早稲田大学審査学位論文

博士（スポーツ科学）

Preventive study on dementia with targeting at physical activity and social participation among community-dwelling older adults

地域在住高齢者における身体活動及び社会参加活動に着目した認知症予防に関する研究

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Chapter 1

Introduction

1. Prevalence of dementia in Japan

Advancement of aging society with declining birthrates, producing the shortage of working population, has been becoming one of the major public health issues during the last decades in Japan.

Japanese government reported that people over 65 years old accounted for only 6.3 percent of the total Japanese population, with 9.1 working-age people (20 to 64 years old) taking care of one elderly person aged 65 and over in 1965, 2.4 working –age people in 2012, and will be 1.2 working –age people in 2050(1). These data strongly indicate that the burden on the nation will be increased and that social security systems including health care insurance systems will be on the brink of collapse for the next few decades. To maintain these systems, particularly long-term care insurance system, decreasing the older adults requiring long-term care through promoting their health status are needed.

However, the number of older adults certificated to need long-term care has been increased from 3.7 million in 2003 to 5.9 million in 2014 (2). The major causing factors of long-term care is “cerebrovascular disease” (17.2%) and “dementia” (16.4%). The number of dementia patients has been rapidly increasing during the last few decades in Japan, and is postulated to reach approximately 7 million in the year 2025 when the first baby boomer will become old-old generation (2). The physical and economic burdens of dementia influence on not only patients, but also on their

care givers including family members. From 2007 to 2012, approximately 500 thousands people retired from their jobs, because of providing nursing care at home (3). Therefore, the amount of economic loss from dementia postulated to be 1.5 billion yen ($14 million) in 2014, and will be increased to 2.4 billion yen ($22 million) by 2060 (4).

These findings suggest that the health insurance cost will increase rapidly from years to come, and that taking measures to prevent dementia or cognitive decline in older adults has become an urgent global public health issue in Japan. To reduce the health care insurance cost, developing efficient population approach and prevailing the intervention program to prevent dementia onset across local community are necessary.

2. Relevant factors of dementia

It is important to identify the factors related with dementia onset or cognitive decline for prevention of dementia, and to develop efficient intervention program focused on the relevant factors of dementia.

Some systematic reviews and meta-analyses have examined the factors related with incidence of dementia (5,6) and suggested that those factors are comprised of related factors which are unmodifiable factors (e.g. age, gender, educational attainment, household income) and risk factors which are modifiable factors (e.g. physical inactivity, lower level of social participation, insufficient nutrition intake, smoking, alcohol intake, being under stress). They also showed that among these risk factors, physical inactivity and lower level of social participation are strongly related to the

incidence of dementia (7,8). Previous study also reported that 12.7% of Alzheimer's disease cases are potentially attributable to physical inactivity (9). Although the mechanism of reduced prevalence of dementia or cognitive function in response to physical activity or exercise is incompletely understood, previous studies showed that physical exercise training produced a larger volume of hippocampus (10) and increased blood flow in the brain (11), and that physical activity enhanced psychological well-being, which is a strong predictor of dementia onset or cognitive decline (12). These physiological and psychological changes in response to exercise seem to be a part of the mechanisms involved in reducing the prevalence of dementia. Moreover, some previous studies suggested that prolonged sedentary behavior might be a risk factor of lower cognitive function (13). However, these previous studies which examined the relationship between physical activity or physical inactivity and congnitive function have been conducted in western countries. Very few study examined these relationships among Japanese older adults has been reported. As there are big differences in lifestyle between Japanese and western older adults, identifing these relationships among Japanese community-dwelling older adults is important to develop the mesure for the prevention of dementia.

Previous study also reported that older adults engaging in social group activity have lower risk of dementia compared with non-participants (8). This finding suggests that increasing the number of individuals who participate in social group activity would be contributed to the prevention of dementia in population level. Although the mechanisms of social participation for prevention of dementia have not been identified, the following physiological and psychological effects might be

considered.

The increases in physical activity with the increase in frequency of going out of door(14) and in experiences of various activities stimulating the cognitive function (16) in social participation might produce above mentioned physiological effects on brain. The increase in the frequency of contact with others (15) through group activities could produce the improvement of self-esteem and/ or self-confidence which contribute to the reduction of the psychological stress. However, Kawachi and his colleagues suggested that high frequency of social participation might cause mental health decline (17). Although high frequency of social participation increases physical activity, it also induce excessive stress, resulted in poor mental health, by increasing the burden of group activity. Since poor mental health including depression was strongly associated with dementia onset, the relationship between social participation and dementia onset might largely differ by the types of group activity or the position within the organization. However, the evidences evaluating these relationship are extremely limited.

