1. Introduction

An active lifestyle plays an important role in an individual’s overall health and regular physical activity has numerous health benefits (ACSM, 2000). Although both the amount and intensity of physical activity frequently decrease with aging (Westerterp & Meijer, 2001; Meijer, et al., 2001; DiPietro, 2001), older individuals can still obtain a desirable amount of physical activity as a result of an appropriate intervention (Stewart, et al., 2001; King, et al., 1998). A recent prospective cohort study suggested that elderly women could lengthen their life by increasing and maintaining physical activity levels (Gregg, et al., 2003). Therefore, older individuals should improve their physical activity level as well as young and middle-aged adults in order to elicit positive health benefits.

A consensus statement recommended accumulating thirty minutes per day of moderate-intensity physical activity, preferably every day of the week (ACSM, 2000; Pate, et al., 1995). However, time spent engaging in moderate-intensity physical activity cannot be easily assessed in certain clinical fields. On the other hand, pedometers are simple and inexpensive body-worn motion sensors that are able to assess and motivate physical activity behaviors (Tudor-Locke & Bassett, 2004; Bassett & Strath, 2002). Although their accuracy tends to be problematic in frail seniors, such as nursing home residents, pedometers can be used with confidence when evaluating ostensibly healthy elderly adult populations for both assessment and motivation purposes (Cyarto, et al., 2004). Taking a higher number of steps each day reduces the risk of cardiovascular disease in middle-aged adults (Yamakawa, et al., 2004). However, in contrast to middle-aged individuals, no clear distinction has yet been found between the number of daily steps and state of health in older individuals, except for the relationship between the number of steps and the Body Mass Index (BMI) in older persons aged from fifty-five to seventy-nine (Chan, et al., 2003). On the other hand, several cross-sectional and longitudinal...
investigations have demonstrated a positive health benefit would be achieved by increasing the amount of time spent engaged in moderate-intensity physical activity, regardless of age (ACSM, 2000; Pate, et al., 1995). The role that the number of steps and the amount of time spent engaged in moderate-intensity physical activity plays in cardiovascular and metabolic state of health may therefore change with aging.

The primary objective of this investigation was to identify any patterns in the number of steps taken per day and time spent in light-, moderate- and vigorous-intensity physical activity in physically active elderly women. Since BMI is one of the major indices of cardiovascular and metabolic health, a secondary objective of this investigation was to examine the relationship between physical activity patterns and BMI in elderly individuals.

2. Methods

2.1. Subjects

Ninety-four Korean women between the ages of sixty and seventy-six participated in this investigation. After explaining the study design and requirements to all participants, all signed a consent form approved by the ethics committee of the Fukuoka University School of Medicine to participate in this study.

In this experiment, all participants were clinically stable during the study, and had been participating in an exercise program at the Seoul Municipal Establishment Eunpyong Senior Welfare Center. The exercise program consisted of aerobic exercise, a dance exercise and a stretching exercise. All subjects participated in this program three times during the experiment period. This program seemed to correspond to three to six METs based on the findings of previous publications (ACSM 2000), whereas the present investigation did not measure the actual intensity of exercise. Thus, the present investigation roughly evaluated the intensity of physical activity (light, moderate or vigorous) in order to avoid the inter-individual difference of the intensity of physical activity during the exercise class. Consequently, the physical activity during the exercise program would be defined as moderate-intensity physical activity by an accelerometer regardless of physical fitness and/or age. The height and body weight of all individuals was measured by an automatic analyzer (Kansai Seiki Co Ltd., Japan). The Body Mass Index (BMI) was calculated as body weight divided by height.

2.2. Physical Activity Assessment

This investigation evaluated the time spent in light-, moderate- and vigorous-intensity physical activity as well as the number of steps taken. The number of steps sometimes includes measurement errors depending on the accuracy of the device used, the season, the characteristics of subjects and so on (Bassette & Strath, 2002). Therefore, in order to reduce measurement errors, a reliable accelerometer was used to calculate the number of steps taken by apparently active elderly persons over a fourteen day period in spring.

All subjects wore a one-axial accelerometer (the Life-Corder, manufactured by Suzuken Co., Japan) (Ayabe, et al., 2004; Crouter, et al., 2003; Kumahara, et al., 2004a; Kumahara, et al., 2004b; Rafamantanantsoa, et al., 2002; Schneider, et al., 2003; Schneider, et al., 2004). This was worn on a belt at waist-level just above the leg continuously for ten days, except while sleeping or bathing. After the data collection period ended, the device was retrieved and the data obtained was transferred to a computer. In order to assess the usual daily physical activity level, this investigation used the final seven days of continuous data from a ten day collection period.

