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Original Article

Effects of increased physical activity on body composition, physical functions, vascular functions, HR-QOL, and self-efficacy in community-dwelling elderly people

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Abstract. [Purpose] The objective of this study was to clarify the effects of increased number of steps on body composition, physical functions, vascular functions, health-related quality of life (HR-QOL) and self-efficacy in elderly people. [Subjects and Methods] The subjects were 47 elderly persons who resided in Port Island in the Chuo Ward of Kobe City in Hyogo Prefecture, Japan. After the calculation of the mean preintervention physical activity (PA), the subjects were instructed to increase their PA to a target baseline + 1,300 steps/day. Body composition, physical functions, vascular functions, HR-QOL, and self-efficacy were measured at baseline, after 3 and 6 months. These items were compared between a group that increased their PA and a group that did not. [Results] After 6 months, 26.1% of the subjects achieved the PA target. No significant improvements were observed in body composition, physical functions, vascular functions, or self-efficacy for either group after 3 and 6 months. However, the HR-QOL improved significantly after 6 months in the achievement group. [Conclusion] Although the intervention to increase PA did not produce significant improvements after 6 months in body composition, physical functions, vascular functions, or self-efficacy, the HR-QOL improved significantly during this relatively short period.
Key words: Physical activity, Local elderly, Physical functions

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INTRODUCTION

Physical inactivity is a risk factor for cardiovascular disease[1)], diabetes[2, 3)], cancer[4, 5)], osteoporosis[6)], cerebral infarction[7, 8)], and other diseases, and is closely related to survival prognosis[9, 10)]. A large cohort study (Japan Public Health Center-based Prospective Study) of about 80,000 subjects in Japan found that physical activity (PA) associated with the mortality rates of cancer, heart disease, and cerebrovascular disease[11)]. A report by the World Health Organization ranked physical inactivity as fourth among the global risk factors for mortality, after hypertension, smoking, and hyperglycemia[12)], whereas a Japanese study ranked it third after smoking and hypertension[13)]. We previously surveyed and studied the influence of daily PA on the physical functions and prognoses of patients with cardiovascular disease. We observed reduced physical functions and higher rates of recurrence and re-hospitalization among patients with low PA levels for all diseases[14–16)]. As decreased PA can reduce physical functions and increase disease-specific mortality, we believe that maintaining high levels of PA is extremely important from the standpoints of disease prevention and survival prognosis.

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The “Health Japan 21” program of the Japanese Ministry of Health, Labor, and Welfare aims to extend healthy life expectancies by supporting health promotion programs for the general public. Increasing PA is an important part of Health Japan 21, which encourages elderly people (age 70 years and older) to increase their PA by 1,300 steps per day (about 15 min, 650–800 m)[13]. It is expected that increased PA will improve physical functions (muscle strength, balance ability), body composition (reduce body weight and fat mass, increase muscle mass), cardiovascular functions (reduce blood pressure and degree of arteriosclerosis), and quality of life (QOL), and that maintaining a healthy lifestyle will produce a variety of physical and psychological benefits, such as increased self-efficacy. However, Health Japan 21 does not state a specific target duration by which increasing PA by 1,300 steps per day can be expected to have physical and psychological effects on healthy elderly people, nor did it specify what the expected effects are. Thus, it is important to show the chronological and quantitative effects of increasing PA by 1,300 steps/day.

The objective of this study was to clarify the effects of increased PA during 6 months on physical functions, body composition, cardiovascular functions, health-related QOL (HR-QOL), and self-efficacy in community-dwelling elderly people. The subjects were categorized into 2 groups based on whether they had met a PA target. The effects were monitored at 3 and 6 months to clarify the physical and psychological changes in the subjects, quantitatively and chronologically. For this study, PA was defined in steps per day.

