A Longitudinal Study of the Relationship between Osteo Sono-Assessment Index and Lifestyle in Elderly Female in Nursing Homes

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Abstract

The aim of this study was to investigate the longitudinal effect of mobility and daily activity, in the form of exercise and everyday activities, on the bones of 102 elderly female nursing home residents who had physical disabilities as well as marked postmenopausal bone loss, using calcaneal ultrasound apparatus for bone evaluation.

Of the 102 subjects initially measured, 74 (mean age, 83.5±6.55 years; range, 64–99 years) could be measured again approximately one year later. The osteo sono-assessment index (OSI) in this study was determined using an ultrasound bone evaluation device. This device measures the speed of sound (SOS) and transmission index (TI) as ultrasound passes through the calcaneus. The OSI is calculated by computer analysis ($OSI=TI \times SOS^2$). For mobility, the OSI decreased significantly by an average of 1.8% after 11.8 months in all of the residents who were using a wheelchair ($n=41$, $p<0.01$). In contrast, the OSI rose significantly by a mean of 1.9% in the ambulatory group ($n=33$, $p<0.01$).

The OSI increased significantly in residents who exercised every day, were out of bed for at least seven hours per day, and walked on a regular basis, suggesting that exercise, mainly in the form of walking, may increase the calcaneal OSI.

Key words: osteo sono-assessment index, elderly female with handicap, nursing home residents, daily activity, calcaneus

Introduction

The rapid increase in the aged population has brought with it a dramatic rise in the prevalence of osteoporosis. In Japan, an estimated ten million people had the disease in 1996. (1) Each year, approximately 100,000 of these develop fractures, a major cause of immobility in the elderly. (1, 2) These are particularly serious problems in women, who experience a rapid decline in bone density after the menopause. (2–4)

The prevention of osteoporosis is important because the condition is difficult to treat. (5–7) Many cross-sectional studies have collected data on bone density and lifestyle factors in adults and children. (8–13) However, this research has been limited to longitudinally or to elderly people who require care or to those who are physically disabled. (14, 15)

Nursing homes for the elderly have dieticians on the staff to

ensure that the nutritional intake is adequate, but few have experts to supervise the quality and amount of exercise that residents take. This, coupled with the fact that the majority of time in a nursing home is spent indoors, means that nursing home residents are less active than elderly people who live at home. Activity is also reduced by physical disabilities, with the result that many nursing home residents do not receive sufficient exercise. This lack of exercise presumably has some adverse effect on the bones.

The aim of this study was to longitudinally investigate the effect of mobility and daily activity, in the form of exercise and everyday activities, on the bones of elderly female nursing home residents who had physical disabilities as well as marked postmenopausal bone loss, using calcaneal ultrasound apparatus for bone evaluation.

Subjects and Methods

The subjects were elderly female residents of three nursing homes in the Hirosaki area of Aomori Prefecture that were approved of the purpose of the study. We included only those women who gave their informed consent or whose families gave informed consent after a nursing home representative had explained the nature of the study to the residents and their families

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at a residents' family meeting. Residents were excluded if they were physically frail or were receiving treatment for osteoporosis. Those who were unable to sit in a chair even with assistance or who had marked equinus contracture of the ankles were also excluded because the device used to measure bone density required that the subjects be able to sit in a chair and to bend the ankle to 90° (midway between plantar flexion and dorsal flexion). A total of 102 subjects underwent initial measurement.

The osteo sono-assessment index (OSI) was determined using an ultrasound bone evaluation device (AOS-100, Aloka Co., Ltd., Tokyo, Japan). This device measures the speed of sound (SOS) and transmission index (TI) as ultrasound passes through the calcaneus. The OSI is calculated by computer analysis ($OSI=TI \times SOS^2$). The device measures calcaneal density on the side with no history of fracture (or on the normal side in patients with hemiplegia caused by cerebrovascular disorders).