The Life-Corder is small (6 × 4.6 × 2.6 cm) and lightweight (40g). This device samples vertical acceleration ranging from 0.06 to 1.94G (one G is equal to the Earth’s gravitational acceleration) at 32 Hz. Based on the acceleration pattern, this device determines the number of steps (in steps per day), time spent engaged in light-intensity physical activity (<3METs) as well as moderate- (3-6 METs) and vigorous-intensity (>6 METs) physical activity (based on minutes per day). The device has been tested and shown to provide comparable results to that of the doubly-labeled water method (Rafamantanantsoa, et al., 2002) as well as to the indirect calorimeter (Kumahara, et al., 2004a) and tri-axial accelerometer (Kumahara, et al., 2004b). In addition, the reported margin of error regarding the number of steps was less than 3% (Crouter, et al., 2003; Schneider, et al., 2003; Schneider, et al., 2004). However, it must be noted that the Life-Corder can detect physical activity above 1.8 METs (Kumahara et al., 2004a),
therefore time spent in light-intensity physical activity might have been somewhat underestimated. Further details on this device have been described in earlier publications (Ayabe, et al., 2004; Crouter, et al., 2003; Kumahara, et al., 2004a; Kumahara, et al., 2004b; Rafamantananantsoa, et al., 2002; Schneider, et al., 2003; Schneider, et al., 2004).

### 2.3. Data Analysis and Statistics

The data were expressed as the mean and standard deviations (Mean±SD) and 95% confidence intervals (CI). The subjects were categorized based on age (60 to 64 years, 65 to 69 years and 70 to 76 years) as well as BMI. The BMI category was divided by the 33rd and 66th percentiles for the normal BMI distribution. The ANOVA and the post-hoc analysis (Sheffe) were used to determine any differences in the physical activity variables among the three groups, respectively. A p-value of <0.05 was considered to be statistically significant for all analyses.

### 3. Results

#### 3.1. Characteristics of Subjects

The characteristics of the subjects are presented in Table 1. Overall, the mean±standard deviation (95%CI) of the number of steps, time spent in light-, moderate- and vigorous-intensity physical activity were 7885±3523 (7163-8606) steps/day, 51.1±19.4 (47.1-55.1) minutes/day, 24.0±20.1 (19.9-28.2) minutes/day and 3.1±6.7 (1.7-4.4) minutes/day.

#### 3.2. Physical Activity Patterns and Aging

As shown in Table 1, although significant differences were seen in height and body weight (p<0.05), BMI was not significantly different, across the three age groups.

The number of steps taken and the time spent in light-, moderate- and vigorous-intensity physical activity are shown in Table 2. Although the number of steps did not significantly vary, the distribution of the time spent engaged in physical activity differed significantly across the respective age groups. As shown in Figure 1, the two older groups spent a significantly longer time engaged in light-intensity physical activity in comparison to the youngest group (p<.05). Furthermore, the oldest group spent significantly less time in moderate- to vigorous-intensity physical activity (16.7±9.0 (13.1-20.2) minutes/day) compared with the youngest group (35.6±29.5 (23.6-47.5) and 28.6±22.5 (21.5-35.7) minutes/day, p<.05).
Table 2 Age and the Number of Steps, Time Spent in Light-, Moderate- and Vigorous-Intensity Physical Activity

<table>
<thead>
<tr>
<th></th>
<th>all (n=94)</th>
<th>60-64 (n=27)</th>
<th>65-69 (n=26)</th>
<th>70-76 (n=41)</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>the number of steps</td>
<td>7885±3523</td>
<td>8270±3833</td>
<td>8128±3977</td>
<td>7143±2262</td>
<td>P=.428</td>
</tr>
<tr>
<td>[steps·day⁻¹]</td>
<td>(7163-8606)</td>
<td>(6722-9819)</td>
<td>(6873-9398)</td>
<td>(6248-8038)</td>
<td>(F=0.858)</td>
</tr>
<tr>
<td>time spent in light-intensity physical activity</td>
<td>51.1±19.4</td>
<td>41.3±16.8</td>
<td>51.7±18.6*</td>
<td>59.7±19.2**</td>
<td>P=.002</td>
</tr>
<tr>
<td>[minutes·day⁻¹]</td>
<td>(47.1-55.1)</td>
<td>(34.5-48.1)</td>
<td>(45.8-57.5)</td>
<td>(52.1-67.3)</td>
<td>(F=6.690)</td>
</tr>
<tr>
<td>time spent in moderate-intensity physical activity</td>
<td>24.0±20.1</td>
<td>28.6±23.2</td>
<td>26.8±22.0</td>
<td>15.5±8.1**</td>
<td>P=.026</td>
</tr>
<tr>
<td>[minutes·day⁻¹]</td>
<td>(19.9-28.2)</td>
<td>(19.2-38.0)</td>
<td>(19.9-33.8)</td>
<td>(12.2-18.7)</td>
<td>(F=3.795)</td>
</tr>
<tr>
<td>time spent in vigorous-intensity physical activity</td>
<td>3.1±6.7</td>
<td>7.0±11.7</td>
<td>1.8±1.8**</td>
<td>1.2±1.2**</td>
<td>P=.002</td>
</tr>
<tr>
<td>[minutes·day⁻¹]</td>
<td>(1.7-4.4)</td>
<td>(2.3-11.7)</td>
<td>(1.3-2.4)</td>
<td>(0.7-1.7)</td>
<td>(F=6.930)</td>
</tr>
</tbody>
</table>