SUBJECTS AND METHODS

The subjects were elderly people (at least 65 years old but younger than 85 years old) who resided in Port Island in the Chuo Ward of Kobe City in Hyogo Prefecture, Japan. Through announcements in our university’s homepage, newspapers, and community bulletin boards in May and June 2014, we sought participants for a project aimed at increasing PA and for this study. The applicants were invited to a lecture on PA (covering the relationship between PA and disease incidence, effects of higher PA, and specific methods of increasing PA) and an explanatory meeting about this study. Sixty-nine subjects agreed to participate in the project and the study, and provided their consent in writing. We excluded subjects with cerebrovascular disease, orthopedic disease, respiratory organ disease, heart disease, or other underlying disease that limited their level of PA; those for whom increased PA was deemed not beneficial; and those who could not walk independently outdoors. Furthermore, all subjects underwent cognitive function screening in the form of the Rapid Dementia Screening Test[17], to confirm that they do not have reduced cognitive function (7 points or lower). This study was conducted with the approval of the ethics committee of the Hyogo University of Health Sciences (no. 14042).

Of the 69 subjects, 22 were excluded because they could not undergo the regular evaluations for some reason, leaving 47 subjects for the analysis. The mean age of the subjects was 71.9 years (65–82 years); there were 12 men and 35 women; their mean body mass index (BMI) was 22.4 kg/m^2 (16.5–29.2 kg/m^2); and their mean preintervention PA was 9110 steps (3,569–19,800 steps). The subjects were categorized into 2 groups: those who had achieved the PA target (achievement group=18 subjects) and those who did not achieve the target (non-achievement group=29 subjects).

PA monitors (Mediwalk MT-KT-2DZ, Terumo Corp.) had been distributed to the subjects; these had been used to measure PA for 7 continuous days before the intervention. The mean PA calculated from these measurements was used as the baseline value. The subjects were given a full explanation on how to use the PA monitors. They were instructed to wear them on their waists at all times, except during sleeping and bathing, to measure their total daily PA. The mean PA was calculated during 7 days in late June and early July 2014. The weather during this period was clear or cloudy, with an average temperature of 23.7 °C. The PA target (mean PA + 1,300 steps) was set based on the mean preintervention PA, and the subjects were instructed to increase their PA by using this target as a standard. They were also instructed to record the total PA for each day on a special form, before sleeping. The PA monitors and PA records were collected at 3 and 6 months after the start of the intervention. Data on the PA monitors were transferred to a computer, and the total PA per day was calculated by using a special software (Smile Data Vision, Terumo Corp.). Subjects whose mean PA after 6 months reached the target level were placed in the achievement group, whereas those who did not reach the target were placed in the non-achievement group. The body composition, vascular functions, physical functions, HR-QOL, and self-efficacy were compared between the groups. Each item was measured before the intervention, after 3 months, and after 6 months.

Body fat percentage, muscle mass, muscle mass percentage, basal metabolic rate, and estimated bone mass were measured with the bioelectric impedance method by using a high-precision body composition monitor (DF860, Yamato-Scale). Each measurement was taken at the same time each day. The subjects were asked to avoid excessive eating and drinking the day before, and to refrain from eating or drinking for 2 h before the measurements.

An ABI/PWV device (BP-203RPEIII form, Omron Co.) was used to measure the brachial-ankle pulse wave velocity (baPWV) and ankle-brachial index (ABI). Measurements were taken after the subjects had rested while lying on a bed for 5 min. Two measurements of each variable were taken, and the mean values were used.

The grip strength of the dominant hand was measured with a grip meter (Hand Grip Meter 6103, Tanita Corp.) in the standing position. Two measurements were taken and the maximum value was used. The knee-extension strength of the dominant leg was measured with a handheld dynamometer (HHD) (Mutas F-1, Anima Corp.) in a sitting position. Two measurements (with at least 30 s rest between them) were taken after the subjects practiced the procedure, and the maximum value was used. The arm length was measured as the distance from the center of the knee joint to the middle of the HHD sensor. Torque

Table 1. Baseline characteristics of the study participants (n=47)

Variables	Total (n=47)	Achievement group (n=18)	Non- achievement group (n=29)
Age (years)	71.9 ± 4.2	71.9 ± 4.5	71.8 ± 3.9
Gender (male/female)	12 / 35	6 / 12	14 / 35
High (cm)	156.1 ± 9.9	155.9 ± 9.7	156.2 ± 9.8
Weight (kg)	54.9 ± 9.9	54.3 ± 8.5	55.3 ± 10.6
BMI (kg/m^2)	22.4 ± 2.7	22.2 ± 2.4	22.4 ± 2.9
Hypertension (%)	29.8	38.9	24.1
Hyperlipidemia (%)	19.1	33.3	10.3
Diabetes (%)	10.6	11.1	10.3
Musculoskeletal disorders (%)	29.8	27.8	31.1
Baseline PA (steps/day)	9,110 ± 3,240	8,270 ± 2,591	9,631 ± 3,431

Data are mean ± standard deviation or %. BMI, body mass index; PA, physical activity
P values were calculated using an unpaired t test for the continuous variables or a χ^2 test for the categorical variables

(Nm) was calculated by multiplying the force applied to the sensor (N) by the arm length (m), which was then divided by the subject's body weight (kg) to obtain the torque-to-weight ratio (Nm/kg).

