

Original article

Relationships between daily life behaviors and physical activity measured using a triaxial accelerometer in elderly community-dwelling Japanese individuals

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Abstract

Objective: This study aimed to measure the physical activity (exercise and non-exercise) of community-dwelling elderly Japanese individuals and to investigate the relationships between physical activity and daily life behaviors.

Methods: Community-dwelling elderly Japanese individuals who resided in town A, city B, Gunma Prefecture, Japan, and were not certified as requiring long-term care were included in this study. Physical activity in 1 week was measured using a triaxial accelerometer. A self-administered questionnaire was applied to assess daily life behaviors. Hierarchical multiple regression analysis was used to examine the factors affecting physical activity.

Results: A total of 107 elderly Japanese (46 men and 61 women) individuals were included. The mean amount of physical activity in men was 37.9 Metabolic equivalents (METs)*h/wk, whereas that in women was 33.8 METs*h/wk. The proportion of exercise to physical activity for men and women was 43.2% and 26.0%, respectively. Men and women took an average of 47,393.7 and 35,305.6 steps/wk, respectively. Step counts and the presence or absence of plant cultivation were the factors associated with the amount of physical activity. The exercise component of physical activity was associated with step count, whereas the non-exercise component was associated with step count, plant cultivation, and frequent outings.

Conclusion: Among community-dwelling elderly Japanese individuals, physical activity levels appear to be affected by step count and the presence or absence of certain factors, such as plant cultivation and frequent outings.

Key words: community-dwelling elderly, physical activity, triaxial accelerometer, daily life behaviors

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Introduction

The percentage of the aging population (≥ 65 years) in Japan is 27.3%, and it is expected to reach its peak of 38.8% by 2060¹⁾. Therefore, Japan faces numerous problems related to medical and long-term care for the elderly.

In the field of geriatrics, there is rising concern about the concept of frailty, including physical, mental, psychologi-

cal, and social factors²⁾. The Japan Gerontological Society considers sarcopenia one of the chief causes of frailty. Sarcopenia is characterized by the systemic decline of skeletal muscle mass and strength^{3, 4)} and is primarily observed in the elderly; thus, several studies have focused on this topic and its relation to frailty within the scope of long-term care prevention.

The Ministry of Health, Labour and Welfare established the “Physical Activity Reference for Health Promotion 2013” in March 2013⁵⁾ and reported that sarcopenia increases the risk of becoming bedridden. These criteria, which recommend that individuals should engage in adequate physical activity even in old age, were the first to focus on the association between physical activity and sarcopenia prevention.

Oshima *et al.*⁶⁾ measured the steps and total moderate-to-vigorous physical activity (MVPA) levels of the elderly aged 60 years and above without exercise restriction using a triaxial accelerometer, and found that men take $6,821 \pm$

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2,869 steps and engage in 21.8 ± 10.9 Metabolic equivalents (METs)*h/wk total MVPA, whereas women take 6,303 $\pm 2,396$ steps and engage in 26.1 ± 12.8 METs*h/wk total MVPA. Additionally, Honda *et al.*⁷⁾ used a triaxial accelerometer to measure the total daily MVPA of the elderly aged ≥ 65 years who did not have long-term care certification, and reported a total MVPA of 2.7 ± 2.1 METs*h/day.

However, in Aoyagi's⁸⁾ interdisciplinary study on the physical activity as well as the physical and psychological health of elderly individuals (aged ≥ 65 years) conducted over 10 years, it was reported that moderate intensity activity of 4,000 steps or five minutes of fast walking can prevent depression and 8,000 steps or 20 minutes of fast walking can prevent hypertension and diabetes.

In contrast, it has been considered that, in addition to physical and mental health, the number of steps and physical activity of the elderly may also be affected by some kind of unintended daily life behavior that can be intervened. Furthermore, it is thought that increase in physical activity could be possible even with non-exercise at the same intensity as walking in daily life behaviors.

Although there are descriptive studies on physical activity in the elderly and reports of physical and mental health being related to physical activity, there are no studies that place intervenable non-exercise on the cause side.

Therefore, this study aimed to measure the amount of physical activity performed by Japanese elderly aged >65 years without long-term care certification. Additionally, the relationships between physical activity and daily life behaviors in this population were investigated.