Authors conducted complete survey enrolled every older adults aged 65 years and older who did not receive long-term care insurance service, and examined the relationship between subjective cognitive decline and types of social group activity. The results showed that volunteer work related to lower risk of cognitive decline in female (18). Iwasa and colleagues examined the relationship between leisure time activity and dementia onset by using five-year follow-up data recruiting Japanese community-dwelling older adults aged ≥70 years. They reported that individuals who participated in hobby group had lower risk of dementia onset (19).Another previous studies

reported that having leading role in the group decreased the risks of depression (20) and all-cause mortality (21).These findings suggest that having leading role in the group also has positive effect on cognitive function among community-dwelling older adults.

Above mentioned findings in the previous studies suggest that promoting social group participation and more active style of social participation for community-dwelling older adults may contribute to prevent dementia.

3. Prevalence of physical activity and social participation in Japan

World Health Organization (WHO) released the guideline of physical activity for prevention of non-communicative diseases, and recommended the amount of 150 min for moderate-to-vigorous physical activity (MVPA) per week. Authors have investigated the time of MVPA in older adults living in rural community in Japan, and reported that 46.3 % of the participants did not meet the recommendation of physical activity by WHO (22). Therefore, promoting physical activity among Japanese elderly should be one of the important strategies for the prevention of dementia.

Although there have been many intervention studies aimed to increase physical activity in community-dwelling elderly, most of them were conducted as classroom type intervention with a limited number of participants. To achieve a social effect of the intervention, which could be contributed to the reduction of medical and long-term care expenses, the more participants and the

longer period of implementation are needed. There have been some studies reporting the effect of community intervention using population strategy for promotion of physical activity, but none of them reported clear effect of the intervention. Therefore, new approach for promotion of physical activity among older adults is necessary.

Promotion of social participation could be new approach to increase physical activity for community-dwelling older adults, because social participation is accompanied with going out of door.

Kikuchi and the colleagues (23) investigated the physical activity and sitting time in older adults and compared physical activity between individuals with higher level of social participation and with lower level of social participation. They reported that individuals with higher frequency of social participation spent more time for physical activity and less time for sitting time than the counter parts. This result suggests that promotion of social participation may increase physical activity in older adults, regardless of their willingness to increase physical activity. Then, promoting social participation could be a new approach to promote physical activity for the older adults having a wide range of stage of physical activity.

According to Japanese national data (24), 39.0% of older adults aged 60 years and over did not participate in any social activity for the past year. However, there are substantial number of "potential participants" who does not still participate in social activity with having willingness to participate in the activity. To increase the number of social group members, it is necessary to take measure which promote social participation for potential participants. Additionally, preventive

approach against withdrawing from the social group for the individuals with high risk for withdrawal is also important.

4. Factors to promote social participation

Previous studies investigated the factors that affect to participate in volunteer work (25), sports groups (26). These studies investigated group activities that comprised specific activities in which participants were interested, but did not examine less specialized types of social groups, such as neighborhood associations or senior citizen clubs in Japanese local communities. Neighborhood associations or senior citizen clubs are the organization which substantial rate of Japanese older adults engage in. A previous study (27) indicated that volunteer workers have more social support, are better educated, and are healthier than non-volunteer workers. However, the factors influencing on participation in social groups may vary according to the group purpose and organizational structure. Identifying the factors promoting or maintaining participation in organization among Japanese community-dwelling older adults has social and scientific significance.

5. Objectives of this study

From the above mentioned social and scientific background concerning dementia or cognitive decline, this study aims to identify following themes;

1) Identifying the association of single and combined factors of sedentary behavior and physical activity with cognitive decline among community-dwelling older adults (Study 1).

2) Examining the adding effect of having leadership position on relationship between social participation and dementia onset by age group using a large cohort study which followed-up 10 years. (Study 2)

3) Identifying the factors that promote or maintain social participation using community-based longitudinal data (Study 3).

Chapter 2

The association of single and combined factors of sedentary behavior and physical activity with subjective cognitive complaints among community-dwelling older adults: cross-sectional study.

1. Introduction

The number of dementia patients has been rapidly increasing during the last few decades worldwide, and is postulated to reach over 100 million in the year 2050 (28). Therefore, taking measures to prevent dementia or cognitive decline has become an urgent global public issue, particularly in developed countries. According to previous studies, subjective cognitive complaints (SCC) might be a meaningful indicator of dementia onset or mild cognitive impairment (29), Although there have been some intervention studies to improve objective cognitive function in older adults with SCC (30), the relationship between SCC and modifiable factors, such as physical activity or sedentary behavior among community-dwelling older adults have been remain largely unproven.