Balance ability was measured as the time the subjects could stand on the dominant leg. Two measurements were taken by using a stopwatch, and the maximum value was used. The maximum one-leg standing time was set at 120 s. If a subject could stand on one leg for 120 s, the test was stopped at that point. Walking ability was evaluated on a 15-m walking path in a hallway with no obstructions. A stopwatch was used to measure the time it took the subjects to walk 10 m at a comfortable pace and at maximum speed. For comfortable walking, the subjects were instructed to walk at their normal speed in daily life. For maximum walking, they were instructed to walk as fast as they could without running. The walking speed was calculated as 10 m × 60 s ÷ walking time.

HR-QOL was measured by using the standard version of the MOS 36-Item Short-Form Health Survey (SF-36v2) in a self-administered format. The points for each item were calculated on a SF-36v2 scoring program (iHope International). The PA self-efficacy scale of Oka et al. was used to evaluate self-efficacy[18]. Five grades of activity stress (intensity, time, number of times) were set for walking activity. The subjects self-recorded their current degree of walking, and the mean values were calculated.

The achievement group and the non-achievement group were compared by using a t-test and the χ^2 test. Comparisons between baseline, 3 months, and 6 months were performed with one-way analysis of variance (Bonferroni method). The significance level was set at <5%. As a sub-analysis, correlation coefficients were calculated between the PA rate of change and the rates of change of the other items. Rates of change were calculated as (6 months − baseline) / baseline × 100. SPSS Statistics version 21.0 was used for statistical analyses.

RESULTS

Table 1 shows the baseline characteristics of all the subjects, the achievement group, and the non-achievement group (Table 1). No significant differences were observed between the groups in age, gender, height, weight, BMI, hypertension, hyperlipidemia, diabetes, musculoskeletal disorders, or preintervention PA.

Table 2 shows the changes in PA, body composition, vascular functions, and physical functions in the achievement and non-achievement groups at baseline, after 3 months, and after 6 months (Table 2). While baseline PA was not significantly different between the groups, PA in the achievement group increased significantly after 6 months and decreased significantly in the non-achievement group. Moreover, PA was significantly lower in the non-achievement group than in the achievement group after 6 months. For body composition, no significant changes were observed between the groups in body fat percentage, muscle mass, muscle mass percentage, basal metabolic rate, or estimated bone mass at baseline, after 3 months, or after 6 months. For vascular functions, no significant differences were observed between the groups in baPWV or ABI at baseline, after 3 months, or after 6 months. For physical functions, no significant differences were observed between the groups in hand-grip strength, knee-extension strength, one-leg standing time, comfortable walking speed, or maximum walking speed at baseline, after 3 months, or after 6 months.

Table 3 shows the changes in HR-QOL and self-efficacy in the achievement and non-achievement groups at baseline, after 3 months, and after 6 months (Table 3). In the achievement group, role functioning ($p<0.05$) and emotional functioning ($p<0.01$) increased significantly after 6 months compared with baseline. In the non-achievement group, role functioning

Table 2. Comparison of physical activity, body composition, vascular functions, and physical functions between the achievement group and non-achievement group

