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Longitudinal study examined to physiological and psychological transition for the development of sensing indicators of daily livings among solitude elderly persons

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KEY WORDS
solitude elderly persons, physical transition, psychological transition , longitudinal study, sensing model of daily livings

Introduction

Japan is experiencing a “super-aging society,” with the rate of elderly people aged 65 and above now at 27.2% and expected to rise in the future [1] . As part of the rising number of elderly people, the number of households in which elderly people live alone is 6,243,000 and the number of households with elderly residents is now 26.3% of the total and is rising annually [2] . However, it is difficult to ascertain the health status of elderly people who live alone and are shut-ins and have low levels of activity.

The primary reason for elderly people requiring support is falling, which accounts for 25.3% of those requiring Support Level 1 and 18.2% of those requiring Support Level 2 [3] . The incidence of falling among community-dwelling elderly people ranges from the low ten-percent range to the twenty-percent range. The incidence of falling increases with age, and it has been reported that 9% of men and 12% of women suffer bone fractures as a result of falling [4] . Thus, falling among the elderly is included in the term “geriatric syndrome” [5] . Geriatric syndrome is characterized by the fact that the patient experiences few difficulties in daily life during the early stages and attributes whatever problems exist to age, but as a result, often fails to realize that the situation is becoming worse over time.

Therefore, the purpose of our project was to develop a system that can detect both physical and psychological health problems as well as signs of geriatric syndrome in the early stages in elderly people living alone through the use of data obtained from sensing devices（indoor wireless door sensors, environment sensors, power strips）and utility data（gas, water, electric power usage）.

In this study, we elucidated changes in the physical and psychological functions of elderly people living alone over a 6 month period using daily life sensor data as well as measurements regarding physical and psychological functions conducted every 3 months.

Methods

1. Study design and subjects

This study was a longitudinal field study. The subjects were 12 elderly people living alone who received support at a community comprehensive support center. The selection condition was that the subjects level of independence in daily life range from independent to Support Level 2. Consent to participate in this study was obtained from the subjects themselves and their family caregivers.

2. Survey methods

1）Measurements

The first session was held on January 19, 2015, the second session was held on March 25 and 26, 2015, and the third session was held on July 2 and 3, 2015. All sessions were held at Kanazawa University.

（1）Clinical characteristics

Clinical characteristics included sex, age, long-term

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care certification, medical history, locomotion method, and history of falling.

(2) Physical functions

① Leg muscle strength: We selected knee extension and flexion muscle strength due to its high degree of correlation with the movements of daily life and locomotion [6]. A physical therapist measured maximum isometric muscle strength using the handheld dynamometer μ TAS-MT1 (Anima).

② Grip strength: A Grip Track Commander (Japan Media) was used to measure grip strength with the subjects in a seated position and their shoulders in the mid-position, elbows flexed to 90 degrees, and forearms and wrists in the mid-position (the American Society of Hand Therapists).

③ Static balance ability: We measured static balance ability with the eyes closed and open using a Gravicorder GS-10 (Anima). Analysis utilized peripheral area (ENV. AREA), and total track length (LNG), which show the function decreases as the value increases.

④ Dynamic balance ability: We used the Functional Reach Test (FR). In a standing position, the subjects raised their arms so that they were parallel to the floor and we measured the distance moved by the tip of the middle finger when performing the forward reach movement.

⑤ Walking ability: We used the 5-meter walk test and the Borg scale [7]. The Borg scale has a maximum score of 20 points. Exercise intensity while walking is subjectively assessed. Scores of 6 to 7 indicate very easy, 8-9 indicate much easier, 10-11 indicate easy, 12-13 indicate a little tight, 14-15 indicate tight, 16-17 indicate fairly tight, and 18-20 indicate very tight.

(3) Psychological and social functions

① Depression: We used the Quick Inventory of Depressive Symptomatology (QIDS-J)[8]. The QIDS-J is a self-administered assessment scale with 16 items. Scores of 0 to 5 indicate normal, 6-10 indicate mild depression, 11-15 indicate moderate depression, 16-20 indicate severe depression, and 21-27 indicate extremely severe depression.

② Cognitive ability: We used the Mini-Mental State Examination (MMSE)[9]. The MMSE has 11 items and a maximum score of 30 points. Scores of 27 to 30 indicate normal.

③ Instrumental activities of daily living: We used Lawton's Instrumental Activities of Daily Living (IADL)[10) 11)]. The IADL has 8 items and a maximum score of 8 points.

④ Fall risk: We used the Fall Risk Assessment scale, which was developed for community-dwelling elderly people [12]. The scale has 15 items. Fall risk is high when 5 or more items are applicable.

(4) Nutritional Status

We measured weight, body mass index (BMI), mid-upper arm circumference (AC), triceps skin fold thickness (TSF), arm muscle circumference (AMC), and mid-upper arm muscle area (AMA).

2) Sensor data: We obtained data over a continuous 24-hour period from wireless sensors in the subjects' homes that recorded activity living speed.

