Journal of Rural Medicine

Original article

Influence of seasonal variations on physical activity in older people living in mountainous agricultural areas

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Abstract

Objectives: Increasing activity levels in older people is important for maintaining quality of life and ameliorating the risks of morbidity related to falls, depression, and dementia. This study aimed to clarify the seasonal variation effects on total energy expenditure, number of steps, time spent in low- and moderate- or high-intensity physical activities, and daily activities performed.
Patients and Methods: This was a cross-sectional study of 22 community-dwelling older individuals (3 men, 19 women; mean age, 75.1 ± 7.3 years) living in three districts of Gero, Gifu, who participated in the Gero Salon Project hosted by the Social Welfare Councils. Evaluations were conducted in each season from September 2016 to August 2017. We used a uniaxial accelerometer, the Lifecorder device, which measures physical activity, and the Physical Activity Scale for the Elderly to evaluate activities of daily living. Data were analyzed using the multiple comparisons (Bonferroni correction) method.
Results: Total energy expenditure and time spent in moderate- or high-intensity activities did not show seasonal variations. However, the lowest number of steps was taken during the winter, and the number of steps increased significantly from winter to spring. The time spent in low-intensity physical activities was significantly longer in the spring and summer than in the winter. There was no significant seasonal difference in total Physical Activity Scale for the Elderly score, leisure activities, domestic activities, or work-related activities. However, there was a significant difference between the summer and winter scores in "outdoor gardening," with the lowest score observed during the winter.
Conclusions: With climate changes in the winter months, "outdoor gardening" becomes difficult, thus decreasing the number of steps taken. Therefore, it is necessary to identify other ways for older people to maintain physical activity during the winter season.

Key words: physical activity, seasonal variation, aged, rural health

(J Rural Med 2019; 14(2): 165–175)

Introduction

Inactivity is a risk factor for cardiovascular and cerebrovascular diseases, diabetes, obesity, and cancer[1]. Global efforts are being made to promote physical activity in people of all ages. Higher physical activity levels can reduce the risks of many of the aforementioned diseases[2], which decrease overall morbidity and mortality rates[3]. Increasing physical activity level is particularly important among older people to reduce fall risk[4], prevent dementia[5], improve depression, and improve overall quality of life (QOL)[6, 7]. Japan has developed a super-aged society; therefore, it is necessary to increase daily physical activity levels to promote and maintain the health of older people.

Many factors can influence physical activity levels; however, in Japan, the seasons of the year are important with respect to maintaining physical activity in older people. To date, several studies have confirmed seasonal variations in

Received: February 4, 2019
Accepted: April 12, 2019
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physical activity[8–11]. In Japan, physical activity reportedly decreases during the winter months. According to a study of 95 healthy older people (aged 65–83 years) who wore Lifecorder (LC) devices for 1 year, the total number of steps taken increased during the spring and summer months and decreased during the winter months[12]. Another previous study compared the number of steps taken by 39 healthy older people (aged 65–80 years) at two time points during the winter and summer. They found that the number of steps decreased significantly in the winter months[13]. In these previous studies, physical activity decreased in the winter, but the results varied among subjects' areas of residence[10]. It was also reported that physical activity differs in urban and rural areas, which necessitates an investigation of physical activity in older people that considers regional characteristics[14]. However, the aforementioned reports did not include residents of mountainous agricultural areas.

Overall physical activity is defined by the performance of exercise and daily activities, which has drawn attention in recent years. Daily activities, static sitting, and standing account for more than 50% of humans' total energy expenditure[15]. These activities can help prevent obesity[16]; however, many previous studies reported findings that focused on walking-centered exercise but did not report changes that resulted from routine daily activities (leisure time, household, and work-related activities).

This study aimed to clarify seasonal variations in total energy expenditure, number of steps taken, time spent in low- and moderate- to high-intensity physical activities and the content of the routine daily activities performed.

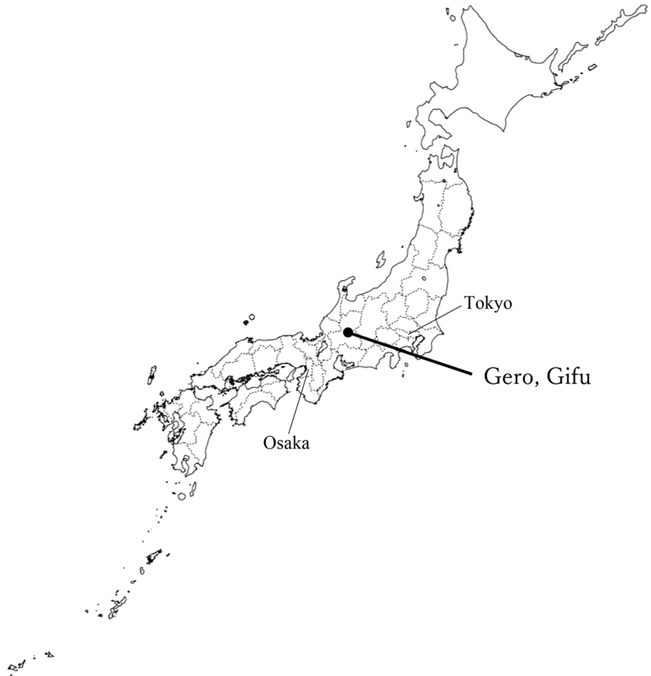

Figure 1 Location of Gero, Gifu.