* significantly different compared with 60-64 yrs (p<.05)
** significantly different compared with 60-64 yrs (p<.01)
# significantly different compared with 65-69 yrs (p<.05)
## significantly different compared with 65-69 yrs (p<.01)

Figure 1 Age and time distribution for the amount of time spent in physical activity

There was a significant difference in the time spent in physical activity at light- (P=.002 F=6.690) and moderate- to vigorous-intensity (P=.009 F=5.035) across the three categories.

* Significantly different compared with 60-64 yrs (p<.05)
** Significantly different compared with 60-64 yrs (p<.01)
# Significantly different compared with 65-69 yrs (p<.05)

3.3. Physical Activity Patterns and Body Mass Index

Across the three BMI groups, the mean (range) of the BMI was 22.1 (19.8 to 23.6) in the first tertile, 25.1 (23.6 to 26.3) in the second tertile and 28.7 (26.3 to 33.2) in the third tertile. Age and height were not significantly different depending on BMI.

The mean with standard deviation (95%CI) of the number of steps taken was 8860±4051
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(7376-10344) steps/day in the first tertile, 7557±3392 (6292-8822) steps/day in the second tertile and 7205±2690 (6203-8208) steps/day in the third tertile. Furthermore, the time spent doing light-, moderate- and vigorous-intensity physical activity was 53.9±16.8 (47.8-60.1), 31.4±24.1 (22.6-40.3) and 1.7±1.4 (1.7-4.4) minutes/day in the first tertile, 53.9±19.2 (47.8-59.3), 20.17±18.6 (22.6-40.3) and 3.2±8.7 (1.2-2.2) minutes/day in the second tertile and 47.2±21.0 (39.4-55.1), 19.8±13.2 (14.8-24.7) and 4.3±7.3 (1.6-7.0) minutes/day in the third tertile. As shown in Figure 2, the time spent in moderate-intensity physical activity differed significantly across the BMI categories (p=.035, F=3.494), and the thinnest group (the first tertile) spent a significantly longer time doing this kind of activity than the other two groups (p<.05).

4. Discussion

There are some parameters regarding daily physical activity that have recently been established based on technological advances (Ayabe, et al., 2004; Bassett & Strath, 2002; Crouer, et al., 2003; Kumahara, et al., 2004a; Kumahara, et al., 2004b; Meijer, et al., 2001; Ramanamanantsoa, et al., 2002; Schneider, et al., 2003; Schneider, et al., 2004; Tudor-Locke & Bassett, 2004; Westerterp & Meijer, 2001). Of these parameters, recent investigations have suggested that the number of steps taken per day would be a simple and practical parameter of physical activity for researchers and practitioners (Bassett & Strath, 2002; Tudor-Locke & Bassett, 2004). One advantage of measuring the number of steps is that this method can evaluate the walking behavior accurately and objectively at a low-cost. However, based on the principals of exercise prescription, not only the amount but also the intensity, duration and frequency of daily physical activity should also be evaluated. Although not all individuals require an exercise test in certain clinical fields, advising patients to exercise should be done after careful consideration of an individual’s health state, risk factor profile, behavioral characteristics, personal goals, and exercise preference. In older adults, therefore, it is desirable to evaluate levels of physical activity in detail. In the current investigation, the number of steps was not significantly different depending on age and BMI. On the other hand, the time spent in moderate-intensity physical activity significantly differed across the age and BMI groups. These results suggest that time spent in moderate-intensity physical activity may be more closely correlated with age and BMI than the number of steps in the sixth to seventh decades of life.

