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Daytime physical activity patterns and physical fitness in institutionalized elderly women: An exploratory study

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ABSTRACT

This study investigated the relationship between daytime physical activity patterns and physical fitness in elderly women. The subjects comprised 19 elderly women who resided in a nursing home. Time spent lying, sitting, standing and walking and the number of steps taken during the daytime from 10:00 to 16:00 were measured to determine physical activity patterns. Physical fitness measures included muscle strength, balance, flexibility and physical performance. The elderly women spent 18.3% of their daytime walking, 7.31% in a standing position, 56.9% sitting and 17.4% lying down. Our results showed that the time spent in walking or standing positions was significantly associated with balance and physical performance such as walking speed, while the time spent in a sitting position was inversely associated with muscle strength, balance and physical performance. The results of this study suggest that the time the elderly spend on weight-bearing activities and in sedentary behavior are associated with physical fitness.

1. Introduction

Habitual physical activity decreases progressively with age (Meijer, Goris, Wouters, & Westerterp, 2001; Westerterp & Meijer, 2001). The evidence clearly indicates that older people who are physically active have lower morbidity and mortality rates than inactive older people (Blair et al., 1989; Fried et al., 1998; Pate et al., 1995; Rohm-Young & Masaki, 1995). A high habitual activity level appears to be a critical factor in improving or maintaining physical health.

The negative consequences of physical inactivity and sedentary behavior, such as prolonged sitting, in older people are also well established. Inactive lifestyles have been associated with mortality, decreased quality of life, chronic disease and health conditions such as cardiovascular disease, stroke, type 2 diabetes, obesity, some forms of cancer and depression (King, 2001; King, Rejeski, & Buchner, 1998; Owen, 2012; Sundquist, Qvist, Sundquist, & Johansson, 2004). Therefore, there has been a growing acknowledgment of the importance of reducing sedentary activities as well as increasing physical activity in older age.

In addition, previous studies have demonstrated that physical activity is associated with physical function. Brach et al. (2004) showed that physical activity and exercise, assessed by a modified leisure-time physical activity questionnaire, were related to physical function in older persons, such as time to walk 400 m and knee extensor strength. Visser et al. (2005) showed that physical activity, assessed using an interviewer-administered questionnaire, had an effect on incident mobility limitation such as difficulty walking or climbing steps. Our previous study (Ikezoe, Mori, Nakamura, & Ichihashi, 2011) also found that daily physical activity assessed using life-space assessment (LSA) was positively correlated with the skeletal muscle mass of the lower extremity.

Thus, a number of studies have examined relationships between habitual physical activity and physical function. However, one limitation of these studies has been that physical activity patterns were assessed by questionnaires. Such subjective responses provide only limited estimates of habitual physical activity, particularly in older adults who commonly have difficulties in recall (Lagerros & Lagiou, 2007; Tehard et al., 2005).

Walking step count measured by motion sensors such as pedometers and accelerometers is an objective and reliable way to assess the physical activity level even in older adults (Davis & Fox, 2007; Harris et al., 2009). Aoyagi, Park, Watanabe, Park, and Shephard (2009) demonstrated that lower-extremity function

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such as walking speed and knee extension torque showed significant positive relationships with daily step count. Park, Park, Shephard, and Aoyagi (2010) found that muscle mass in the lower limbs of older adults, as measured by whole-body dual X-ray absorptiometry, was associated with walking step count in daily life.

As well as increasing the number of walking steps taken per day, increasing the duration of weight-bearing activity such as walking and standing and decreasing inactive time in sitting and lying positions will be also critically important factors in preventing functional limitations in frail elderly people. However, to our knowledge, no investigations have examined the duration of activity types such as walking, standing, sitting and lying for habitual physical activity of daily living. The associations of these physical activity patterns with physical function in frail elderly people are also unclear.

The aim of this study was to examine the time spent on each activity of daily living using motion sensors, to gain objective and accurate results, and to investigate the relationship between physical activity patterns and physical function in elderly women.

2. Subjects and methods

2.1. Subjects

The subjects comprised 19 elderly women, with a mean age of 83.8 years (standard deviation (SD) = 8.0, range = 71–96). All were residents of a nursing home in Kyoto, Japan, and therefore lived under the same conditions. The subjects were able to ambulate independently or with an assistive device, did not have an unstable physical condition, and did not demonstrate severe dementia. Subjects with physical dysfunctions that may influence outcome measures, such as acute neurological impairment (acute stroke, Parkinson's disease, paresis of the lower limbs), severe musculoskeletal impairment and severe cognitive impairment, were excluded.

