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<https://doi.org/10.15017/10780>

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出版情報：健康科学. 30, pp.39-44, 2008-04-15. 九州大学健康科学センター  
バージョン：  
権利関係：

—Original—

## Effect of daily physical activity level on muscle volume, bone mineral density and gait characteristics in older women.

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### Abstract

The association of monthly-averaged daily physical activity with the risk factors related to hip fracture was investigated in older adults aged 70 and over. Daily physical activity was assessed by using an accelerometer attached with a pedometer. We assessed the variables related to possible risk factors inducing hip fracture, i.e., muscle volume in arm and leg, bone mineral density in spine and leg, gait ability, and body sway during standing in active (n=43, > 7,000 steps per day) and inactive groups (n=37, <2,800 steps per day). The active group had significantly higher bone mineral density in major trochanter, greater muscle volume of quadriceps, and gait abilities than inactive group. It was implied that a sedentary lifestyle is associated with the risk factors related to hip fracture, such as gait abilities, bone mineral density of major trochanter and muscle mass of quadriceps, indicating that maintaining the daily physical activity is effective in preventing fall possibly through counteracting the decline of muscle mass, bone mineral density and gait characteristics in elderly women.

*Key Words:* muscle mass, bone mineral density, gait ability, body sway, physical activity

(Journal of Health Science, Kyushu University, 30: 39-44, 2008)

### Introduction

The population of adults aged 65 years and older became 4.38 million, i.e., 9.0% of Korean population in 2005, and the aging society already started. In 2010, the number of old people is expected to continuously increase up to 5.3 million, i.e., 10.6% of the population, and in 2020 it will be 7.6 million, 15.6%, of the population<sup>1)</sup>. Many diseases and disabilities associated

with aging can be prevented or delayed with regular physical activity. Regular physical activity is an important component of a healthy lifestyle, related to many physical health benefits, including protection against cardiovascular diseases, osteoporosis, sarcopenia and depression<sup>2)</sup>. American College of Sports and Medicine (ACSM) and the Centers for Disease Control and Prevention, recommend that all

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adults should exercise regularly, and have published guidelines of the levels of exercise necessary to gain health benefits<sup>2,3</sup>). Regular physical activity, in addition, is also important for the health of older adults, given the increased prevalence of disorders is preventable by exercise in older age<sup>3-4</sup>). Additional benefits from physical exercise for older population include increased longevity, reduced bone loss, an increased ability to maintain functional independence, and a reduced risk of falls and fractures<sup>5-6</sup>).

Despite these benefits, a sedentary or inactive lifestyle is common in Korean societies. 50% of women aged 75 and over performs no additional physical exercise during their normal daily activities. Physical inactivity is associated with fall related fracture<sup>7</sup>). Low muscle volume, low bone mass and poor gait characteristics are important risk factors associated with falls and fall-related fracture, and these factors are indicative of a reduction, slowing, or other difficulty in physical activity. Although the effects of physical inactivity and exercise intervention on the risk factors of hip fracture have been reported, few studies have reported actual daily physical activity levels in relation to the reduction of risk factors of hip fracture<sup>8</sup>). In the present study we investigated the relationship between daily physical activity in women aged 70 and older, and risk factors possibly related to hip fracture. The aim of the present study is to determine whether muscle volume, bone loss and gait parameters are associated with the level of daily physical activity in older women.

## Methods

### *Subjects*

Volunteers who aged 70 years women and older provided a detailed medical history and underwent a physical examination. Volunteers were excluded from subject to the following analysis, who had greater MMSE (mini mental status examination) score greater than 23, received bone-related medication, or had significant current illness or a history of a chronic disease that may have influenced bone-metabolic disease, and orthopedic disease.

We measured physical activity in 170 volunteers as mentioned below and then classified the volunteers into two groups of subject. The volunteers whose daily walking steps was greater than 7,000 was assigned to active group (n=43), and lower than 2,800 to inactive group (n=37) Written informed consent were obtained from all subjects in accordance with the requirements by the ethics committee of Dong-A University.

### *Physical Activity*

By using electronic accelerometer with a storage capacity of 36 days (modified Kenz Lifecorder, Suzuken Co., Ltd., Nagoya, Aichi, Japan; for details of the mechanism, see the reference 9), the number of steps and the intensity of physical activity were recorded every 4 seconds throughout a day. The accelerometer, attached to a waist belt on either the left or right side of the body, was worn throughout each 24-h period for one month.

