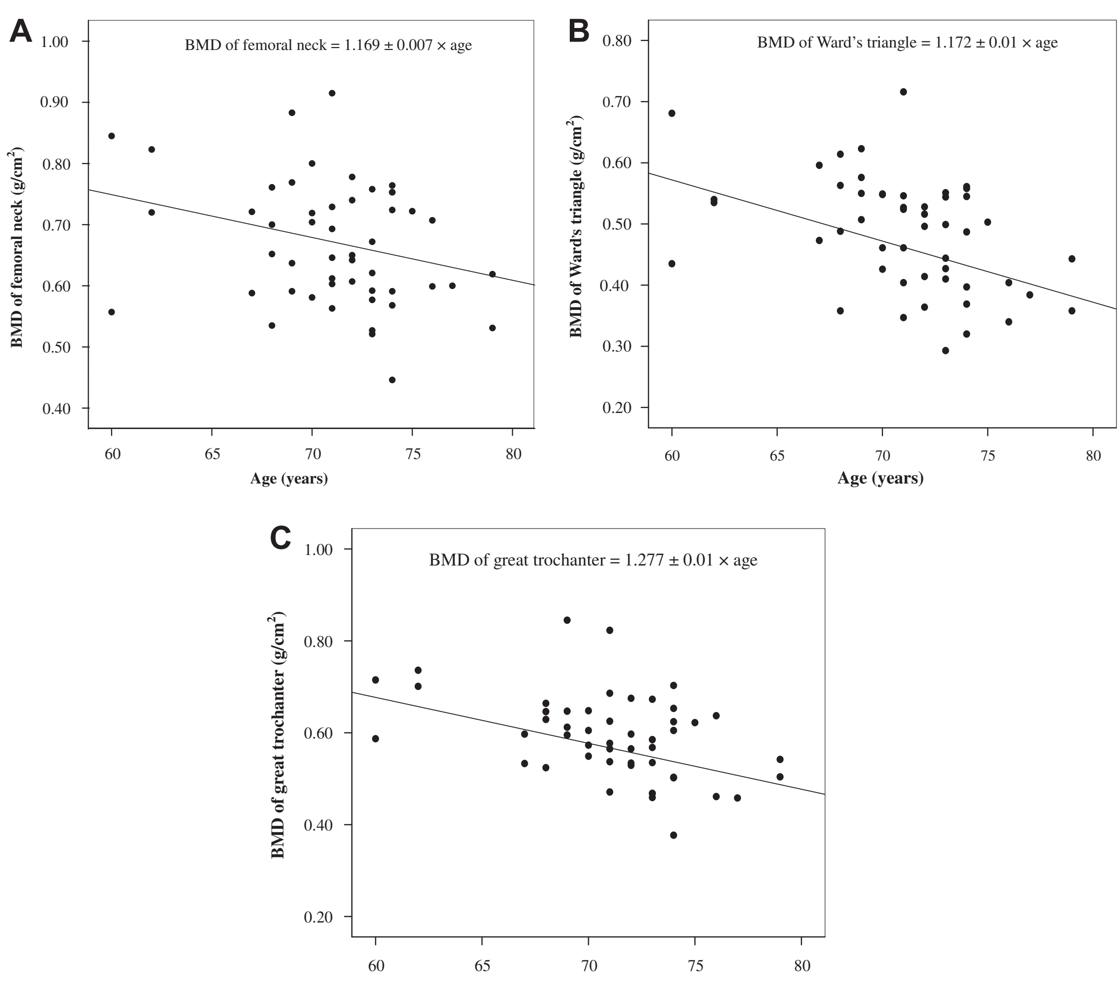

Fig. 1. Distribution of bone mineral density (BMD) at the femoral neck, Ward's triangle, and the great trochanter in 50 healthy women. The distribution of BMD was inversely related to age at initial examination using linear regression. (A) BMD at the femoral neck versus age ($p < 0.05$); (B) BMD at the Ward's triangle versus age ($p < 0.05$); and (C) BMD at the great trochanter versus age ($p < 0.05$).

Table 2
Loss of bone mineral density (BMD) in healthy elderly female 2 years after initial examination with age stratification.

Age (y)	n	Loss of BMD at femoral neck (g/cm^2)	Mean loss/y (%)	Loss of BMD at Ward's triangle (g/cm^2)	Mean loss/y (%)	Loss of BMD at Great trochanter (g/cm^2)	Mean loss/y (%)
61−70	18	−0.008 ± 0.037*	−0.40	−0.055 ± 0.079**	−2.74	−0.011 ± 0.017**	−0.56
≥71	32	−0.014 ± 0.017***	−0.68	−0.014 ± 0.029**	−0.71	−0.014 ± 0.023***	−0.72
Total	50	−0.012 ± 0.026**	−0.58	−0.029 ± 0.055***	−1.44	−0.013 ± 0.021***	−0.66