Patients and Methods

The study subjects in this cross-sectional field survey study were 22 community-dwelling older people (3 men, 19 women; mean age, 75.1 ± 7.3 years old) living in the three districts of Gero, Gifu, who participated in the Gero Salon Project hosted by the Social Welfare Councils. Gero, Gifu, is located at the center of Japan and is classified as a mountainous agricultural area (Tahata) because forests account for more than 80% of the total land area and the cultivation rate is less than 10% (Figure 1)[17]. Gero City has an altitude of 3,052.6 m at its highest elevation and 220.0 m at its lowest and is classified as a cold area[18]. The mean temperature throughout the year is approximately 12°C[19].

The evaluation period was September 2016 to August 2017. Autumn included the months from September to November, winter included December to February, spring included March to May, and summer included June to August[20]. Measurement dates were set for each season and the evaluations were conducted at four time points.

Exclusion criteria comprised: those who received support based on certificates of financial need and/or certificates of need in long-term care, those who could not wear the LC for a full 7 days, those with a suspected decline in cognitive function based on cognitive function test results, and those who could not complete all the evaluations in the four seasons. In this study, those with suspected declining cognitive function were evaluated using the Japanese version of Test Your Memory (TYM-J). Subjects were excluded if their scores were less than 38[21].

This study was approved by the Chubu University Ethics Review Committee (approval number: 280073). Verbal and written explanations of the research protocol and personal information protection protocols were provided to all subjects, and their written informed consents were obtained.

Basic information

At the beginning of the study period (autumn), we recorded the age, sex, height, weight, and body mass index (BMI) of each subject and performed physical examinations. Systolic and diastolic blood pressures and heart rates were measured using an electronic sphygmomanometer (HEM-7120; Omron Corporation, Kyoto, Japan) at consistent time points throughout the study period.

A questionnaire was provided to each subject at four distinct time points to obtain social information and identify exercise habits, hobbies, and work-related activities. We recorded life events such as ceremonial occasions that could have affected the subjects' physical activity levels.

We recorded weather condition data throughout the study period by gathering information on temperature, precipitation, wind speed, and sunshine duration in Gero city and snowfall in the adjacent areas (Takayama, Gifu); the number of typhoons approaching the Tokai region; and the annual precipitation ratio during the rainy season in the Tokai region from the Meteorological Agency database[19]. For each season, we used the weather data for the week that the LC was worn in our analysis. In addition, for comparison with the average yearly results, the values for the past 5 years were also investigated. Moreover, the snowfall in the adjacent area from December to March over the past 5 years was investigated.

Physical activity evaluation

In this study, we employed the LC (LifeLyzer05 Coach: Suzuken Co., Ltd., Nagoya, Japan) (Figure 2), a uniaxial accelerometer that measures physical activity. We distributed device precaution leaflets and provided individual oral explanations to each subject as to the manner of wearing the LC. The LCs were placed in front of the lumbar region. The subjects were instructed to wear the device constantly throughout the day, except during sleep, for a 7-day period[22]. Since the LC is not waterproof, we instructed the subjects to avoid wearing it while engaging in water-based activities such as swimming or bathing. In the final analysis, we included the data of only those subjects who were able to wear and record the LC measurements on all 7 days. LC data including total energy expenditure; number of steps taken; and time spent in low- and moderate- to high-intensity activities (average values for 1 week) were analyzed using the LC.

Physical activity evaluation (Physical Activity Scale for the Elderly)

In addition to the LC measurements, we used the Physical Activity Scale for the Elderly (PASE) to evaluate specific daily activities performed. PASE is a questionnaire comprising three sub items: leisure time, household, and work-related activities. The leisure time activity was based on five types of activity: walking outside the home, light sport/recreational activities, medium sport/recreational activities, high sport/recreational activities, and muscular strength and endurance exercises. The household activity section comprised six types of activity: light housework, heavy housework or chores, home repairs, lawn work or yard care, outdoor gardening, and caring for another person. Since work-related activities comprised only one type of activity, the PASE comprised a total of 12 types of activity[23].