	Achievement group (n=18)			Non- achievement group (n=29)		
	Baseline	3 month	6 month	Baseline	3 month	6 month
Physical activity (steps/day)	8,270 ± 2,591		10,496 ± 2,729*	9,631 ± 3,431		8,501 ± 2,910**†
Body composition						
Body fat (%)	28.9 ± 9.2	29.1 ± 9.6	29.0± 8.8	31.3 ± 7.3	31.3 ± 7.4	31.8 ± 7.7
Muscle mass (kg)	15.1 ± 3.4	14.8 ± 3.2	15.2 ± 3.3	15.0 ± 3.8	14.9 ± 3.7	15.1 ± 4.1
Muscle rate (%)	27.9 ± 3.9	27.5 ± 4.1	28.0 ± 3.9	26.7 ± 3.9	26.9 ± 3.1	27.5 ± 3.6
Estimated bone quantity (kg)	1.8 ± 0.4	1.8 ± 0.4	1.8 ± 1.9	1.8 ± 0.4	1.8 ± 0.4	1.8 ± 0.5
Vascular function						
baPWV (cm/s)	1,769.3 ± 273.3	1,769.0 ± 360.8	1,739.0 ± 318.2	1,815.0 ± 310.9	1,810.5 ± 320.9	1,827.5 ± 308.1
ABI	1.2 ± 0.1	1.2 ± 0.1	1.2 ± 0.1	1.2 ± 0.1	1.2 ± 0.1	1.2 ± 0.1
Body function						
Hand grip (kg)	25.9 ± 5.8	25.6 ± 5.6	26.2 ± 6.6	25.2 ± 6.9	25.0 ± 6.2	24.7 ± 7.3
Knee extension strength (Nm/kg)	28.3 ± 11.7	30.3 ± 10.4	30.3 ± 13.9	27.2 ± 9.6	27.1 ± 9.9	27.4 ± 9.3
One leg standing time (sec)	77.3 ± 44.0	84.9 ± 40.9	79.9 ± 38.2	56.5 ± 39.7	66.8 ± 45.4	68.8 ± 44.8
Comfortable walking speed (m/min)	88.6 ± 8.7	90.5 ± 10.9	90.4 ± 10.2	87.2 ± 13.8	87.7 ± 13.5	89.8 ± 11.6
Maximal walking speed (m/min)	118.6 ± 15.9	121.6 ± 18.1	119.3 ± 14.7	114.9 ± 14.2	115.4 ± 14.3	112.6 ± 15.4

baPWV: brachial-ankle pulse wave velocity (reflecting degree of vascular stiffness); ABI: ankle brachial index
*vs. Achievement group baseline, p<0.01, **vs. Non-achievement group baseline, p<0.01, †vs. Achievement group 6 month, p<0.05

Table 3. Comparison of HR-QOL and self-efficacy between the achievement group and non-achievement group

	Achievement group (n=18)			Non-achievement group (n=29)		
	Baseline	3 month	6 month	Baseline	3 month	6 month
SF-36						
Physical functioning	89.4 ± 6.6	90.6 ± 7.0	90.7 ± 8.0	90.4 ± 7.6	88.5 ± 11.7	89.7 ± 9.9
Role functioning	87.8 ± 19.0	92.4 ± 12.9	94.3 ± 9.8 *	92.4 ± 11.6	82.5 ± 17.3 †	83.2 ± 23.6 †
Pain	82.2 ± 18.4	83.9 ± 22.0	78.2 ± 21.7	80.3 ± 16.2	77.2 ± 20.2	85.0 ± 12.2
Vitality	70.8 ± 15.2	70.5 ± 12.5	71.2 ± 13.4	77.5 ± 13.5	72.0 ± 14.9	79.3 ± 13.4
Social functioning	88.9 ± 17.6	91.7 ± 13.8	95.8 ± 8.3	90.4 ± 16.0	85.6 ± 16.5	86.5 ± 19.6
Emotional functioning	88.4 ± 18.0	89.8 ± 14.6	97.2 ± 6.2 **	86.2 ± 17.7	85.9 ± 17.6	87.2 ± 21.1
Mental health	79.7 ± 14.0	81.1 ± 13.9	80.6 ± 13.8	78.6 ± 15.7	79.1 ± 12.8	84.2 ± 11.0
Self efficacy						
Gait	93.8 ± 12.3	95.6 ± 7.9	94.5 ± 8.8	86.4 ± 16.6	85.4 ± 17.3	91.4 ± 10.3

*vs. achievement group baseline, p<0.05
**vs. non-achievement group baseline, p<0.01
†vs. non-achievement group baseline, p<0.01

(p<0.01) decreased significantly after 3 and 6 months compared with baseline. No significant difference in self-efficacy was observed between the groups.