The number of steps declines as age increases from thirty to seventy years of age among Japanese individuals (Bassett & Strath, 2002). On the other hand, in a potentially active community ranging from eighteen to seventy-five years of age, nearly all subjects walked 10,000 or more steps per day. Consequently, no significant relationship was found

Figure 2 There was a significant difference in moderate-intensity physical activity across the three categories (p=.0489, F=3.120). The number of subjects was 32 in the first tertile (19.8-23.6 kg·m⁻²), 31 in the second tertile (23.6-26.3) and 31 in the third tertile (26.3-33.2). * There was a significant difference compared with the first tertile (p<.05).
between age and the number of steps (Bassett, et al., 2004). Similarly, in the current investigation, since all subjects participated in an exercise program, the number of steps was relatively high. Thereafter the mean number of steps for the oldest group (7143±2262 steps/day) approximated to the average value for Japanese residents in the 30-39 year old group (7233 steps/day) (Bassett & Strath, 2002). Consequently, the number of steps was not significantly different across the three age tertiles, whereas the mean difference from the youngest group (60-64 years) to the oldest group (70-76 years) was 1127 steps/day, or the same as the finding of a previous investigation (Bassett & Strath, 2002). Furthermore, a longitudinal study demonstrated that in elderly adults the time spent walking did not decrease, despite increasing age (Bijnen, et al., 1998). Therefore, although further investigations should be conducted in order to clarify the relationship between age and the number of steps, it is obvious that older individuals can maintain an adequate number of steps despite increasing age.

One of the original aspects of the current investigation was that time spent doing light-intensity physical activity compensated for the age-related decline of time spent in moderate-intensity physical activity in older individuals from seventy to seventy-six years of age. To our knowledge, no previous investigation has examined the age-related decline in the distribution of time spent engaged in physical activity in older individuals. However, Meijer, et al. (2001) confirmed that older subjects spent a significantly longer time engaged in lower-intensity activities than twenty to thirty-five year old subjects. The present investigation demonstrated that, as shown in Figure 1, individuals from seventy to seventy-six years of age spent a longer time in light-intensity physical activity and less time in moderate-intensity physical activity compared to individuals sixty to sixty-six years of age. Furthermore, time spent engaged in moderate-intensity physical activity was even less for individuals from sixty-five to sixty-nine years of age. On the other hand, time spent engaged in light-intensity physical activity significantly increased with increasing age. These results indicate that the intensity of physical activity may decline with aging in the sixth or higher decades of life, even in relatively active older women.

In the current investigation, time spent engaged in moderate-intensity physical activity was, in contrast to the number of steps taken, significantly different depending on BMI and age. Although a longitudinal study (Bijnen, et al., 1998) demonstrated that elderly individuals spent a stable amount of time walking with increasing age, the usual walking speed was inversely associated with age in older individuals (Himann, et al., 1988). Furthermore, older individuals who had participated in twenty to thirty minutes of moderate-intensity physical activity most days of the week had better physical function than older adults who are active throughout the day or who were inactive, whereas any type of physical activity was better than no activity because of its protective effect against functional limitations (Brach, et al., 2004). As a result, it seems desirable that levels of physical activity in elderly individuals be evaluated based on the intensity of physical activity rather than the number of steps taken. However, it is not easy to assess time spent in moderate-intensity physical activity. Although accelerometers have been accepted as one of the best assessment devices for moderate-intensity physical activity (Ayabe, et al., 2004; Kumahara et al., 2004a; Kumahara et al., 2004b; Rafamantantsoa, et al., 2002), the costs of such instruments and data-treatment procedures still remain impractical, in comparison to the number of steps as determined by pedometers. Therefore, specific modifications and/or new procedures should be developed for assessing moderate-intensity physical activity in elderly individuals.

There are some limitations in the current investigation. Although this investigation targeted the age-related decline of daily physical activity in active elderly women, all subjects participating in the center based exercise program took part in dance exercise three times a week. Thus, more than simply being active elderly women, the subjects seemed to have proactive personalities. Thus, future studies should examine individuals of a wide variety of physical conditioning, including sedentary people. Furthermore, it is desirable that age-related decline in the intensity of physical activity is examined longitudinally in a larger number of elderly men and women.

In summary, the present investigation was conducted to identify any patterns in the number of steps taken per day and time spent in light-, moderate- and vigorous-intensity physical activity in physically active elderly women. Subsequently,
we found that, in active elderly Korean women, the distribution of time spent in physical activity was significantly different depending on age and BMI. Of particular note, time spent in moderate-intensity physical activity was inversely correlated with age and BMI, whereas the number of steps did not differ across all age and BMI categories. Therefore, active elderly individuals should be encouraged to improve the intensity of their daily physical activity rather than merely increase the number of steps they take in order to prevent obesity and slow down negative aspects of the aging process.

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