Once bone density had been measured, the factors reported to affect osteoporosis were investigated using a questionnaire that was administered by the caregivers and nurses. The questionnaire focused on mobility and daily activity (e.g., ability to perform everyday activities and time spent out of bed), but also included questions on exercise, exposure to sunlight, and diet (Table 1). The questions related to life within a nursing home and were selected from the Osteoporosis Screening Manual and from previous studies of bone density. (3, 10, 11, 13) OSI measurement and the questionnaire were then repeated in the same subjects using the same method approximately 11.8 months later (mean interval). As at the initial assessment, subjects were excluded if they were physically frail or if they had started osteoporosis treatment or if they had been confined to bed for a long period since the initial assessment. As bone density is subject to seasonal variation, both the initial and repeat measurements were performed between December and January of the

Table 1 Questionnaire items

• Sex	• Feeding
• Age (yr)	• Dressing
• Height (cm)	• Grooming
• Body weight (kg)	• Toileting
• Body mass index (BMI)	• Bathing
• Medical history and complications	• Severity of dementia
• Previous occupation	• Bed arrangement
• Barthel index (ability to perform everyday activities: BI)	• Number of years in institutions
• Time spent out of bed	• Type of heating
• Mobility	• Exercise
• Rolling over in bed	• Food
• Maintaining seated position in chair	• Meal skipping
• Maintaining standing position	• Weekly frequency of intake of each food group

following year at all three nursing homes.

For reference purposes, the OSI was also measured in women (n=57) at a short-term residential care facility for generally healthy elderly people where diet is supervised in the same manner as in nursing homes.

The OSI was compared at the time of the initial and repeat measurements for each questionnaire item. A single-sample t-test was used for the analysis. Differences were considered to be significant when $p < 0.05$. SPSS statistical software for Windows (Ver. 10, SPSS Co., Ltd.) was used for the statistical analysis.

Results

Of the 102 subjects initially measured, 74 (mean age, 83.5 ± 6.6 years; range, 64–99 years) could be measured again approximately one year later. Of the 28 who could not be remeasured, the reasons were death in 16 cases and physical frailty in

Table 2 Overview of subjects and questionnaire results

Item	Nursing home	Short-term residential care facility for generally healthy elderly people
Subjects	74	57
Age	83.5 ± 6.6 yr (64–99 yr)	81.2 ± 5.7 yr (66–92 yr)
Height	141.2 ± 9.00 cm (121.0–158.0 cm)	142.4 ± 6.2 cm (128.4–158.0 cm)
Body weight at initial measurement	42.4 ± 9.7 kg (25.5–82.5 kg)	45.7 ± 9.6 kg (28.0–67.0 kg)
BMI at initial measurement	21.3 ± 4.4 kg/m ² (12.2–37.3 kg/m ²)	22.5 ± 4.2 kg/m ² (16.0–30.8 kg/m ²)
Body weight at repeated measurement	40.7 ± 9.0 kg (28.6–71.0 kg)	—
BMI at repeated measurement	20.5 ± 4.3 kg/m ² (13.8–37.8 kg/m ²)	—
BI	51.3 ± 33.5 (0–100)	Most subjects was a perfect score. The mean was 98.8.
OSI		
Total data		
Initial measurement	1.673 ± 0.162 ($\times 10^6$)	2.019 ± 0.140 ($\times 10^6$)
Repeated measurement	1.667 ± 0.173 ($\times 10^6$)	—
Residents using a wheelchair (n=41)		
Initial measurement	1.631 ± 0.123 ($\times 10^6$)	—
Repeated measurement	1.593 ± 0.121 ($\times 10^6$)	—
Ambulatory residents (n=33)		
Initial measurement	1.725 ± 0.191 ($\times 10^6$)	—
Repeated measurement	1.758 ± 0.185 ($\times 10^6$)	—
OSI comparison of groups according to age (1)		
70–74 yr	1.768 ± 0.133 ($\times 10^6$) : n=6	2.028 ± 0.050 ($\times 10^6$) : n=3
75–79 yr**	1.644 ± 0.124 ($\times 10^6$) : n=13	2.041 ± 0.043 ($\times 10^6$) : n=12
80–84 yr**	1.684 ± 0.141 ($\times 10^6$) : n=18	2.009 ± 0.141 ($\times 10^6$) : n=24
85–89 yr	1.698 ± 0.222 ($\times 10^6$) : n=22	1.948 ± 0.113 ($\times 10^6$) : n=12
90–94 yr*	1.592 ± 0.086 ($\times 10^6$) : n=13	2.115 ± 0.031 ($\times 10^6$) : n=3

* and ** indicates that the result differed significantly between the nursing homes and the residential care facility. (*= $p < 0.05$, **= $p < 0.01$)

(1); Residents ranging in age from 60 to 69 years or 95 years or older could not be compared due to insufficient numbers.

the remaining 12 cases. An overview of the subjects who were measured twice and the results of the OSI measurement are shown in Table 2.