3. Analytical methods

We used one-way analysis of variance to analyze the changes from the first to the second sessions during the winter and the change to the third session in the spring. The statistical software was IBM SPSS Base System ver. 23. Statistical significance was set at under 5%.

4. Ethical considerations

This study was conducted with the approval of the Medical Ethics Committee of Kanazawa University (No.555-1). When conducting the surveys, both the subject and his or her family caregiver were provided with both written and oral explanations of the purpose of the study and the ethical considerations, and their signed, written consent to participate in this study was obtained. The following were the ethical considerations: From the perspective of protecting private information, we encoded physical measurement and interview data and achieved linkable anonymity through the use of a conversion table. The data and conversion chart were stored in a secure, locked cabinet.

Results

1. Overview of subjects (Table 1)

The subjects were 9 female (75%) and 3 male (25%). The mean age was 78.1 ± 7.5, and 66.7% of the subjects were "advanced elderly" people aged 75 or older. Five subjects (41.7%) had received Long-Term Care Certification, 4 were certified as Support Level 1 and 1 were certified as Support Level 2. All subjects had some type of illness and were being treated at a medical facility. Our analysis of the methods of locomotion used by the subjects indicated that 10 walked un-assisted (83.3%) and 2 walked with a walking cane (16.7%). Seven subjects (58.3%) reported falling within the previous 1 to 2 years.

2. Changes in physical function (Table 2)

Table 1. Characteristics of participants N=12

Variable		N (%)
Gender	Male	3 (25.0)
	Female	9 (75.0)
Age	M±SD	78.1 ± 7.5
	75 <	4 (33.3)
	75 ≧	8 (66.7)
Assistance certification	Adapt	5 (41.7)
	Not adapt	7 (58.3)
Medical history	Present	12 (100)
	Not present	0
Method of transfer	Walking	10 (83.3)
	Cane	2 (16.7)
Fall history	Present	7 (58.3)
	Not present	5 (41.7)

Leg strength as measured by left knee extension muscle strength declined in the winter but recovered in the spring (20.3 ± 4.2 kg vs. 13.7 ± 5.4 kg vs. 20.5 ± 5.3 kg, p=0.002). However, knee flexion muscle strength declined during winter on both the left and right sides but recovered in the spring (right: 9.6 ± 2.7 kg vs. 5.9 ± 2.8 kg vs. 10.6 ± 2.5 kg, p=0.001; left: 9.4 ± 2.4 kg vs. 5.6 ± 2.6 kg vs. 11.0 ± 2.4 kg, p=0.001). There were no significant differences in grip strength.

Our investigation of balance ability indicated that the total track distance for center of gravity sway (eyes open) was (28.8 ± 11.6 cm vs. 41.8 ± 16.1 cm vs. 28.8 ± 11.3 cm, p=0.031) and FR was (25.1 ± 4.7 cm vs. 21.3 ± 5.3 cm vs. 27.9 ± 6.2 cm, p=0.019), which indicated that both declined in the winter and recovered in the spring. There were no significant differences in walking ability and nutritional state.

3. Changes in psychological and social functions (Table 3)

Table 2. Physical transitions of participants for six months N=12

Variable			baseline	after three months (winter term)	after six months (spring term)	p value
Knee muscle strength (kg)	Extenion	Right	20.4 ± 4.9	16.3 ± 6.2	18.9 ± 5.6	0.202
		Left	20.3 ± 4.2	13.7 ± 5.4	20.5 ± 5.3	0.002
	Flexion	Right	9.6 ± 2.7	5.9 ± 2.8	10.6 ± 2.5	0.001
		Left	9.4 ± 2.4	5.6 ± 2.6	11.0 ± 2.4	0.001
Grip strength (kg)		Right	19.5 ± 3.8	18.7 ± 3.0	18.6 ± 3.8	0.790
		Left	18.7 ± 3.0	16.6 ± 3.1	17.1 ± 3.4	0.242
Static balance ability	Opened eyes	ENV. AREA (㎠)	1.8 ± 1.2	2.5 ± 1.5	1.7 ± 1.2	0.267
		LNG (㎝)	28.8 ± 11.6	41.8 ± 16.1	28.8 ± 11.3	0.031
	Closed eyes	ENV. AREA (㎠)	2.8 ± 1.5	3.0 ± 1.6	2.3 ± 1.8	0.557
		LNG (㎝)	43.9 ± 16.7	56.6 ± 23.5	44.4 ± 24.4	0.285
Dynamic balance ability		Functional Reach Test (㎝)	25.1 ± 4.7	21.3 ± 5.3	27.9 ± 6.2	0.019
Walking ability		5m Gait Speed	3.6 ± 0.9	4.0 ± 1.7	4.0 ± 1.8	0.727
		Borg Scale	11.2 ± 2.4	11.0 ± 2.1	11.2 ± 2.4	0.980

one-way ANOVA

Table 3. Psychological and social transitions of participants for six months N=12