Calculating correlation coefficients between the PA rate of change and the rates of change of the other items did not show significant correlations with the rates of change of body composition, vascular function, body function, or self-efficacy. However, significant correlations were observed with the rates of change of role functioning (r=0.41, p<0.01), social functioning (r=0.34, p<0.05), and emotional functioning (r=0.32, p<0.05).

DISCUSSION

Of the 69 subjects, 18 (26.1%) achieved the PA target. Although no significant differences between the achievement and non-achievement groups were observed in age, gender, BMI, or concomitant disease, the subjects in the achievement group walked about 1,500 steps more than their baseline PA, which means they added a certain amount of exercise in their daily lives. Moreover, the baseline number of steps in both groups was higher than that of the average elderly Japanese person (males 5,436, females 4,604)[13], which suggests that many of the people who were interested in this study had a high degree of health awareness.

No significant differences in the body composition items were observed between baseline and after 3 or 6 months. A randomized controlled trial (RCT) with 182 subjects conducted by Slentz et al. reported strong correlations between PA and body fat mass, lean body mass, and waist circumference[19]. The PA level used in their RCT differed from that of the present study; however, the length of the intervention was roughly the same. However, the subjects of the RCT were generally overweight, with BMI from 25 to 35 kg/m^2 and mean body fat percentage of about 35%, whereas the mean BMI and mean fat percentage of our subjects were 22.4 kg/m^2 and 30%, respectively. Thus, most of the subjects in the present study had standard physiques. This indicates that increased PA during a short period of about 6 months can improve body composition in obese subjects; however, when the subjects have a standard physique, there is almost no impact on body composition. Furthermore, Nakae et al. reported that subjects who took at least 1,000 more steps per day for 1 year after receiving support for increasing their PA had significantly lower body weight, fat percentage, and BMI[20]. The age, BMI, and fat percentage of the subjects in their study were similar to those in our study. To improve body composition in subjects with standard physiques, PA may need to be increased for at least 6 months.

Neither group exhibited significant differences in vascular functions after 3 or 6 months. The baPWV reflects the degree of vascular stiffness, with higher values indicating higher stiffness[21]. Previous studies have found links between daily PA and baPWV[22, 23]; however, the effects of interventions that increase PA on the baPWV have yet to be established. As the baPWV is affected by vascular stiffness, we hypothesized that increased PA would improve the baPWV; however, our results did not show an impact on vascular stiffness. This may be because the baPWV values of the subjects were within the normal range, or because of the short 6-month duration of the intervention.

For physical functions, no significant differences were observed in balance ability or walking ability. The knee-extension strength, balance ability, and walking ability mainly reflect lower-limb functions, and previous studies have reported a link between PA and lower-limb function[24, 25]. However, Takahashi et al. reported that elderly persons who engaged in 30 min of walking per day, 5 days per week, for 12 weeks did not exhibit significant differences in the cross-sectional area of lower-limb muscles[26]. They concluded that walking alone cannot increase muscle mass—a finding supported by the present study. It seems to be difficult to improve lower-limb functions by increasing PA by 1,300 steps per day for a short period of 6 months.

For HR-QOL, the achievement group showed significantly higher scores on role functioning after 6 months compared with baseline, whereas the scores in the non-achievement group decreased significantly after 3 and 6 months. It has been previously reported that maintaining or increasing PA contributes to maintaining or improving HR-QOL[27]—a finding supported by the present study. We surmise that obtaining sufficient exercise by increasing PA has positive mental and psychological effects that lead to increased HR-QOL. In contrast, role functioning decreased significantly after 3 months and 6 months in the non-achievement group, and PA also declined significantly at these time points. A significant correlation was also observed between the PA rate of change and the rate of change of role functioning, which indicates an association between PA and role functioning even over a short period of 6 months.

The limitations of this study were that many of the subjects had relatively high levels of PA and a high degree of health awareness. Therefore, the subjects' levels of psychological and physical functions may have differed from a random sample of community-dwelling elderly people. However, many health-related initiatives for community-dwelling elderly people attempt to increase PA, such as that in this study. We thus believe that our results would be relevant to future initiatives for increasing PA in community-dwelling elderly people. In the future, it will be important to accurately assess the effects of increased PA on physical functions, body composition, vascular functions, and mental/psychological areas through large studies on increasing PA in community-dwelling elderly people.

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