Respondents were instructed to provide two ranked responses (frequency, duration) for leisure activities. The scores for households and work-related activities were based on “Yes” or “No” responses. The PASE score ranges from 0 to 400 or more[23]. In this study, the scores for the 3 sub (leisure time, household, and work-related activities) and 12 types of activity were added to generate a total score for the PASE. The PASE was used with permission from the New England Research Institutes (NERI, Watertown, MA, USA).

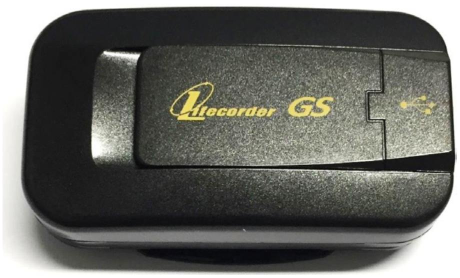

Figure 2 Lifecorder device.

Evaluation of physical function

The parameters used to evaluate physical function comprised: Grip Strength, Arm Curl, Chair Stand, Chair Sit and Reach, Timed Up and Go Test, 5-m Walking Speed, Four-Square Step Test, and One-Leg Standing with Eyes Open[24–27]. Each item was measured twice, and the best value was used in the data analysis. The first and second measurements for the arm curl and the chair stand were conducted before and after the physical function measurements considering the potential for fatigue. Physical function measurements were performed on the initial evaluation day only at the beginning of the study period in the autumn.

Evaluation of psychological function

Psychological function was evaluated using the TYM-J[21], 15-item Geriatric Depression Scale[28], 8-item Short-Form Health Survey[29], and Japanese version of the abbreviated Lubben Social Network Scale[30]. Psychological function tests were conducted using a self-reporting method on the initial evaluation day only, at the start of the study period in the autumn, similar to the physical function measurements.

Living function

In this study, weakness was evaluated using a Kaigo-Yobo Checklist[31]. The subjects’ living functions were surveyed using the Tokyo Metropolitan Institute of Gerontology Index of Competence[32]. Living function measurements were obtained on the initial evaluation day only at the start of the study period in the autumn.

Data analysis

Mean and standard deviation values of age, height, weight, BMI, blood pressure, heart rate, and physical function were calculated at the start of the evaluation period in the autumn. The medians and first and third quartile values were calculated from the psychological and living function test questionnaire scores. Seasonal exercise habits (4 items), hobbies (2 items), and work activities or lack thereof (2 items) were analyzed using the χ^2 test. Seasonal variations in the average temperature, average precipitation, average wind speed, average sunshine duration, total energy expenditure, number of steps taken, time spent in low- and moderate- to high-intensity activities, and PASE scores were analyzed using multiple comparisons (Bonferroni correction method). All statistical analyses were conducted using SPSS Statistics version 24 (IBM Corp., Armonk, NY, USA). The significance level was set at 0.05.

Results

Subjects' attributes

Table 1 shows the subjects' basic information and physical, psychological, and living functions at the start of the evaluation period (autumn) (Table 1).

Questionnaire survey

No seasonal variations were observed with respect to exercise habits, hobbies, or work-related activities based on the questionnaire responses (Table 2). In addition, none of the subjects experienced life events such as ceremonial occasions during the study period.

Weather conditions

Table 3 shows the seasonal variations in weather conditions. During the study period, the average temperatures were 15.1 ± 4.7°C in autumn, 2.3 ± 2.6°C in winter, 10.7 ± 5.5°C in spring, and 23.8 ± 1.8°C in summer. There were no significant differences between the temperatures in the autumn and winter. In contrast, the temperature differences between all other time points were significant. The average temperatures over the past 5 years were 14.5 ± 5.2°C in autumn, 0.9 ± 1.3°C in winter, 10.8 ± 4.8°C in spring, and 22.8 ± 2.2°C in summer.

The average precipitation values were: 11.2 ± 20.3 mm in autumn, 7.7 ± 17.0 mm in winter, 2.5 ± 6.1 mm in spring, and 6.2 ± 10.6 mm in summer; there were no significant differences between the seasons. The average precipitation values over the past 5 years were 3.9 ± 9.3 mm in autumn, 3.1 ± 7.5 mm in winter, 6.4 ± 13.1 mm in spring, and 14.0 ± 26.0 mm in summer.

The average wind speeds were 3.0 ± 1.8 m/s in autumn, 3.0 ± 1.2 m/sec in winter, 2.5 ± 0.9 m/sec in spring, and 2.0 ± 0.8 m/s in summer, and there were no significant differences between the seasons. The average wind speeds over the past 5 years were 1.1 ± 0.2 m/s in autumn, 1.4 ± 0.5 m/s in winter, 1.3 ± 0.2 m/s in spring, and 0.8 ± 0.1 m/s in summer.