Variable		baseline	after three months (winter term)	after six months (spring term)	p value
Psychological and social ability	Dipression 1)	7.4 ± 4.2	3.8 ± 3.2	4.1 ± 2.8	0.024
	MMSE 2)	29.1 ± 1.4	28.8 ± 1.5	28.9 ± 1.5	0.914
	IADL 3)	7.4 ± 0.9	7.7 ± 0.5	7.7 ± 0.7	0.607
	Fall Risk 4)	3.3 ± 2.6	3.2 ± 2.6	3.2 ± 2.4	0.983
Nutritional status	Weight (kg)	55.8 ± 9.1	55.6 ± 9.4	54.4 ± 9.4	0.922
	BMI (kg/㎡) 5)	23.5 ± 3.4	23.3 ± 3.7	22.9 ± 3.6	0.912
	TSF (mm)	17.5 ± 4.9	15.7 ± 5.9	15.1 ± 5.8	0.538
	AC (㎝)	25.8 ± 2.3	26.9 ± 3.1	26.4 ± 3.0	0.660
	AMC (㎝)	20.3 ± 1.6	22.4 ± 2.9	21.6 ± 2.2	0.086
	AMA (㎠)	32.9 ± 5.2	40.7 ± 11.2	37.6 ± 7.7	0.092

one-way ANOVA 1) Quick Inventory of Depressive Symptomatology (QIDS-J), 2) Mini-Mental State Examination (MMSE)
3) Instrumental Activities of Daily Living (IADL), 4) Fall Risk Assesment scal (Suzuki T, et al.), 5) body mass index (BMI)

Table 4. Activity living speed during the day or night N=10

ID	baseline Day m/sec	Night m/sec	Through the winter Day m/sec	Night m/sec
1	0.975	0.817	0.747	0.611
2	0.571	0.333	0.824	0.600
3	0.456	0.342	0.299	0.157
4	0.505	0.555	0.867	0.870
5	0.811	0.868	1.180	1.021
6	0.051	0.041	0.786	0.985
7	0.652	0.519	0.919	0.598
9	0.699	0.445	0.500	0.519
10	0.878	0.831	0.592	0.545
12	0.603	0.587	0.584	0.529

Day（6:00-20:59）, Night（21:00-5:59）

QIDS-J results improves as winter progressed (7.4 ± 4.2 points vs. 3.8 ± 3.2 points vs. 4.1 ± 2.8 points, p=0.024). Mean scores for the MMSE and IADL remained nearly at maximum score during the 6 month period. There were no significant differences in the fall risk and nutritional state of the subjects.

4. Activity living speed during the day or night (Table 4)

The results of our comparison of the speed of daytime and nighttime activities indicated that 8 subjects (80%) at baseline and 7 subjects (70%) through the winter showed slower movement during activities of daily life during the nighttime as compared to during the daytime.

Discussion

Both the total track distance for center of gravity sway (eyes open) and Functional Reach Test, which indicate left knee extension muscle strength, left and right knee flexion muscle strength, and balance ability –aspects on which daily activities and locomotion depend – declined during the winter but recovered in spring. In the Ishikawa prefecture of Japan, the period in the winter during which snowfall and freezing occur, lasts for a long time, and as a result, elderly people who live alone tend to engage in outdoor activities less often. We believe this led to the reduced muscle strength and reduced dynamic and static balance ability. On the other hand, according to the QIDS-J results, although the mean score at the time the study began (January) was 7.4 points, which indicates mild depression (6-10 points), the mean score improved as winter progressed. We believe this is related to the fact that winter is a time of inactivity and fewer daylight hours.

Based on these results, we believe that elderly people living alone in the Ishikawa prefecture of Japan experience reduced physical and psychological function during the winter, which puts them at higher risk of falling. However, the fact that these functions generally recover in spring suggests that there is a need to longitudinally monitor the changes that occur in physical and psychological functions during the winter and link these to signs that indicate geriatric syndrome.

We were able to ascertain the speed of the activities of daily life of elderly people who live alone (m/sec), which we used as part of a sensing model for activities of daily life. The speed of the activities of daily life tended to be reduced during the night as compared to that during the day, regardless of the season of the year. This may indicate that elderly people who live alone may have been walking along dark hallways, which we believe is a nighttime fall risk. The significance of the development of a sensing model for activities of daily life is that it can "allow the early detection of problems with safety and health while maintaining the privacy of elderly people who live alone"[13]. Identifying the relation of changes in physical and psychological functions due to the season and monitoring changes on an annual basis remain issues for future study.

Conclusion

As a result of this longitudinal field study that involved in-home sensing and taking the measurements regarding the physical and psychological functions of the elderly people who live alone in the Ishikawa prefecture of Japan, we elucidated the following:

1. Leg muscle strength, balance ability, and depression all temporarily worsened during the winter but generally recovered in spring.
2. Activity living speed allowed us to infer the nighttime risk of falling.

The above suggest that using daily life sensor data and measurements regarding physical and psychological functions, which longitudinally monitored signs of geriatric syndrome, was effective when used on elderly people who live alone.

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独居高齢者の生活行動センシング指標の開発にむけた縦断的検討による心身機能および生活行動スピードの推移

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