This study provides insights into physical activity in this population, thereby leading to recommendations for preventive methods for frailty and sarcopenia, which elderly individuals can implement in their daily lives. The study also furthers the discussion on effective approaches to enhance health-promotion activities in this population.

Materials and Methods

Participants

Residents were selected from communities that readily cooperated and where the study could be conducted easily. The participants were elderly men and women (aged ≥ 65 years as of September 1, 2016) residing in wards 1–5 of Town A, City B, Gunma Prefecture, Japan, who were not certified as long-term care dependent.

Town A is located in the southwestern region of Gunma prefecture and comprises wards 1–10. Each ward is represented by a neighborhood association level, and the communities include a mix of agricultural and residential areas. The town has a population of 12,587 (6,157 men and 6,430 women)⁹⁾. Wards 1–5 have a population of 3,162 (1,533 men and 1,629 women), of which 1,059 (455 men and 604

women) are aged ≥ 65 years. Wards 1–5 are in the proximity of Town A's Japan Railway line station. The wards comprise many old residential homes, and the community has not undergone any major changes. The residents of Town A have participated in at least two physical activity studies conducted by research institutions. Of these, one study focused on elderly individuals; thus, this community generally readily participates in research studies. The leader of each ward was asked to identify all the individuals eligible for participation.

The survey was conducted between September and November 2016, the time of the year with average annual temperature and weather (average yearly temperature at a certain place is $15.8^{\circ 10)$), to account for variations in the levels of seasonally dependent physical activities.

Measurement of physical activity

A triaxial accelerometer (Active Style Pro; HJA-750C, OMRON HEALTHCARE Co., Ltd., Kyoto, Japan) was used to measure the amount of physical activity and its components, exercise and non-exercise, and step counts.

The triaxial accelerometer uses original algorithms to detect acceleration in the three axes and applies different estimated formulas to each to achieve highly accurate activity intensity estimates. Furthermore, this device can classify movements wherein there are no changes in the degree of inclination of the upper body as exercise, and activities that are accompanied by inclination changes of the upper body, such as carrying objects or using a vacuum cleaner, as non-exercise, regardless of the intensity of the activity. These classifications are based on changes in the gravitational acceleration signal. It uses relational expressions between resultant acceleration and activity intensity during each physical activity to measure the relative amounts of exercise and non-exercise movements^{11, 12)}. High resolution is required to detect slight motions, including the activities of daily living. The triaxial accelerometer has an extremely fine resolution of 3 mG¹³⁾ and is thus ideal for measuring the amount of non-exercise.

The recommended epoch length of the triaxial accelerometer for children is <60 s^{14–17)}; however, for assessing physical activity in adults, there are no noted benefits of using an epoch length of <60 s^{18, 19)}. As the participants of this study were elderly individuals, and considering the memory capacity of the device, an epoch length of 60 s was selected.

The individuals were asked to wear their triaxial accelerometers from the time they woke up on Monday morning until bedtime on Sunday. They were instructed to remove the accelerometer only while bathing and sleeping so as to detect their amount of physical activity over a duration of one week.

In accordance with previous studies on adults, including the elderly^{8, 20–22)}, we only considered data from triaxial

accelerometers worn for ≥ 10 hours per day. Furthermore, only data from those who met the criteria for ≥ 5 days were included in the analysis. The weekly amounts of physical activity, exercise, non-exercise, and step counts were calculated based on the following equation:

Cumulative values of measurements taken/number of days the triaxial accelerometer was worn $\times 7$.

The values for amounts of physical activity, including exercise and non-exercise, were estimated only for activities that had an intensity of ≥ 3 METs.

Basic characteristics and daily life behaviors

Basic characteristics and daily life behaviors were surveyed using a questionnaire that included sex, age (six categories), and number of cohabitating family members and their relationship with the participant (spouse, child, grandchild, or parent).

The following parameters of daily life behaviors were assessed on a binomial scale: intentional or planned exercise for maintaining or improving physical strength (hereafter, intentional or planned exercise), frequent outings, frequency of engagement in household chores (hereafter, frequent household chores), plant cultivation, having a pet that requires walking, community roles, and frequent participation in community events. The means of transportation for outings (walking, bicycle, car, motorcycle) were also surveyed. Furthermore, in addition to inquiring as to each participant's mean daily time spent on outings (min), body movement (min), and household chores (min), we surveyed the mean frequency of planned exercise per week and mean duration per planned exercise session to calculate the mean weekly total exercise time (min) as a product of the two.