Physical activity has been shown to be strongly related with reduced incidences of dementia or cognitive decline (7), and 12.7% of Alzheimer's disease cases are potentially attributable to physical inactivity (9). Prolonged sedentary behavior is known to increase the risk of health problems, such as obesity, type 2 diabetes, or mortality, independently from physical

inactivity (31). Furthermore, a recent systematic review (13) suggested that sedentary behavior is associated with lower cognitive function. Some studies, however, have shown a positive association between sedentary behavior and cognitive function (32–34). These inconsistent results could have occurred by differences in the influence of sedentary behavior on cognitive function according to type of activity. Kikuchi and colleagues reported that sedentary behavior consisted of passive sedentary behavior (e.g., television viewing) and mentally active sedentary behavior (e.g., reading, and computer use) (35). Assessing the association of these lifestyle factors with SCC might contribute to the prevention of cognitive decline.

Recent studies have also revealed the combined effects of sedentary time and physical activity on risk of mortality (36), cardio-metabolic health (37), and cardiovascular disease (38). The findings of these studies suggest that the similar association of the combined effects of sedentary time and physical activity with SCC might be observed. However, to date, the association of the combined effects of sedentary time and physical activity with SCC has not been reported. Identifying these combined effects on SCC may contribute to developing an efficient multi-domain intervention program for the prevention of dementia or SCC.

The present study aims to examine the association of single and combined factors of sedentary behavior and physical activity with SCC among community-dwelling older adults.

2. Methods

Participants

This cross-sectional study targeted independently living individuals aged ≥65 years who resided in Tsuru, Yamanashi Prefecture, Japan. This municipality has been previously classified as an urban area (39). At the time of this survey, the city's population was 31,663 and the prevalence rate of those aged ≥65 years was 25.3% (n = 8011). In total, 6677 older adults who had never received long-term health-care insurance service benefits were enrolled to participate in the survey. In January 2016, the questionnaire survey was mailed to all participants, with a reminder mail sent to non-responders 2 weeks after the questionnaire was sent to encourage a higher response rate to the survey.

The survey's purpose and methods were printed on the front page of the questionnaire, including a notification informing that those who returned the questionnaire consented to study participation. This study protocol was approved by the ethics committee of Waseda University (approved number: 2015-218).

Measurements

Subjective cognitive complaints

SCC was evaluated using the Kihon Checklist (KCL), which is widely used to assess the risk of frailty throughout Japan (40). The KCL includes three questions related to cognitive function: Do your family or friends point out your memory loss? Do you make a call by looking up phone numbers? Do you find yourself not knowing today's date? Those who chose an undesirable answer to any of these questions were classified as having SCC. Meguro examined the validation of this

scale as a screening tool for cognitive decline and concluded that the scale is relatively meaningful for assessing individuals with a Clinical Dementia Rating stage above 0.5 (41). Tomata and colleagues concluded that the KCL would be useful for predicting the incidence of dementia (42).

Physical activity

To evaluate physical activity, the Japanese version of the International Physical Activity Questionnaire Short-version (IPAQ-SV) was conducted (43). Total time spent on moderate-to-vigorous physical activity (MVPA) was obtained by adding times reported for physical exercise of vigorous intensity, that of moderate intensity, and walking. Participants were divided into two groups based on the World Health Organization's recommendation for older adults (<150 min/week, ≥150 min/week) (44).

Sedentary behavior

Sedentary behavior time was assessed as subjective average duration of television viewing and reading books or newspapers during the last seven days. Computer use time was not assessed because the prevalence of older Japanese adults in urban areas having or using a computer is substantially low. These items were based on a previous questionnaire about sedentary behaviors (23) and modified so that participants could provide one of five response categories for each question and so that missing values could be prevented. The amount of time spent on sedentary behavior was classified into four groups for each activity: <1 h/day, 1–2 h/day, 2–3 h/day, and ≥3

h/day for television viewing; <10 min/day, 10–20 min/day, 20–30 min/day, and ≥30 min/day for reading.

Covariates

Demographic variables included sex, age (<75 years or ≥75 years), educational attainment (<10 years or ≥10 years), residential status (solitary or other), and employment (worker or non-worker). Health behaviors included alcohol status (drinker or non-drinker), and smoking status (smoker, former smoker, or never). Health status included medical history (hyperlipidemia, stroke, hypertension, and diabetes), stress (under stress or non-stressed), loss-event experience (experienced the loss of one's family or spouse over the past 1 year or not), and depression (participants who scored above five on the Geriatric Depression Scale−Short Version (45), and based on previous study (46), were categorized as "depressed").