For mobility, the OSI decreased significantly by an average of 1.8% after 11.8 months in all of the residents who were using a wheelchair ($n=41$, $p<0.01$, Figure 1). In contrast, the OSI rose significantly by a mean of 1.9% in the ambulatory group ($n=33$, $p<0.01$, Figure 1). For basic activities, there was a significant reduction in the OSI for subjects who required assistance to roll over in bed ($p<0.01$, Figure 2) and for subjects who required assistance to sitting posture ($p<0.05$, Figure 3).

The subjects were arbitrarily assigned to groups consisting of those who were out of bed for at least four hours (residents who were mostly confined to bed except at meal times), those who were out of bed for five to six hours (residents who also sat in a chair at times other than meal times), and those who were out of bed for at least seven hours (residents who were also actively out

of bed at times other than meal times). Analysis of the OSI for the three groups showed a significant increase in OSI in residents who were out of bed for at least seven hours ($p<0.05$, Figure 4). The residents were also divided into groups based on the level of exercise as follows: those who never exercised, those who exercised sometimes, and those who exercised every day, and the OSI for the three groups were then analyzed. The results showed a significant increase in the OSI in the group that exercised every day ($p<0.05$, Figure 5).

The OSI was also investigated based on whether residents were on a soft diet or a normal diet, and on whether or not meals were skipped or only partially eaten on a regular basis, but no statistically significant difference was found between the groups.

Fig. 1 Change in the OSI according to mobility.

Fig. 2 Change in OSI in subjects classified on the basis of ability to roll over in bed.

Fig. 3 Change in OSI in subjects classified on the basis of ability to sit down in a chair.

Fig. 4 Change in OSI in subjects classified on the basis of time spent out of bed.

Fig. 5 Change in OSI according to exercise.

Discussion

The mean OSI at the initial assessment of the nursing home residents was $1.673 \pm 0.1624 (\times 10^6)$. This was significantly lower than the value for the residents in the residential care facility measured for reference purposes ($2.019 \pm 0.1402 [\times 10^6]$; $n=57$) (two-sample t-test, $t=12.808$, $p<0.01$). The OSI for nursing home residents was also lower than the value reported by Mitsui et al. (17) in a study of 345 ordinary elderly women who were aged 65 years or older and living at home ($2.187 \pm 0.2122 [\times 10^6]$).

Bone mineral density is not the only parameter that is important for assessing the pathologic features of osteoporosis; changes

in bone structure and elasticity are also helpful. Dual energy X-ray absorptiometry (DXA), the technique most commonly used to measure bone mineral density, only provides information on the density of bone. Some studies have found that ultrasonography is more useful than DXA for assessing the weakening of bone structure (12, 14) because it assesses bone structure and elasticity as well as bone mineral density. In addition, ultrasonography does not currently require special qualifications and can therefore provide useful information for managing osteoporosis-related fractures in institutions such as nursing homes and group homes where there is no resident doctor. (14)

Diet and nutritional intake at nursing homes is strictly supervised by dietitians at each nursing home based on the guidelines for the provision of meals in social welfare institutions in the Ministry of Health, Labour and Welfare Nutritional Requirements of Japanese. (18) There were no differences between the three nursing homes in this study with respect to food groups consumed in the week before the day of assessment (Table 3). There was therefore no marked difference in the meal quality either between the nursing homes or between the residents, provided that meals were not missed or only partially eaten. Lack of uniformity of meal quality has been a problem in previous studies of bone density in elderly people living at home. (10, 11, 19)

A diet high in calcium and appropriate exercise are important lifestyle factors in osteoporosis prevention. (5, 6) The residents of the three nursing homes in our study had a more balanced diet than elderly people living at home (10–12) because of the involvement of a dietician in meal planning. This reduced the marked variation in nutritional intake noted in a previous study of elderly people living at home. (11) We were therefore able to examine the effect of daily physical activity on bone by minimizing the variation in meals and nutritional intake, which have a major effect on bone.