Statistical analysis

We analyzed the effects of daily life behaviors on the amount of physical activity, exercise, and non-exercise for all participants by sex and early old/late old age categories. First, we measured the participants' physical activity. Next, a *t*-test was performed to determine the difference between the two groups according to sex or according to age categories. Differences between four or more groups with respect to age and sex in the early old age and late old age categories were analyzed using one-way analysis of variance.

Next, the proportion of the amount of physical activity that consisted of exercise was investigated based on sex and age groups. Furthermore, the relations between daily life behaviors and other variables (amounts of physical activity, exercise, and non-exercise and step counts) were examined using the *t*-test and Pearson's correlation coefficient. Items that emerged as significant during relational testing were considered independent variables, and a hierarchical multiple regression analysis was performed; the analysis included the amount of physical activity, exercise, and non-exercise

as dependent variables. We entered age and sex groups in Step 1, step count in Step 2, and items of daily life behaviors that were statistically significant in the *t*-test or correlation analysis in Step 3. We also confirmed that there was no multicollinearity among any of the independent variables in the regression analysis (variance inflation factor (VIF) < 5). IBM SPSS Statistics Version 23 was used for all analyses, and $p < 0.05$ was considered statistically significant.

Ethical considerations

This study was approved by the Gunma University Ethical Review Board for Medical Research Involving Human Subjects (receipt no. 160096) and the Ethics Committee of Jobu University (16-N02).

Results

Participant selection

Of the 128 individuals introduced by the ward leader, six refused to participate in the survey. In addition, 15 who did not meet the criteria for wearing the triaxial accelerometer were excluded, and the remaining 107 were included in the analysis. The number of men was 46 (43.0%), and the number of individuals classified as early old was 51 (47.7%). The valid response rate among the population of elderly individuals residing in the study region was 10.1%.

Amount of physical activity (amount of exercise and non-exercise) and step counts (Table 1)

Men engaged in a mean amount of physical activity of 37.9 METs*h/wk, of which exercise accounted for a mean of 16.4 METs*h/wk and non-exercise accounted for a mean of 21.5 METs*h/wk. The mean amount of physical activity for women was 33.8 METs*h/wk, of which exercise accounted for a mean of 8.8 METs*h/wk and non-exercise accounted for a mean of 25.1 METs*h/wk. Men engaged in a significantly higher amount of exercise than women ($p < 0.01$). Exercise accounted for 43.2% and 26.0% of the overall physical activity in men and women, respectively. This difference was statistically significant, with men proportionally engaging in more exercise than women ($p < 0.01$). The mean step count was 47,393.7 steps/wk for men and 35,305.6 steps/wk for women; men took significantly more steps per week ($p < 0.05$).

The mean amount of physical activity among the participants in early old age was 40.0 METs*h/wk, of which exercise accounted for a mean of 14.6 METs*h/wk and non-exercise accounted for a mean of 25.4 METs*h/wk. The mean amount of physical activity in participants in late old age was 31.6 METs*h/wk, of which exercise accounted for a mean of 9.7 METs*h/wk and non-exercise accounted for a mean of 21.9 METs*h/wk; both the amount of physical activity ($p < 0.01$) and the amount of exercise ($p < 0.05$) were

Table 1 Amount of physical activity (exercise and non-exercise) and step counts by sex and age group

	N	(%)	Physical activity (METs · h/wk)				Exercise (METs · h/wk)				Non-exercise (METs·h/wk)				Steps (/wk)			
			Mean	(SD)	Statis- tic	Signif- icance	Mean	(SD)	Statis- tic	Signif- icance	Mean	(SD)	Statis- tic	Signif- icance	Mean	(SD)	Statis- tic	Signif- icance
1. Men	46	(43.0)	37.9	(17.9)			16.4	(14.7)			21.5	(10.7)			47393.7	(28134.2)		
2. Women	61	(57.0)	33.8	(16.1)	1.21	ns	8.8	(8.2)	3.16	**	25.1	(11.2)	-1.66	ns	35305.6	(19134.6)	2.51	*
1. Early old age	51	(47.7)	40.0	(16.7)			14.6	(13.0)			25.4	(10.2)			46801.4	(24548.6)		
2. Late old age	56	(52.3)	31.6	(15.9)	2.63	**	9.7	(10.6)	2.15	*	21.9	(11.7)	1.63	ns	34765.7	(22328.5)	2.66	**
1. Men: early old age	21	(19.6)	39.8	(18.2)			19.3	(15.4)			20.5	(7.9)			53798.2	(28384.0)		
2. Men: late old age	25	(23.4)	36.3	(17.9)	3.56	*	13.9	(13.9)	5.88	**	22.4	(12.7)	3.46	*	42014.0	(27326.1)	5.13	*
3. Women: early old age	30	(28.0)	40.1	(16.0)			11.3	(10.0)			28.8	(10.3)			41903.7	(20570.4)		
4. Women: late old age	31	(29.0)	27.8	(14.0)	4 < 3		6.3	(5.1)	4 < 1		21.5	(11.1)	1 < 4 < 3		28920.3	(15413.2)	4 < 3 < 1	
Total	107	(100.0)	35.6	(17.0)	-		12.0	(12.0)	-		23.5	(11.1)	-		40502.4	(24071.3)	-	