The daily number of steps, averaged over the month, and the average daily period of exercise at intensity higher than moderate for an elderly person were estimated.

### *Bone mineral density*

Measurement of bone mineral density at L2-L4, femoral neck, Ward's triangle, major trochanter and total bone were estimated by dual energy x-ray absorptiometry (DPXA, Lunar, Madison, WI, U.S.A.).

### *Volume of arm and thigh Muscle*

Using Computer Tomography (Samsung GE systec 300i), Hounsfield Units of the muscle density was measured. On upper extremity, two slices were obtained at 10 and 11cm from acromion and on lower extremity, two slices were obtained at 21 and 22cm from trochanter major to estimate the muscle volum (cm<sup>3</sup>) of brachial biceps muscle and quadriceps femoris muscle. After six months, physical activity was analyzed and muscle density was re-evaluated at the identical site.

### *Body sway during stand up*

Body sway was measured by using the Dynamic Posturography (AMTI OR 6-7-2000, Massachusetts, and U.S.A.). Data was stored on computer by 50 Hz. Subjects stood on Dynamic Posturography with

bare-foot and they looked at eye-level target at a distance of approximately 1m in front of them for 30seconds. Subjects watching the target, they were instructed .to stand up in steady as possible as they could after resting for 2 minutes, and subjects stood again on the plate and closed their eyes for 30 seconds. Body sway was obtained as the product of locus length, anteroposterior and lateral sway.

#### **Gait ability**

For the estimation of gait ability, the Good Walker's Index<sup>10</sup> was used. Each subject performed 10 m maximal walk speed test, maximal step length test, one-legged-stand, 40cm step up and down test, and functional reach and trunk flexion tests. During the estimation of gait ability, all subjects wore the same shoes.

#### **Statistical Analysis**

Statistical analysis was performed by SPSS 10.0. Data is presented as a means  $\pm$  SD. Independent t-test was used to compare the active and inactive groups. Statistical significance was accepted as  $p < .05$ .

#### **Results**

Physical characteristics in active and inactive groups are presented in Table 1. Body mass was significantly greater and relative body fat was lesser in active than in inactive group.

The MMSE, daily physical activity, and body sway in active and inactive groups are presented in Table 2. Month-averaged daily physical activity, maximal step length, 10 m maximal walking time, and functional reach were significantly higher in active group than inactive group.

**Table 1. Characteristics in active and inactive groups**

Variables	Active(n=43)	Inactive (n=37)
Age (yrs)	74.0 $\pm$ 3.18	76.1 $\pm$ 2.94
Height (cm)	153.7 $\pm$ 3.10	152.8 $\pm$ 4.09
Body mass (kg)	57.3 $\pm$ 4.37	52.8 $\pm$ 4.21*
Body fat (%)	35.2 $\pm$ 4.2	31.9 $\pm$ 3.4*
Systolic blood pressure (mmHg)	139.7 $\pm$ 21.7	145.4 $\pm$ 6.9
Diastolic blood pressure (mmHg)	80.1 $\pm$ 17.1	82.1 $\pm$ 11.2
Daily walking steps (steps/day)	7809 $\pm$ 645	2282 $\pm$ 437*

Value are mean $\pm$ SD

\*  $p < 0.05$  vs. active group

**Table 2. The MMSE, physical activity, and body sway in active and inactive groups**

Variables	Active(n=43)	Inactive (n=37)
MMSE	27.2 $\pm$ 1.11	27.1 $\pm$ 1.21
Month-averaged daily physical activity (steps/day)	7237 $\pm$ 1563	2117 $\pm$ 824*
PeakVO <sub>2</sub> /body mass (mL/kg/min)	17.5 $\pm$ 2.69	13.2 $\pm$ 3.12
Maximal step length (cm)	86.4 $\pm$ 9.13	58.2 $\pm$ 10.63*
10m maximal walk time (s)	7.1 $\pm$ 1.25	10.1 $\pm$ 2.15*
Functional reach (cm)	28.3 $\pm$ 3.71	13.1 $\pm$ 6.02*
Lateral moving distance(cm/min)	1.02 $\pm$ 0.09	1.37 $\pm$ 0.13
Anteroposterior moving distance(cm/min)	0.92 $\pm$ 0.07	1.37 $\pm$ 0.12