Table 1 Subjects' basic attributes and physical and psychological functions at the study start

Measurement and survey items			Value
Basic attributes	Age (years)		75.1 ± 7.3
	Height (cm)		149.9 ± 8.7
	Weight (kg)		51.1 ± 9.1
	Body mass index (kg/m^2)		22.6 ± 3.5
	Systolic blood pressure (mmHg)		137.3 ± 21.4
	Diastolic blood pressure (mmHg)		78.3 ± 8.3
	Heart rate (bpm)		77.2 ± 2.2
Physical function	Grip Strength-right (kg)		26.8 ± 8.1
	Grip Strength-left (kg)		25.9 ± 8.6
	Arm Curl (times/30 sec)		24.0 ± 3.6
	Chair Stand (times/30 sec)		21.1 ± 5.3
	Chair Sit and Reach (cm)		14.3 ± 9.6
	5 m Walking Speed (m/sec)		1.4 ± 0.2
	Timed Up and Go Test (sec)		6.3 ± 2.1
	Four Square Step Test (sec)		7.7 ± 2.3
	One Leg Standing with Eyes Open (sec)		29.5 ± 22.7
Psychological function	Japanese version of Test Your Memory		44 (41.5–44.5)
	The 15-item Geriatric Depression Scale		2.5 (0–4)
	SF-8	Physical summary score	48.1 (42.1–51.9)
		Mental summary score	53.5 (47.8–56.0)
	Japanese version of the abbreviated Lubben Social Network Scale		18 (17.5–22.5)
Living function	Kaigo-Yobo Checklist		2 (0.5–3)
	Tokyo Metropolitan Institute of Gerontology Index of Competence		13 (12.5–13)

SF-8: 8-item Short-Form Health Survey. Basic attribute and physical function data are reported as mean ± standard deviation. Psychological and living function data are reported as median (first-third quartile value).

Table 2 Seasonal variations in the questionnaire survey

Questionnaire survey		Autumn	Winter	Spring	Summer	p value
Exercise habits	0 days/week	27.3 (6)	13.6 (3)	13.6 (3)	18.3 (4)	n.s.
	1 day/week	13.6 (3)	13.6 (3)	18.3 (4)	22.7 (5)	
	2–3 days/week	22.7 (5)	22.7 (5)	22.7 (5)	22.7 (5)	
	4–6 days/week	4.6 (1)	13.6 (3)	13.6 (3)	13.6 (3)	
	7 days/week	31.8 (7)	36.5 (8)	31.8 (7)	22.7 (5)	
Hobby-type activities	Presence of hobby	77.3 (17)	72.7 (16)	72.7 (16)	68.2 (15)	n.s.
Work-related activities	Working	13.6 (3)	9.1 (2)	13.6 (3)	13.6 (3)	n.s.

Values are presented as % (n). Multiple comparisons were analyzed using the χ^2 test. The significance level was set at 0.05. n.s., not significant.

Table 3 Seasonal variations in weather conditions

Weather condition	Autumn	Winter	Spring	Summer	p value
Temperatures (°C)	15.1 ± 4.7 (14.5 ± 5.2)	2.3 ± 2.6 (0.9 ± 1.3)	10.7 ± 5.5 (10.8 ± 4.8)	23.8 ± 1.8 (22.8 ± 2.2)	Autumn < Summer ($p < 0.01$) Winter < Autumn, Spring, Summer ($p < 0.01$) Spring < Summer ($p < 0.01$)
Precipitation (mm)	11.2 ± 20.3 (3.9 ± 9.3)	7.7 ± 17.0 (3.1 ± 7.5)	2.5 ± 6.1 (6.4 ± 13.1)	6.2 ± 10.6 (14.0 ± 26.0)	n.s.
Wind speed (m/sec)	3.0 ± 1.8 (1.1 ± 0.2)	3.0 ± 1.2 (1.4 ± 0.5)	2.5 ± 0.9 (1.3 ± 0.2)	2.0 ± 0.8 (0.8 ± 0.1)	n.s.
Sunshine duration (h)	4.0 ± 0.3 (4.2 ± 3.2)	3.8 ± 0.5 (4.3 ± 2.6)	5.5 ± 0.3 (6.3 ± 4.3)	5.0 ± 0.7 (5.1 ± 3.8)	Autumn < Spring, Summer ($p < 0.01$) Winter < Spring, Summer ($p < 0.01$)

Values are expressed as mean ± standard deviation. Values in parentheses are the mean and standard deviation of the past 5 years. Multiple comparisons were analyzed using the Bonferroni correction method. The significance level was set at 0.05. There was no significant difference between the temperatures in autumn and spring. In contrast, temperature differences between all the other time points were significant. n.s., not significant.