ns: not significant; * $p < 0.05$, ** $p < 0.01$. Differences between two groups were assessed by the *t*-test and differences between the three or four groups were analyzed using one-way analysis of variance.

significantly higher among participants in early old age. Exercise accounted for 36.5% and 30.7% of the overall physical activity among individuals in early old age and late old age, respectively, indicating no significant between-group differences with regard to age.

The step count of the participants in early old age was 46,801.4 steps/wk, whereas that of individuals in late old age was 34,765.7 steps/wk; individuals in early old age took significantly more steps than those in late old age ($p < 0.01$).

Next, the individuals were divided into four groups based on sex and age. As a result, significant differences were found among the four groups for all parameters, including the amount of non-exercise.

Relationship between physical activity/step counts and daily life behaviors (Table 2)

Individuals who engaged in more physical activity tended to live with a spouse ($p < 0.01$), engage in intentional/planned exercise ($p < 0.05$), walk for outings ($p < 0.01$), and cultivate plants ($p < 0.01$). There was a significant positive relation between the amount of physical activity and total exercise time ($p < 0.05$).

Individuals who exercised more also tended to live with a spouse ($p < 0.01$), engage in intentional/planned exercise ($p < 0.01$), and walk for outings ($p < 0.01$); however, they did not frequently perform household chores ($p < 0.05$). A significant positive correlation was observed between exercise level and total exercise time ($p < 0.01$), and a significant negative correlation was observed between exercise level and time spent performing household chores ($p < 0.01$).

Individuals with high amounts of non-exercise tended to take frequent outings ($p < 0.05$), frequently engage in household chores ($p < 0.05$), cultivate plants ($p < 0.01$), and have a pet in need of walking ($p < 0.05$); however, they had no roles in the community ($p < 0.05$) and did not frequently participate in community events ($p < 0.01$). A significant positive correlation was observed of the level of non-exercise physi-

cal activity with time spent performing household chores ($p < 0.01$) and overall body movement time ($p < 0.01$).

Individuals who took more steps tended to live with a spouse ($p < 0.01$), live away from their parents ($p < 0.01$), engage in intentional/planned exercise ($p < 0.01$), walk for outings ($p < 0.01$), and do plant cultivation ($p < 0.05$). A significant positive correlation of step count was observed with total exercise time ($p < 0.05$) and time spent on outings ($p < 0.05$), and a significant negative correlation was noted between step count and time spent performing household chores ($p < 0.01$).

Hierarchical multiple regression analysis of physical activity (Tables 3–5)

An analysis focusing on the amount of physical activity as the dependent variable reported a negative association with age in Step 1, although this association was not significant in Step 2. There was a significant relationship between step count and plant cultivation in Step 3 (Table 3).

Using the amount of exercise as the dependent variable, a significant relationship was reported between sex and age group in Step 1; however, the relationship with age group became insignificant in Step 2. Furthermore, there was a significant association between the level of exercise and step count. In Step 3, wherein the parameters of daily life behaviors were added, only step count continued to demonstrate a significant association with the level of exercise (Table 4).

Using the amount of non-exercise as the dependent variable, no significant relationships were observed in Step 1; however, there was a significant relationship between sex and step count in Step 2. In Step 3, sex was no longer a significant factor; however, a significant relationship was observed between number of steps, plant cultivation, and frequent outings (Table 5). Additionally, the VIF was < 2 among all the independent variables in the regression analysis examined at this step; thus, there were no strong correlations among the respective independent variables.