The subjects were informed about the study procedures before testing and provided written informed consent before participating. The study was approved by Kyoto University Graduate School and Faculty of Medicine Ethics Committee.

2.2. Physical activity assessment

Physical activity pattern in the daytime was assessed objectively using the Activity Monitoring and Evaluation System (A-MES; Solid Brains Inc., Kumamoto, Japan), which consists of two three-dimensional acceleration sensors and technical software. The small sensors were attached to the anterior surface of the right thigh and the sternum by a custom-made fixation tape.

Three positions (lying, sitting, and standing) and walking were distinguished by the technical software using the data obtained from the sensors. Positions were estimated from the tilt direction for gravity by direct current composition of a sensor signal as follows: trunk sensor in a horizontal direction = lying posture; trunk sensor in a vertical direction and thigh sensor in a horizontal direction = sitting posture; trunk and thigh sensors in a vertical direction = standing posture; both sensors in a vertical direction and large vertical accelerations periodically recorded = walking. Time spent in each position and walking was recorded, and total time during the daytime was calculated from the time data. The ratio of each position and walking in the daytime was calculated using the following equation: ratio in the daytime (%) = total time of each position and walking/measurement time $\times$ 100.

The number of steps taken in the daytime was measured using an accelerometer (Yamasa Tokei Keiki Co., Ltd., Tokyo, Japan). The accelerometer was set superior to the iliac crest using a custom pouch. Physical activity patterns assessed using accelerometers show that older people are less active in the morning and evening (from 1600) (Davis & Fox, 2007). Therefore, we assessed physical activity during the daytime from 1000 to 1600 h. The participants were asked to maintain usual physical activity levels.

There is evidence of substantial seasonal changes in the physical activity patterns of the elderly (Aoyagi and Shephard, 2009; Shephard and Aoyagi, 2009; Togo, Watanabe, Park, Shephard, & Aoyagi, 2005; Togo et al., 2008; Yasunaga et al., 2008). Changes in weather may also affect physical activity. Our data were collected for two days in autumn (from October to November) and winter (from December to January) under fine weather conditions such as when the sun was shining in a cloudless sky and average accelerometer step counts and time spent in different activity levels were obtained.

Although the A-MES device has previously been shown to be valid and reliable in the measurement of the time data for each position and for walking in elderly subjects (Kawagoshi et al., 2011), the validity and accuracy of our subjects was assessed in a pilot study. Ten healthy elderly women (mean age, 82.7 years; SD, 7.42) were recruited for the validity analysis. Time spent in each position and walking was continuously assessed for 30 min in a specific room using this device and visual observation by video monitoring synchronously. The accuracy of the measurements of each position and of walking was calculated using the following equation: Accuracy (%) = measurement time of this device/visual observation time $\times$ 100. The accuracies for each position and for walking were 98.8–100.9%. Spearman's correlation coefficient was calculated to examine the relation between the measurement times of the device and the visual observation times. The results of the correlation coefficients for each position and for walking were 0.96–0.97 ($p < 0.01$). These results indicated a high degree of validity and accuracy in measuring time spent on activities.

2.3. Physical fitness measurements

Physical fitness measures included muscle strength, balance, flexibility and physical performance.

1. Muscle strength

   Quadriceps strength was used to represent muscle strength. Quadriceps strength of the right side was measured by a hand-held dynamometer (μ-Tas F-1, ANIMA Co., Tokyo, Japan) during a 3 s isometric contraction of the knee extensor. With the patient in a sitting position, the hip and knee were at 90° angles and the force sensor was placed 10 cm above the lateral malleolus. The maximal isometric strength was determined as the larger of the two repeated measurements after pre-measurement trials with manual resistance. Torque (Nm) was calculated by multiplying strength by the lever arm (distance between the lateral knee joint line and the point of force application).
2. Balance test

   The one-legged stance test (OLST) with eyes open, postural sway in the standing position, and the stepping test in the standing position were used to measure balance function.

   The OLST was performed in the standing position with the subject's arms by their sides. Timing was begun when the subjects raised one leg. Timing was stopped if the subjects moved the foot they were standing on, touched the suspended foot to the ground, or reached the maximum balance time of 120 s. Two trials were performed with the dominant foot if the maximum balance time was not reached on the first trial. The best balance time of the recorded trials was used for analysis.