MMSE : mini mental status examination

\*  $p < 0.05$  vs. active group

**Table 3. Bone mineral density and muscle mass in active and inactive groups**

Variables	Active(n=43)	Inactive (n=37)
<i>Bone mineral density</i>		
L2-4 (g/cm <sup>2</sup> )	0.86 ±0.10	0.73 ±0.12
Femoral Neck (g/cm <sup>2</sup> )	0.72 ±0.07	0.65 ±0.10
Ward's Triangle (g/cm <sup>2</sup> )	0.47 ±0.07	0.45 ±0.10
Trochanter (g/cm <sup>2</sup> )	0.59 ±0.13	0.53 ±0.05*
<i>Muscle volume</i>		
Biceps brachii (cm <sup>3</sup> )	49.4±5.24	39.1±9.72
Quadriceps (cm <sup>3</sup> )	53.0±8.20	48.6±6.35*

\* p < 0.05

Bone mineral density of lumbar 2-4 and three variables obtained from femur bone, and muscle volume are presented in Table 3. Bone mineral density of trochanter and muscle volume of quadriceps were significantly higher in active group than inactive group.

## Discussion

We found lesser bone mineral density in major trochanter and muscle volume of quadriceps femoris in the inactive group than in the active group. These two factors are related to hip fracture<sup>11)</sup>. These findings, thus, could imply the association between daily activity level and bone fracture in elder women. In addition we found lesser maximal step length, maximal walk time, and functional reach in inactive than in active group. These variables are related to physical functions and consequently associated to the ability to walk in stable. These findings imply the association between daily activity level and stability during walking. Thus, it was suggested that inactivity is related to hip fracture through anatomical and functional reasons, i.e., inactive people have less bone mineral density, and have less stability during walking and consequently increasing possibility of falling and bone fracture.

Regular physical activity is an important in healthy lifestyle because it provides benefits in physical health, including protection against cardiovascular diseases, osteoporosis, sarcopenia and fall and fall related fractures. In the present study, we investigated the difference in muscle volume, bone mass and gait characteristics between the active (>7000 steps/day) and inactive older women (<2800 steps/day). Maximal step

length and functional reach are related to balance ability, and a shortening of maximal step length is one of the risk for falls. Medell et al. investigated the ability to take a maximal step of young (mean age, 21 years), unimpaired old (mean age, 69 years), and balance-impaired old women (mean age, 77 years)<sup>12)</sup>. They reported that the mean maximal step length was significantly longer in the young women (by 16%) than in the unimpaired elderly; and also it was significantly longer in the unimpaired elderly (by 30%) than in the balance-impaired old. For this reason, it is thought that the maintenance of a proper maximal step length is related to the balance ability and falls for elderly people. In the present study, the active elderly women showed a significantly higher maximal step length, faster maximal walk speed in 10m distance and functional reach than inactive women. It is plausible to conclude that inactive women have higher risk of fall than active women.

Osteoporosis is a disease that causes clinical symptoms, social problems and economic loss in an aging society. Actually, the hip fracture by fall in older is related with osteoporosis, and is very dangerous because of inducing permanent disability, long hospitalizations or death after all<sup>13)</sup>. ACSM reported that an appropriate exercise preventing osteoporosis improved the muscle strength and the flexibility and the cardiovascular condition in elderly women and recommended performing such exercise program to decrease the possibility of fall and incidence of osteoporotic fracture<sup>14)</sup>. Some previous studies suggest that physical activity has positive effects on increasing

bone mineral density<sup>15,16</sup>). Vainionpää et al reported that the intensity of exercise, measured by the level of acceleration of physical activity, was significantly related with changes in bone mineral density<sup>17</sup>). The present study also found significant higher bone mineral density of trochanter in the active elderly women than in the inactive. Therefore, we thought that elderly people need physical activity for the prevention of osteoporosis by low bone mineral density.

In conclusion, a sedentary lifestyle (< 2800 steps per day) and the risk factor for hip fracture could be associated, and maintaining the daily physical activity (>7000 steps per day) could be effective for the prevention of fall through counteracting the decline of muscle mass, bone mineral density and gait characteristics in elderly women.

### Acknowledgements

This Paper was supported by the Dong-A University Research Fund in 2005.

Yoochan Kwon was visiting researcher in Institute of Health Science, Kyushu University in 2005.

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