Nagoya J. Health, Physical Fitness, Sports Vol.31, No.1 (March 2008)

Bone mineral density and physical activity assessed by steps per day in institutionalized and ambulatory older people

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Reduced physical activity with aging has been considered a risk factor for osteoporosis. We examined the relationship between bone mineral density (BMD) and daily physical activity as assessed by steps per day in institutionalized, who have higher incidence of fracture, and ambulatory older people. Fifty-three institutionalized and twenty-seven ambulatory older people participated in the study. The BMD of the lumbar spine and total femur were measured using dual energy X-ray absorptiometry, and the steps/day were recorded by an accelerometer. The number of steps/day taken by the institutionalized was 1278 ± 201, which was significantly lower than that of the control, 5030 ± 427 ($P < 0.001$). A highly significant difference in femoral BMD was seen between groups ($P < 0.001$). However, there was no significant difference in lumbar BMD between the groups, and high incidences of lumbar disorder, 66.7% in the control and 67.9% in the institutionalized, were observed. The extremely low level of physical activity of the institutionalized probably affects the reduced femoral BMD but not lumbar BMD. The better femur BMD of the ambulatory group may indicate that setting a target number of steps/day to minimize femoral bone loss with aging is beneficial.

Keywords: bone mineral density, step counter, institutionalized older people, physical activity

Introduction

Osteoporotic fractures, particularly of the hip, have become a serious social problem with increasing numbers of older people in developed countries. Fractures substantially reduce the mobility level or activities of daily living (ADL) in older people. The most tragic result of this disease is a household- or bedridden state, which increases the cost of medical treatment and care.

A higher incidence of osteoporotic fracture has been reported among institutionalized older people than among age-matched community residents[1, 2]. The causes may be that they are more likely to fall and that they have lower bone mineral density (BMD). Several studies have reported reduced BMD of institutionalized people[3-5].

There are many concomitant risk factors for lower BMD and fracture, such as advancing age, low body weight, physical inactivity, disease, and nutritional deficiency. In general, physical activity declines with aging, especially in institutionalized older people, due to physical disability[6]. Traditionally, questionnaires have been most frequently used for assessing daily physical activity. Recently, methods to monitor the number of steps taken, such as the pedometer and accelerometer, have become common for assessing daily physical activity because they are easy to use and inexpensive[7-9]. However, as for as we know, there is no available study on examining the relationship between BMD and daily physical activity assessed by daily steps. In the present study, we compared the BMD of institutionalized and age-matched relatively healthy local residents in order to examine the relationship between BMD and daily physical activity expressed as steps/day.

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Table 1. Prevalence of disease diagnoses and ADL of institutionalized group.

Prevalence of disease diagnoses	
Diabetes mellitus	13.2%
Cerebrovascular disease	47.1%
Fracture of femural neck	7.5%
Heart disease	13.2%
Activity of daily living (ADL)	
Requires assistance in bathing	75.5%
Requires assistance in dressing	56.6%
Requires assistance in toileting	54.7%

Methods

Participants

This study was approved by the Research Ethics Committee of Nagoya University, and informed consent was obtained from all participants. Fifty-three institutionalized subjects (f35 m18, mean age 80.5 ± 0.9 (SE) years) commute to a day-care center affiliated with a private hospital once or twice a week. Their diagnoses and degrees of disability, defined by Nagoya City Office, are quite varied, ranging from cerebral bleeding to muscle weakness. They are able to eat a normal diet by themselves, but most need assistance in dressing, taking a bath, and using the toilet. Disease diagnoses and ADL capabilities are shown in Table 1. Further, institutionalized older people were divided into two groups, that is, those who are able to perform the ADL described above by themselves and those who were not. None had a history of upper gastrointestinal surgery or was under treatment of osteoporosis. Twenty-seven local residents (f20 m7, mean age 79.3 ± 1.1 years) who exercise, playing a golf-like ball game, walking, swimming and holding part-time jobs were also included as a control group. They are all ambulatory, but some have mild hypertension and diabetes requiring medication.

Measuring bone mineral density

The BMD of the lumbar spine and total femur were measured using a dual energy X-ray absorptiometry scan (LUNAR DPX-LIQ, USA) equipped with software version 1.2 and 1.3y by a trained X-ray technician (CT). The BMD of the lumbar spine was calculated using the mean value of vertebrae L1-L4, excluding those that had a disorder such as a pressure fracture or spur or the BMD was more than 10% higher than the adjacent vertebra. We were unable to measure the BMD of those who did not have two normal adjacent vertebrae. The BMD results were also expressed as a Z-score, which indicates the number of standard deviations above or below the mean BMD value for people of the same age.

Assessing daily physical activity

Daily physical activity was estimated from the mean number steps taken per day measured by an accelerometer (Lifecorder, Suzuken, Japan)[7-9]. Subjects were asked to use an accelerometer for a week between waking and going to bed except while taking a bath or shower. This apparatus counts and records daily steps automatically.

Statistics analysis

The data between the groups were compared using Wilcox's signed rank test. $P < 0.05$ was considered statistically significant.