Statistical analysis

Multiple imputation with full conditional specification was conducted, with 50 multiply imputed datasets created (47). The imputed model included SCC, physical activity, reading time, television viewing time, demographic variables, health behavior, and health status. Thereafter, multiple logistic regression analysis was conducted on 50 imputed data and the estimated odds ratios (ORs) and standard errors were combined with Rubin's rules (48). ORs and 95% confidence intervals (CIs) were calculated to examine the association of physical activity or sedentary behavior and their

combination with SCC. The OR was calculated after adjusting for demographic variables, health behavior, and health status. To compare the results, multiple logistic regression analysis on the subset of complete case data was performed. A p-value of 0.05 was used to indicate statistical significance for all analyses. SAS 9.4 (SAS Institute, Cary, NC) was used for all calculations.

3. Results

In total, 5328 participants responded to the questionnaire (79.8% valid response rate). The missing values imputed by multiple imputation ranged from 0 (0%) to 875 (16.4%). Up to 2424 participants (45.5%) were men, and 2834 participants (53.2%) were <75 years of age at the time of the survey. Up to 1732 participants (32.5%) showed SCC and 2467 (46.0%) reported high physical activity (≥150 min/week of MVPA time). A total of 952 participants (17.9%) watched television for <1 h/day, while 1389 (26.1%) watched television for 1–2 h/day, 1254 (23.5%) watched television for 2–3 h/day, and 1427 (26.8%) watched television for ≥3 h/day. Up to 1094 participants (20.5%) read books or newspapers for <10 min/day, while 1240 participants (23.3%) read for 10–20 min/day, 1173 (22.0%) read for 20–30 min/day, and 1458 (27.4%) read for ≥30 min/day (Table 1).

Table 1. Participants' characteristics

		Subjects (n=5328)	
		n	%
Sex	Male	2424	45.5
	Female	2904	54.5
Age	<75 year	2834	53.2
	≥75 year	2494	46.8
SCC	Non-SCC	3544	66.5
	Having SCC	1732	32.5
	Missing	52	1
Educational attainment	<10 year	4436	83.3
	≥10 year	751	14.1
	Missing	141	2.6
Residential status	Other	4555	85.5
	Solitary	649	12.2
	Missing	124	2.3
Self-rated health	Good	4214	79.1
	Poor	1056	19.8
	Missing	58	1.1
Employment	Worker	1448	27.2
	Non-worker	3820	71.7
	Missing	60	1.1
Alcohol status	Non-drinker	3505	65.8
	Drinker	1766	33.1
	Missing	57	1.1
Smoking status	Never	2979	55.9
	Ever	1732	32.5
	Smoker	567	10.6
	Missing	50	0.9
Medical history of hypertension	No	3065	57.5
	Yes	2263	42.5
Medical history of diabetes	No	4614	86.6
	Yes	714	13.4
Medical history of hyperlipidemia	No	4840	90.8
	Yes	488	9.2
Medical history of stroke	No	5117	96
	Yes	211	4
Depression	<5 points	2737	51.4
(Geriatric Depression Scale score)	≥5 points	1716	32.2
	Missing	875	16.4
Loss-event experience	Having experience	2063	38.7
	Did not have experiences	3155	59.2
	Missing	110	2.1
Stress	Under stress	2787	52.3
	Non-stress	2434	45.7
	Missing	107	2
Physical activity	<150 min/week	2451	46.3
	≥150 min/week	2467	46
	Missing	410	7.7
Television viewing time	<1 h/day	952	17.9
	1-2 h/day	1389	26.1
	2-3 h/day	1254	23.5
	≥3 h/day	1427	26.8
	Missing	306	5.7
Time of reading books or newspapers	<10 min/day	1094	20.5
	10-20 min/day	1240	23.3
	20-30 min/day	1173	22
	≥30 min/day	1458	27.4
	Missing	363	6.8

Multiple logistic regression analysis revealed that physical activity was significantly related to SCC (OR = 0.85, 95% CI = 0.74–0.97), and that reading behavior for ≥10 min/day was associated with a significantly lower risk of SCC than reading behavior for <10 min/day (10–20 min/day, OR = 0.63; 95% CI = 0.53–0.75; 20–30 min/day, OR = 0.59; 95% CI = 0.49–0.71; ≥30 min/day, OR = 0.47; 95% CI = 0.40–0.57). These reading behavior results revealed a dose-response relationship between reading time and SCC. With regard to television viewing, the group who viewed television for 1–2 h/day showed a significantly higher risk for SCC compared with the group who viewed television for <1 h/day (OR = 1.21, 95% CI = 1.00–1.47). However, the OR for ≥2 h/day was not found to be significant, and a dose-response relationship between time for television viewing and SCC was not observed (Table 2).