The average sunshine durations were 4.0 ± 0.3 h in autumn, 3.8 ± 0.5 h in winter, 5.5 ± 0.3 h in spring, and 5.0 ± 0.7 h in summer, significantly longer in spring and summer than in autumn and winter. The average sunshine durations over the past 5 years were 4.2 ± 3.2 h in autumn, 4.3 ± 2.6 h in winter, 6.3 ± 4.3 h in spring, and 5.1 ± 3.8 h in summer (Table 3).

The average snowfall in the adjacent areas was 7.2 cm from December 2016 to April 2017. The average snowfall over the past 5 years was 6.2 cm.

The number of typhoons approaching the Tokai region was 4 in 2016 and 3 over the past 5 years.

The average annual precipitation ratio during the rainy season in the Tokai region was 67% in 2017 and 90.7% over the past 5 years.

LC data

The total energy expenditures measured using the LC were 1,445.8 ± 221.7 kcal in autumn, 1,430.1 ± 238.9 kcal in winter, 1,457.3 ± 203.5 kcal in spring, 1,456.4 ± 209.1 kcal in summer. There were no significant differences in total energy expenditures among the seasons (Figure 3).

In contrast, the numbers of steps taken were 5,712.4 ± 3,412.6 in autumn, 4,917.6 ± 3,172.8 in winter, 6,242.0 ± 3,228.6 in spring, and 5,740.7 ± 3,029.8 in summer. The lowest number of steps was taken in the winter, and a significant increase in the number of steps taken was observed from winter to spring ($p < 0.01$) (Figure 4).

The times spent in low-intensity activities were 44.9 ± 22.8 min in autumn, 38.4 ± 20.2 min in winter, 50.4 ± 20.1 min in spring, and 50.3 ± 22.8 min in summer. The amounts of time spent were significantly longer in the spring ($p < 0.01$) and summer ($p < 0.01$) than in the winter (Figure 5).

The times spent in moderate- to high-intensity activities were: 15.2 ± 17.5 min in autumn, 13.3 ± 16.6 min in winter, 16.0 ± 17.9 min in spring, and 12.6 ± 13.7 min in summer; there were no significant differences among the seasons (Figure 6).

Physical Activity Scale for the Elderly

Table 4 shows the seasonal variations in the PASE scores. There were no significant seasonal differences in total PASE scores or in leisure time, domestic, and work-related activities. However, among the low items, there was a significant

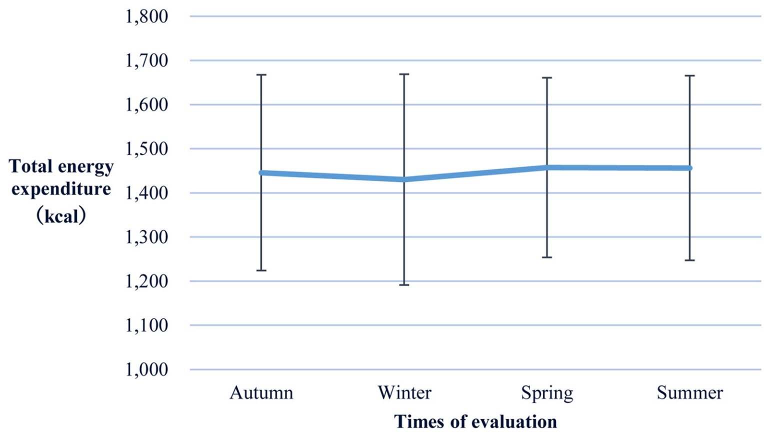

Figure 3 Seasonal variations in total energy expenditure measured by the Lifecorder. Multiple comparisons were analyzed using the Bonferroni correction method. The significance level was set at 0.05. There were no significant seasonal differences in total energy expenditure.

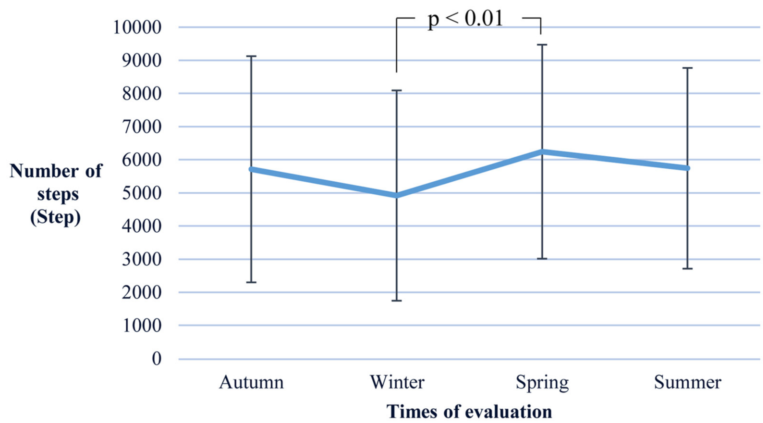

Figure 4 Seasonal variations in the number of steps taken measured by the Lifecorder. Multiple comparisons were analyzed using the Bonferroni correction method. The significance level was set at 0.05.

difference between the summer and winter scores in "outdoor gardening", with the minimum score value having occurred in winter ($p < 0.01$) (Table 4).