When conducting this study, we hypothesized that “the OSI would decrease after one year in both the inactive group that

Table 3 Weekly frequency of intake of each food group

Food	Frequency of Intake Per Week		
	Nursing Home A	Nursing Home B	Nursing Home C
Grain	21	20	20
Potatoes	10	7	8
Meat	10	9	14
Fish	18	16	19
Food preserved by boiling in soy	15	12	8
Fruit	5	7	7
Seaweed	6	5	8
Green and yellow vegetables	20	21	21
Light-colored vegetables	20	16	18
Mushrooms	11	8	2
Dried food	0	3	10
Milk	3	3	4
Other dairy products	5	4	2
Shellfish boiled in sweetened soy sauce	1	1	8
Eggs	4	3	5
Oils and fats	10	12	14
Confectionary	1	0	3
Packed and sterilized food	1	0	0
Instant noodles	0	0	0
Juice	1	2	1
Coffee	1	0	4

Period: Frequency of intake in the week before the day of assessment.

mostly used wheelchairs and the active group that were mostly ambulatory, but the reduction in the OSI would be minimal in the residents in the active group who exercised every day, whereas the OSI in the inactive group would decrease significantly". In a longitudinal study of nursing home residents by Krieg et al. (14) the stiffness index decreased by a mean of 1.01% after 23 months, although the device they used to measure bone density (Achilles bone densitometer [Lunar Co., Ltd., Madison, U.S.A]) differed from the one we used. Cross-sectional studies(8–12) have also generally shown that bone mass peaks in the 20s to 30s and decreases thereafter at a rate of approximately 0.3–0.5% per year (or 2.0–3.0% immediately after menopause). Our research also showed a significant reduction in the OSI in relatively inactive residents who used a wheelchair and also required assistance with everyday activities. These residents also did virtually no exercise. The mean OSI (1.8%) over the 11.8-month period in residents who used a wheelchair was slightly greater than in the Krieg et al. study and other cross-sectional studies. It was concluded that a marked reduction in physical activity was responsible for the decrease in the OSI in residents who used a wheelchair, since the major differences between the daily activity level of nursing home residents and residential care facility residents were the degree of independence in everyday activities and the length of time spent out of bed (nursing home: mean 5.3 ± 2.37 hours; residential care facility: mean 9.8 ± 1.68 hours).

Our results showed a mean increase of 1.9% in the OSI after 11.8 months in the ambulatory group. Dalsky et al. (20) noted a significant increase in lumbar bone density measured by DXA in 17 women between 55 and 70 years of age who took part in an exercise program, walking, jogging and stair-climbing, from 9 to 22, suggesting that exercise may increase bone density. A study by Krolner et al. (21) that used DXA to measure lumbar bone density in 16 women between 55 and 73 years of age who had undergone exercise training (walking and running) for 21 months produced similar results. There are two possible reasons why the OSI increased in our subjects even though they did not participate in an exercise program as in the Krolner et al. and Dalsky et al. studies.

One possibility is that the OSI increased as result of walking and daily exercise. In other words, the fact that informed consent was obtained from the residents and nursing home staff before OSI measurement may have highlighted to the residents and staff the importance of the relationship between bones and daily exercise and walking. This may have led the staff to actively encourage residents to walk and exercise, thereby increasing the OSI. This is supported by the fact that at the repeat assessment, a check of the records kept by the caregivers and nurses over the previous year revealed that statements about walking and other forms of exercise were made virtually every day after the initial assessment, whereas virtually no mention was made of this at the time of the initial assessment. The managers of all three nursing homes also reported verbally that the time ambulatory residents spent exercising and walking increased by approximately two to three fold after the initial assessment. The fact that increases in the OSI were concentrated in the group that were out of bed for at least seven hours each day and the group that exercised every day also suggested that the significant increase in the OSI occurred because the residents were actively encouraged to walk to prevent osteoporosis at the three nursing homes as a result of this study. The above findings and the special characteristics of life in a nursing home suggest that, if continued, even relatively light exercise may increase the OSI in residents with an initially low OSI who have not actively exercised due to physical disability and whose daily nutritional intake is supervised by a dietician, even though the increase may be temporary and confined to the calcaneus.

Further work is needed to investigate the possibility that walking and other forms of exercise increase the OSI in elderly women, giving careful consideration to inter-tester and intra-tester reliability and at the same time continuing research into safe levels of exercise in elderly women. Minimizing the skipping of meals and encouraging exercise and physical activity under the supervision of experts such as physiotherapists can help to prevent fractures caused by bone weakness and falls in nursing home residents.

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