Table 2 Associations between physical activity/step counts and daily life behaviors

		n (%)	Physical activity (METs*h/wk)		Exercise (METs*h/wk)		Non-exercise (METs*h/wk)		Steps (wk)	
			Mean (SD)	Significance	Mean (SD)	Significance	Mean (SD)	Significance	Mean (SD)	Significance
Cohabitation with spouse	Yes	85 (79.4)	37.9 (16.9)	**	13.4 (12.8)	**	24.5 (10.9)	ns	43964.1 (24590.8)	**
	No	22 (20.6)	26.7 (14.6)		6.9 (5.6)		19.9 (11.5)		27217.4 (16431.0)	
Cohabitation with parents	Yes	8 (7.5)	24.4 (11.1)	ns	4.4 (4.1)	ns	20.0 (10.4)	ns	27282.6 (8905.9)	**
	No	99 (92.5)	36.5 (17.1)		12.7 (12.2)		23.8 (11.2)		41570.6 (24609.8)	
Intentional/planned exercise	Yes	78 (72.9)	37.9 (17.6)	*	13.7 (13.1)	**	24.2 (11.6)	ns	43470.2 (26113.0)	**
	No	29 (27.1)	29.3 (13.5)		7.6 (6.5)		21.7 (11.2)		32519.8 (15093.4)	
Outings, mostly walking	Yes	44 (41.1)	41.2 (17.4)	**	17.8 (14.9)	**	23.4 (11.0)	ns	51203.7 (28116.4)	**
	No	63 (58.9)	31.6 (15.6)		8.0 (7.1)		23.6 (11.3)		33028.5 (17445.0)	
Frequent outings	Yes	86 (80.4)	36.5 (17.3)	ns	11.9 (11.6)	ns	24.7 (11.5)	*	41147.8 (23768.4)	ns
	No	21 (19.6)	31.6 (15.2)		12.7 (13.6)		19.0 (7.9)		37859.1 (25706.8)	
Frequent house chores	Yes	80 (74.8)	35.7 (17.5)	ns	10.6 (11.5)	*	25.1 (11.1)	*	38570.2 (24238.0)	ns
	No	27 (25.2)	35.1 (15.6)		16.3 (12.7)		18.8 (10.0)		46227.3 (23058.9)	
Plant cultivation	Yes	68 (63.6)	39.7 (17.5)	**	13.0 (12.3)	ns	26.7 (11.6)	**	44695.3 (23992.4)	*
	No	39 (36.4)	28.3 (13.0)		10.3 (11.3)		18.1 (7.6)		33191.7 (22694.6)	
Pet that requires walking	Yes	13 (12.1)	43.3 (21.8)	ns	14.0 (16.9)	ns	29.3 (13.3)	*	47439.5 (32379.5)	ns
	No	94 (87.9)	34.5 (16.0)		11.8 (11.2)		22.7 (10.6)		39543.0 (22748.2)	
Roles in the community	Yes	64 (59.8)	34.1 (15.2)	ns	13.0 (12.5)	ns	21.1 (8.5)	*	42231.3 (24554.5)	ns
	No	43 (40.2)	37.7 (19.2)		10.5 (11.2)		27.2 (13.4)		37929.0 (23380.3)	
Frequent participation in community events	Yes	74 (69.2)	33.9 (17.5)	ns	12.5 (12.9)	ns	21.4 (10.0)	**	41307.0 (25654.3)	ns
	No	33 (30.8)	39.2 (15.4)		11.0 (9.7)		28.2 (12.1)		38698.0 (20324.9)	
		Mean (SD)	Correlation coefficient (r)	Significance	Correlation coefficient (r)	Significance	Correlation coefficient (r)	Significance	Correlation coefficient (r)	Significance
Cohabiting family (n)		2.6 (1.5)	0.18	ns	0.17	ns	0.08	ns	0.14	ns
Total exercise time (min/w)		225.1 (241.1)	0.19	*	0.26	**	0.01	ns	0.24	*
Outing time (min/d)		109.5 (84.6)	0.18	ns	0.18	ns	0.08	ns	0.23	*
House chore time (min/d)		122.3 (104.9)	-0.04	ns	-0.32	**	0.29	**	-0.25	**
Body movement time (min/d)		218.1 (127.0)	0.19	ns	-0.08	ns	0.37	**	0.02	ns

ns: not significant. * $p < 0.05$, ** $p < 0.01$. The nominal scale was analyzed by *t*-test and the ratio scale was analyzed by the Pearson product-moment correlation coefficient.