Discussion

We measured the total energy expenditure, number of steps taken, time spent in low-intensity and moderate- to high-intensity activities in older people living in three mountainous agricultural areas and compared the results among the seasons. We found that the total energy expenditure and the time spent in moderate- to high-intensity activities did not follow seasonal variations. In contrast, the least number of steps was taken in winter, and there was a significant increase in the number of steps taken from winter to spring. Additionally, the time spent in low-intensity activities was significantly longer in the spring and summer than in the winter.

In the present study, a significant increase in the number of steps taken was observed from winter to spring, which may have been temperature-related. The average temperature in the target area of this study was 2.3°C in the winter and 10.7°C in the spring, representing a significant difference. A previous study reported an investigation of seasonal variations in the number of steps taken by healthy community-dwelling older people. They showed that the least number of steps was taken in the winter and the greatest numbers of steps were taken in the fall and spring[12]. In the present study, the least number of steps was taken in the winter and the step count was the highest in the spring, which is similar to the result of the previous study[12]. Another study that compared the number of steps taken by 39 healthy older

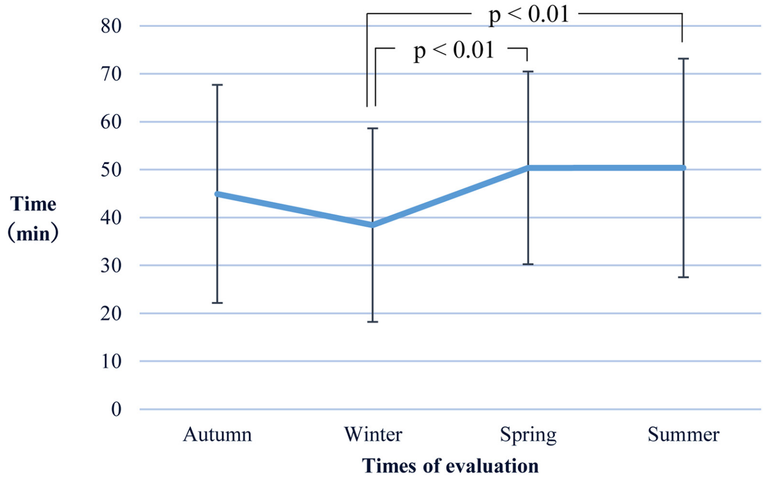

Figure 5 Seasonal variations in the time spent in low-intensity activities measured by the Lifecorder.
Multiple comparisons were analyzed using the Bonferroni correction method. The significance level was set at 0.05.

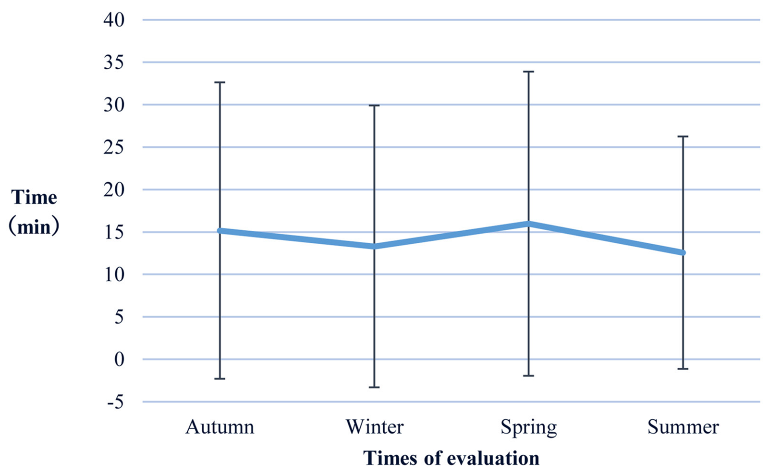

Figure 6 Seasonal variations in the time spent performing moderate- to high-intensity activities measured by the Lifecorder.
Multiple comparisons were analyzed using the Bonferroni correction method. The significance level was set at 0.05. There were no significant inter-season differences in moderate- to high-intensity activities.

people between winter and summer showed that the number of steps decreased significantly in the winter[13]. Their target area was a cold area in which the average temperature in the winter was 3.3°C. Thus, those authors considered that the decrease in temperature led to the reduction in the number of steps. It has also been reported that physical activity decreased in winter compared with summer and that the rise in temperature positively influenced physical activity[33].