Results

No significant differences in age and physical characteristics were seen between groups, as shown in Table 2. Table 3 shows the number of steps/day, lumbar and femoral BMD, and the incidence of lumbar disorder of each group. The number of steps/day of the institutionalized was 1278 ± 201, which was significantly lower than that of the control, 5030 ± 427 ($P < 0.001$). A highly significant difference in femoral BMD was seen between groups ($P < 0.001$). However, there was no significant difference in lumbar BMD between groups, and a high incidence of disorders, 66.7% in the control and 67.9% in the institutionalized, was observed. In addition, we compared steps/day and BMD of institutionalized people classified by their degree of disability, that is, those who are able to bathe, dress, and use the toilet or not, in Table 4. Although there was significant difference in steps/day, 3179 ± 445 for slightly disabled and 622 ± 108 for severely disabled ($P < 0.001$), no statistical differences were seen in BMD.

Discussion

In general, a physically active lifestyle is beneficial in reducing bone loss in older people[10]. However, the high incidence of disorders of the lumbar spine, 66.7% for the healthy and 67.9% for the institutionalized subjects, indicates that physical activity may not affect the lumbar BMD. On the other hand, extremely low physical activity may be a cause of the lower femoral BMD of the institutionalized group. Our present results seemed to be in accordance with

Table 2. The number of participant, age, and physical characteristics of the ambulatory and institutionalized older people.

	n	Age (years)	Hight (cm)	Weight (kg)	BMI (kg/m^2)
Ambulatory	27 (f20, m7)	79.3 ± 1.1	153.4 ± 2.0	52.8 ± 1.8	22.4 ± 0.6
Instituted	53 (f35, m18)	80.5 ± 0.9	151.2 ± 1.2	51.1 ± 1.3	22.3 ± 0.5

All data expressed mean±SEM

Table 3. The steps/day, lumbar and femoral BMD, and the incidence of disorder of lumber spine of both groups.

	Steps/day	Lumbar spine (g/cm^2)	Z-score	Disorder (%)	ND (%)	Femur (g/cm^2)	Z-score
Ambulatory	5030 ± 427	0.809 ± 0.050	-0.430 ± 0.326	67	26	0.798 ± 0.039	0.093 ± 0.259
Institutinalized	1278 ± 201***	0.799 ± 0.026	-0.585 ± 0.192	68	19	0.656 ± 0.022***	-0.219 ± 0.156***

Data are expressed mean±SEM. ND indicates that BMD was not detectable because of the disorder of lumber spine.
***$P < 0.001$.

Table 4. The age, physical characteristics, steps/day, and BMD of institutionalized group classified by ADL.

	Slight disabled	Severe disabled
n	13 (f10, m3)	40 (f25, m15)
Age (years)	81.1 ± 1.5	80.4 ± 1.0
Height (cm)	147.7 ± 1.8	152.4 ± 1.3
Weight (kg)	50.3 ± 1.8	51.0 ± 1.6
BMI (kg/m^2)	23.1 ± 0.8	21.9 ± 0.8
Steps/day	3179 ± 445	622 ± 108***
BMD (g/cm^2)		
Lumbar spine	0.761 ± 0.059	0.817 ± 0.030
Z-score	-0.949 ± 0.371	-0.503 ± 0.234
Disorder (%)	61.5	70.0
Femur	0.653 ± 0.036	0.657 ± 0.026
Z-score	-0.131 ± 0.734	-0.249 ± 0.183

All data are expressed mean ± SEM. ***$P < 0.001$.

previous studies regarding the effect of physical activity on BMD in older people. Participation in vigorous physical activity has been shown to decrease the risk of hip fracture, but the same has not been found for vertebral fracture[11]. Osteoporotic fractures, particularly in the spine, are seen in 29% of a population in the sixth decade to 39% in the ninth decade[12].

The number of steps/day reported by previous studies was 6413 ± 2267 (SD) for women (n = 48, 39.0 ± 11.5 years)[7], 5569 ± 2093 for men (n = 48, 40.9 ± 11.2 years)[7], and 7370 ± 3080 (n = 109, 44.9 ± 15.8 years)[9]. Compared with these previous studies, the healthy controls in this study seem to be relatively active for their high age. However, there was no significant difference in femur BMD between the slightly disabled and severely disabled groups. The results may indicate that keeping active is essential in minimizing the loss of femur BMD with aging and that there may be a threshold that is effective against loss of femur BMD. The lower femur BMD of the institutionalized group independent of physical activity may be due to their higher amount of medication.

Determining the factors contributing to BMD is not the purpose of this study. Apart from daily steps, no significant differences in indices contributing BMD were seen between the two groups. Some studies reported low nutritional intake and poor vitamin D status in institutionalized people[4, 13, 14]. However, if these factors play a key role in determining the difference in femoral BMD between the healthy controls and the institutionalized, it is difficult to explain why there is no difference in lumbar BMD and a high incidence of lumbar disorder in all groups.

Our observation is that the reduced femur BMD in institutionalized people may be a key determinant of their high incidence of fracture. The better femur BMD with a Z-score of approximately 1 of the healthy controls means physical activity may play a key role in minimizing the loss of femur BMD. However, large-scale studies should be necessary to determine the effective number of daily steps.

Acknowledgement

The authors would like to thank the staff of Masuko Memorial Hospital and Ms. Megumi Tsuge for technical assistance. This research was supported by Ministry of Education, Culture, Sports, Science and Technology of Japan Grant 16650163.

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(2007年12月17日受付)