Discussion

Physical activity in community-dwelling elderly Japanese individuals (aged ≥ 65 years) who were not long-term care dependent

In this study, we visited elderly people over 65 years who were not certified as long-term care-dependent and who were introduced to us by the leader of each ward. We asked them to participate in our study consisting of triaxial accelerometer measurements and a questionnaire survey to obtain objective and subjective measurements of physical activity in daily life behaviors; we then examined the relationship between physical activity and daily life behaviors. The results showed that non-exercise in daily life behavior has elements of physical activity.

The average amounts of physical activity, exercise, and non-exercise were 37.9 METs*h/wk, 16.4 METs*h/wk, and 21.5 METs*h/wk for men, respectively, and 33.8 METs*h/wk, 8.8 METs*h/wk, and 25.1 METs*h/wk for women, respectively.

Oshima's study⁶⁾ was based on a triaxial accelerometer for measuring the physical activity of elderly people (≥ 60 years) who mainly resided in Kyoto City and among whom medical examination revealed no disease-related physical restrictions. In comparison, the participants of the present study had higher levels of physical activity and non-exercise, whereas the amount of exercise was almost the same.

Moreover, the proportion of the amount of exercise relative to the total amount of physical activity was low. This indicates that the amount of non-exercise in participants in

Table 3 Amount of physical activity determined using hierarchical multiple regression analysis

	Step 1 β	Step 2 β	Step 3 β
Sex	-0.10	0.10	0.06
Age group	-0.25*	-0.01	0.00
Number of steps (steps/wk)		0.85**	0.80**
Cohabitation with spouse			0.06
Intentional/planned exercise			0.08
Outings, mostly walking			-0.34
Plant cultivation			0.13*
Total exercise time (min/wk)			-0.04
R ² /Adjusted R ²	0.08*/0.06	0.70**/0.69	0.72/0.69

*p<0.05, **p<0.01.

Table 5 Amount of non-exercise determined using hierarchical multiple regression analysis

	Step 1 β	Step 2 β	Step 3 β
Sex	0.17	0.24**	-0.05
Age group	-0.13	-0.04	-0.04
Number of steps (steps/wk)		0.32**	0.22*
Frequent outings			0.22*
Frequent house chores			0.10
Plant cultivation			0.25*
Pet that requires walking			0.14
Roles in the community			-0.12
Frequent participation in community events			-0.20
House chore time (min/d)			0.10
Body movement time (min/d)			0.16
R ² /Adjusted R ²	0.04/0.03	0.13**/0.11	0.43**/0.37

*p<0.05, **p<0.01.

the present study increased their amount of overall physical activity.

Relationships between physical activity and daily life behaviors

Considerable age-related differences were observed in participants' physical activity levels. Furthermore, considerable age- and sex-related differences were observed in the amount of exercise. A four-group comparison by sex and age group revealed considerable differences in the amount of physical activity, exercise, and non-exercise; however, the hierarchical multiple regression analysis revealed no such significant relationships. This indicates that sex and age group were not directly associated with the amount of physical activity, exercise, and non-exercise. In contrast, the hierarchical multiple regression analysis revealed significant

Table 4 Amount of exercise determined using hierarchical multiple regression analysis

	Step 1 β	Step 2 β	Step 3 β
Sex	-0.30**	-0.09*	-0.07
Age group	-0.23*	0.03	-0.02
Number of steps (steps/wk)		0.91**	0.85**
Cohabitation with spouse			-0.05
Intentional/planned exercise			0.06
Outings, mostly walking			0.07
Frequent house chores			-0.05
Total exercise time (min/wk)			0.01
House chore time (min/d)			-0.05
R ² /Adjusted R ²	0.15**/0.13	0.86**/0.85	0.87/0.86

*p<0.05, **p<0.01.

associations between step count and total physical activity, amount of exercise, and amount of non-exercise. This indicates that step count considerably influences the physical activity of elderly individuals.

It should be noted that no multicollinearity was observed, because the VIF was <5 for all independent variables in the regression analysis in this time.