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

declined significantly with aging in healthy women aged ≥61 years. Most previous studies also showed that the decrease in BMD at most sites was related to age [11,14−16]. Our secondary goal was to examine the rate of bone loss at the hip in elderly healthy women and determine whether bone loss progresses with age. Longitudinally, BMD at all three sites studied decreased significantly with increased age. For postmenopausal Hong Kong Chinese women, the rate of bone loss was 0.65−2.56%/year [11], similar to our findings. Yang et al reported that BMD of the femoral neck would significantly decline in both genders after age 65 years, and that the risk of hip fracture would increase significantly [17]. Most studies of hip fracture focused on hip BMD and femoral BMD. In another study, Yang et al found that the BMD of the Ward's triangle was significantly lower than that of the other two sites of the hip (the femoral neck and the great trochanter), and especially, it was much lower after hip fracture [9]. In this study, we found that the mean rate of BMD loss at the Ward's triangle in the 61−70 years age group was 6.85 times higher than that of the femoral neck, and 4.89 times higher than that of the great trochanter. BMD at the Ward's triangle was significantly lower than that of the femoral neck and the great trochanter. The mean loss rates were nearly the same in all three areas beyond age 70 years. The participants in Yang et al's study lived in northern Taiwan, while those in our study lived in southern Taiwan. Despite the difference in population and residence between the two studies, the results were similar.

There are several advantages to this study. First, the longitudinal design is an improvement over the cross-sectional design because the longitudinal study provides better estimates of the rate of bone loss. Second, the present study focused on a longitudinal analysis of the hip in women age >60 years, and thereby avoided the potential bias that can arise from including groups of recent postmenopausal women whose rapid bone loss may alter the analysis. Third, analysis of the hip region provides a more accurate evaluation than that of the spine, which can easily be affected by age-related osteoarthritis, sclerosis, aortic calcification, and osteophytes. Densitometry of bone using dual-energy X-ray absorptiometry can be biased by arthritic changes. Degenerative changes may increase bone mineral content and BMD readings and fictitiously cause a larger projected area, particularly at the spine [5]. Fourth, we excluded women with medication or metabolic disease, which is known to alter the skeleton. Finally, all women were ambulatory, which can exclude the effects of prolonged immobilization.

There are still some limitations to this study, however. The cohort is representative of relatively healthy elderly women, so these data cannot be generalized to community-dwelling elderly women who may have some disease or condition that affects bone metabolism. Second, since the participants were healthy volunteers and may be relatively more active than typical community-dwelling elderly women, bone loss may be underestimated in this age group. Finally, there was only a 2-year interval between measurements. It would be important to extend this investigation to examine a 5-year follow-up to determine whether similar trends continue.

The population of women aged >60 years is growing, and is expected to grow exponentially. According to vital statistics, the elderly currently make up 8.5% of Taiwan's population, and the size of this age group is increasing, which indicates that the society is aging. BMD of the femoral neck plays a role in utilizing the FRAX diagnostic tool [18,19], and our study provides useful data for its application in the FRAX. With increasing age and decreasing BMD in the femoral neck with time, the 10-year possibility of fracture increases.

We found that the women in our study experienced a much higher rate of bone loss than those of two other studies (Table 3). For example, the mean bone loss rate at the femoral neck was 0.012 g/cm^2/y in our study, compared to 0.005 g/cm^2/y in the Framingham study and 0.0045 g/cm^2/y in the Rotterdam study [20,21]. The mean rate of BMD loss at the femoral neck was about 2.4 and 2.7 times higher in our study than in the Framingham and Rotterdam studies, respectively. Similarly, the mean rate of BMD loss was about 9.7 and 5.7 times higher at the Ward's triangle and 2.6 and 5.9 times higher at the great trochanter than in the other two studies. The possible causes may be differences in genetics [22], eating habits [23,24], and lifestyles [7]. In our previous study of men aged >65 years, the annual loss rate was nearly the same in the Ward's triangle and the great trochanter, but the annual loss rate at the femoral neck was more obvious in men (−0.032 g/cm^2/y) than in women (−0.012 g/cm^2/y) [25].

In conclusion, bone loss in ethnic Chinese women should be given more attention, because there is much more bone loss in this group than in Caucasian women [5,20,21].

Table 3
Comparison of annual change in bone mineral density (g/cm^2/y) in elderly women[a].

	This study (n = 50)	Framingham study [20] (n = 698)	Rotterdam study [21] (n = 2452)
Femoral neck	−0.012	−0.005	−0.0045
Ward's triangle	−0.029	−0.003	−0.0051
Great trochanter	−0.013	−0.005	−0.0022

[a] All participants were aged ≥61 years, with the exception of those in the Rotterdam study, who were aged ≥55 years.

Acknowledgments

This research was supported by the National Health Research Institutes, Taiwan (NHRI- EX90-8903PL and NHRI-EX99-9935EI), Kaohsiung Medical University Hospital (KMUH97-7R34), and National Cheng Kung University Hospital (NCKUH-9903055 and NCKUH-10003013).

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