In a study that examined the relationship between weather conditions and physical activity, physical activity was shown to have decreased by approximately 10% in environments characterized by low temperatures and high precipitation volumes[34]. Another prior study examined the influence of changes in weather conditions on physical activity among 127 community-dwelling older people. They found that physical activity decreased in winter versus summer and that the average maximum temperature and average sunshine duration influenced physical activity; however, the effects of precipitation and wind speed were small[35]. In the present study, the sunshine duration was significantly longer in spring and summer, so it is possible that physical activity increases with increased sunshine duration in addition

Table 4 Seasonal variations in the Physical Activity Scale for the Elderly

Item	Autumn	Winter	Spring	Summer	p value
Total points	119.1 ± 7.7	108.2 ± 9.5	124.4 ± 8.8	130.0 ± 7.9	n.s.
Leisure activity	24.1 ± 3.7	20.3 ± 5.0	18.5 ± 3.0	22.1 ± 4.6	n.s.
Walk outside	18.7 ± 3.4	15.5 ± 4.6	9.7 ± 1.5	16.0 ± 3.1	n.s.
Light sport/recreational activities	2.2 ± 0.9	2.7 ± 1.3	3.0 ± 1.0	1.2 ± 0.5	n.s.
Medium sport/recreational activities	1.0 ± 0.7	0.7 ± 0.5	2.4 ± 1.6	0.3 ± 0.3	n.s.
High sport/recreational activities	0.0	0.4 ± 0.3	0.8 ± 0.5	1.9 ± 1.4	n.s.
Muscular strength and endurance exercises	1.9 ± 1.8	1.0 ± 0.7	2.6 ± 1.8	2.7 ± 1.8	n.s.
Household activity	91.6 ± 5.1	82.5 ± 8.4	100.3 ± 8.1	101.0 ± 5.6	n.s.
Light housework	25.0 ± 0	23.9 ± 1.1	23.9 ± 1.1	25 ± 0	n.s.
Heavy housework or chores	22.7 ± 1.6	21.6 ± 1.9	23.9 ± 1.1	25 ± 0	n.s.
Home repairs	2.7 ± 1.9	5.5 ± 2.5	5.5 ± 2.5	2.7 ± 1.9	n.s.
Lawn work or yard care	24.5 ± 3.7	16.3 ± 3.9	26.2 ± 3.5	26.2 ± 3.5	n.s.
Outdoor gardening	11.8 ± 2.1	7.3 ± 2.1	14.5 ± 1.9	17.3 ± 1.5	Winter < Summer ($p < 0.01$)
Caring for another person	4.8 ± 2.6	8.0 ± 3.2	6.4 ± 2.9	4.8 ± 2.6	n.s.
Work-related activity	3.4 ± 2.6	5.5 ± 5.5	5.6 ± 5.5	7.0 ± 4.6	n.s.

Values are expressed as mean ± standard deviation. Multiple comparisons were analyzed using the Bonferroni correction method. The significance level was set at 0.05. n.s., not significant.

to the temperature. Although previous studies reported the influences of precipitation and wind speed, in the present study, seasonal variations in physical activity were influenced by temperature and sunshine duration variations only because there were no seasonal variations in precipitation or wind speed in the study location. However, the seasonal variations in precipitation values during this study differed from the average yearly trend as the precipitation value in the rainy season was low. As the average rainfall in summer in the past 5 years was more than double that in other seasons, the possibility of an effect on physical activity cannot be denied. Therefore, to clarify the influence of weather conditions, a longer-term survey is necessary.

The time spent in low-intensity activities was significantly shorter in the winter in the present study. This is thought to have resulted from a decrease in the number of steps taken in the winter. Exercise intensity calculations using the LC are dependent upon acceleration and the number of steps taken. Exercise intensity measured using the LC was divided into nine stages from 1, which indicated no movement, to 9, which indicated intense exercise. Exercise intensity stages 1–3 (< 3 metabolic equivalents) represented low-intensity activity. Exercise intensity stages 1 or 2 corresponded to indoor walking, while exercise intensity stage 3 corresponded to routine outdoor walking[36]. Therefore, the time spent in low-intensity activities was shortened as the number of steps taken decreased during the winter. In this study, we used the PASE to investigate seasonal variations in daily activity content. We considered that a decrease of the number of steps taken in winter might be influenced by "outdoor gardening". According to our results, "outdoor gardening" was associated with significant changes in winter and summer. Fear of falls and injuries reportedly impedes physical activity among older people[37]. Gardening environments require the ability to maintain a stable gait across rough terrain. We considered that the temperature drop in the winter and freezing of the road increased the fear of falls and injuries in older people. Thus, "outdoor gardening" activities decreased in the winter.