Health Japan 21 (2nd term)²³⁾ expresses physical activity goals in accordance with an individual's step count. Our results indicate that high-value step counts are associated with increased physical activity, reaffirming the importance of setting goals in terms of step counts. Increasing the daily or weekly step counts may be a relevant way to prevent frailty and sarcopenia through activities that the elderly can practice in their daily lives.

However, the hierarchical multiple regression analysis revealed no significant relationship between the self-declared time spent engaging in intentional/planned exercise and the amount of physical activity or exercise. This indicates that reporting having spent more time engaging in intentional/planned exercise was not directly related to either the amount of physical activity or objectively measured exercise. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT), in the Nationwide Person Trip Survey (2015)²⁴⁾, reported that "hobbies and recreation" and "travels and excursions" are some of the most popular activities in which elderly individuals engage during their free time; however, a considerable number of elderly also take part in "learning, self-development and training" and "sports". This indicates that hobbies, recreation, travel, and excursions contribute to increased physical activity and exercise, even when the individual performing these activities is not intentionally trying to be more active or exercise more.

Regarding daily life behaviors, a significant relationship was observed between the amount of physical activity/non-exercise and plant cultivation.

All individuals in the present study were community dwellers, and 63.6% cultivated plants in farmlands and gardens. Therefore, a reason for the higher amount of non-exercise could be frequent participation in outdoor activities, such as fruit and vegetable farming and activities that require frequent crouching or bending.

Cultivation requires going outdoors almost daily, and observing the growth of plants can be fulfilling. Therefore, it is reasonable to assume that plant cultivation exerts long-lasting effects on the motivation to go outdoors and may, therefore, contribute to increased amounts of physical activity by increasing the amount of non-exercise. Weeding and farm work have estimated intensities of 3.5 and 4.3–7.8 METs, respectively⁹. In the present study, plant cultivation included activities that involved bending, such as plant cultivation and watering plants, with intensities equivalent to ≥ 3 METs. Plant cultivation also included time spent in the same position, such as transplanting a nursery tree, activities such as shoveling soil or mud, and moderate-to-high intensity activities (e.g., carrying and transporting heavy objects). Given that there were considerable differences in step counts depending on the presence or absence of plant cultivation, added amounts of non-exercise (such as those involved in plant cultivation), plus increased step counts resulting from regular outings may have increased the overall amount of physical activity.

Furthermore, considering the features^{7, 10–12, 23, 24} of the triaxial accelerometer used in this study, the results may have been affected by activities that require bending, including indoor activities, such as using the vacuum cleaner or doing laundry.

A significant relationship was observed between frequent outings and the amount of non-exercise independent of step counts. According to an MLIT survey²³, outings for the elderly frequently include “shopping for daily items” and “dining, socializing, and participating in recreation,” followed by “medical visits,” with a mean frequency of three outings per month²³.

The triaxial accelerometer has three axes; therefore, the amount of activity other than the vertical movement of the body is reflected in the results. While the participants of the present study might have engaged in non-exercise of an intensity of ≥ 3 METs, such activities might not be reflected in step counts. Thus, increasing the step count and encouraging activities of daily living, such as plant cultivation and

frequent outings, can increase the physical activity in community-dwelling elderly Japanese.

The limitations of this study included a possible selection bias in favor of highly compliant individuals who were introduced by the ward leader. Moreover, the participants may have demonstrated relatively high amounts of physical activity at baseline. In addition, because this study targeted elderly people ≥ 65 years without certification for need of long-term care, we did not collect data on their past or present medical history. Therefore, it is possible that restricted daily life behaviors could have increased or decreased some participants' levels of physical activity. Moreover, the triaxial accelerometer cannot measure physical activity underwater or on a bicycle. Therefore, the above-mentioned activities were not reflected in this data, and may, thus, have been underestimated.

Further studies are warranted to better understand the mechanisms through which plant cultivation and frequent outings facilitate the increase in the amounts of non-exercise and physical activity. Furthermore, future investigations should determine if the same results can be obtained with a larger population of elderly individuals living in different locations, such as urban or hilly rural areas.

Conclusion

The amounts of physical activity, exercise, and non-exercise in community-dwelling elderly Japanese individuals were associated with step counts. Moreover, the amount of physical activity was related to the presence or absence of plant cultivation. The amount of non-exercise was related to plant cultivation and frequent outings, thereby indicating that daily life behaviors, other than walking, may contribute to physical activity.

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