However, physical activity that decreased from autumn to winter recovered in the spring. It is possible that the decrease in physical activity during winter may not have affected the overall health conditions of the older people in this study. Therefore, considering physical activity throughout the year, declining physical activity in the winter is possibly related to a positive action pattern that cannot be denied.

There was no significant difference among seasons with respect to the time spent in moderate- to high-intensity activities. Moderate- to high-intensity sports and recreational activities involve excessive movements, such as with golf, baseball, swimming, ballroom dancing, mountaineering, and so on. In this study, we researched the exercise habits at the different seasonal time points. We found that the time spent in moderate- to high-intensity activities did not show seasonal variations because the exercise habits did not change throughout the year. Additionally, similar to the time spent in moderate- to high-intensity activities measured with the LC, there were no seasonal variations in the content of daily activities that were considered moderate- or high-intensity on the PASE. From the coefficients of each item on the PASE, the five items including "light housework", "heavy housework or chores", "home repairs", "lawn work or yard care", "caring for another person" corresponded to moderate- or high-intensity activities. The subjects in this study were sufficiently active in their communities according to the results of the Tokyo Metropolitan Institute of Gerontology Index of Competence. Since seasonal variations in life events and hobbies that could have affected physical activity were not recognized, and household chores and household roles were not changed. Therefore, all five items showed no seasonal variations, and it seemed that the time spent in moderate- to high-intensity activities showed no seasonal variations.

Regarding total energy expenditure, the amount of energy expended to perform exercise-related activities was 25–30% and the proportion increased as the exercise intensity increased[38]. We found no seasonal variations in total energy expenditure or time spent in moderate- to high-intensity activities.

In this study, the number of steps taken and the time spent in low-intensity activities were the lowest during the winter. This is thought to be due to a decline in "outdoor gardening". According to our results, if it were possible to increase "outdoor gardening" activities in the winter, it would be possible to maintain physical activity levels year-round among older people living in mountainous agricultural areas. However, icy road surfaces and winter snowfall increase the fall risk. Furthermore, the number of fruit-bearing agricultural crops decreases, so there is a need to identify alternative means of exercise that can be performed indoors during the winter months[39]. Therefore, we propose that it is better to emphasize methods of increasing physical activity while performing daily activities. Koizumi *et al.* reported that increasing health awareness by providing people with a targeted number of steps that they should take led to an actual increase in the number of steps taken. Therefore, it is possible that a greater effect can be achieved by setting target values.

In contrast, total energy expenditure and time spent in moderate- to high-intensity activities showed no seasonal variations. Time spent in moderate- to high-intensity activities achieved 4 points in the measurement modalities in this study; however, the activities that achieved this score did not equal the standard 20 min or more that is necessary for health promotion[40]. Thus, to facilitate feedback and effect behavioral changes in older people with less than sufficient moderate- to high-intensity activities and overall reductions in physical activity, it is important to have regular evaluation meetings and provide encouragement.

Study limitations

The target population of this study was community-dwelling older people living in a mountainous agricultural area. Older residents of urban areas may not have similar results; therefore, further examinations in other areas are necessary. There were many women but few men in this study. Since the focus of this study was seasonal variations in physical activity among older people living in a mountainous agricultural area, we did not analyze the results by sex. However, it has been reported that physical activity in men, as measured by the accelerometer method, is greater than that in women[41]. Therefore, it is necessary to conduct examinations that also consider participant sex. The subjects of this study were chosen from those of the salon project organized by the Social Welfare Council, and we excluded those whose cognitive functions appeared to be declining. Our subjects' overall physical and psychological functions were relatively high. Therefore, we predicted that the subjects of this study would be highly aware of their health and would have many opportunities for social exchange. In the future, it will be necessary to perform additional studies to examine whether the results of the present study can be extrapolated to frail and older people with cognitive impairments.

However, this research was a limited 1-year survey, and a prolonged analysis has not yet been conducted. Therefore, to compare the physical activity over a 1-year period to a longer-term investigation, it will be necessary to clarify the influence of seasonal reductions in physical activity on many aspects of life among older people.

Conclusion

This study aimed to clarify the seasonal variations in total energy expenditure, number of steps taken, time spent in low- and moderate- to high-intensity physical activities, and amount of daily activities performed. The results obtained in the study revealed that physical activity decreased in the winter. The data obtained in this study will be useful for promoting the health of older people living in rural areas.

Conflicts of interest: None declared.

Acknowledgements

We thank the members of the Social Welfare Council for their cooperation with the survey as well as the members of the Gero Salon Project. I express my sincere gratitude to everyone who provided guidance in the preparation of this manuscript.

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