Table 2. Association of physical activity or sedentary behavior with SCC.

		Adjusted		
		OR	95%CI	P value
Physical activity				
	<150 min/week	reference		
	≥150 min/week	0.85	0.74 0.97	0.01
Television viewing time				
	<1 h/day	reference		
	1-2 h/day	1.21	1 1.47	0.05
	2-3 h/day	1	0.83 1.22	0.97
	≥3 h/day	1.09	0.9 1.32	0.36
Time of reading books or newspapers				
	<10 min/day	reference		
	10-20 min/day	0.63	0.53 0.75	<0.01
	20-30 min/day	0.59	0.49 0.71	<0.01
	≥30 min/day	0.47	0.39 0.57	<0.01

Data adjusted for sex, age, educational attainment, residential status, self-rated health, alcohol status, smoking status, medical history, loss-event experience, stress and depression.

Table 3 shows the combined relationship of physical activity and sedentary behavior with

SCC. The results of multiple logistic analysis revealed that the risk of SCC decreased with increased MVPA time and reading behavior, and the combined group who reported high physical activity and long reading time (≥30 min/day) showed a low risk for SCC (OR = 0.40, 95% CI = 0.32–0.50).

Table 3. The combined relationship of physical activity and sedentary behavior with SCC.

	Adjusted			
	OR	**95% CI**		**P value**
Physical activity (PA) × reading behavior				
<150 min/week for PA and <10 min/day for reading	reference			
≥150 min/week for PA and <10 min/day for reading	0.93	0.72	1.2	0.57
<150 min/week for PA and 10-20 min/day for reading	0.64	0.5	0.81	<0.01
≥150 min/week for PA and 10-20 min/day for reading	0.57	0.45	0.72	<0.01
<150 min/week for PA and 20-30 min/day for reading	0.63	0.49	0.8	<0.01
≥150 min/week for PA and 20-30 min/day for reading	0.51	0.4	0.65	<0.01
<150 min/week for PA and ≥30 min/day for reading	0.51	0.4	0.66	<0.01
≥150 min/week for PA and ≥30 min/day for reading	0.4	0.32	0.5	<0.01

Data adjusted for sex, age, educational attainment, residential status, self-rated health, alcohol status, smoking status, medical history, loss-event experience, stress, depression, television viewing time.

4. Discussion

The present study revealed that physical activity and reading books or newspapers were associated with SCC among community-dwelling older adults. MVPA for ≥150 min/week and reading books or newspapers for ≥10 min/day were found to be at significantly lower risk for SCC compared with MVPA for <150 min/week or reading for <10 min/day. The combination of physical activity and reading books or newspapers was also found to be significantly associated with SCC. The combined group who reported ≥150 min/week physical activity and ≥30 min/day reading showed 60% lower SCC than the combined group who reported <150 min/week physical activity and <10 min/day reading. The strength of this study is that it was based on data obtained from a complete survey with

a high response rate of 79.8% and that it accounted for missing values by multiple imputation. Therefore, the present study has low selection bias and shows high external validity for other municipalities similarly matched to the study area.

A previous meta-analysis has shown that physical activity is related with reduced incidence of dementia and cognitive decline (7). These results are largely consistent with that of the present study. Although the mechanism of reduced dementia or cognitive function in response to physical activity on exercise is incompletely understood, previous studies showed that exercise training produced a larger hippocampus (10) and increased blood flow in the brain (11), and that physical activity enhanced psychological well-being, which is a strong predictor of dementia onset or cognitive decline (12). These physiological and psychological changes in response to exercise appear to be a part of the mechanism involved in reducing the risk of SCC.

This study revealed that different categories of sedentary behavior differed in their relationship with SCC. While reading books or newspapers was observed to be strongly related with SCC, television viewing was not observed to have a dose-response relationship. This finding that television viewing was not related with SCC is inconsistent with the results of previous studies (49–51). Geda and colleagues conducted a cross-sectional study that enrolled older adults aged 70–89 years to investigate the association between television viewing time and incidence of mild cognitive impairment. They reported a significantly lower mild cognitive impairment incidence and a significantly lower OR of 0.48 in participants who reported ≤6 h/day of television viewing compared with those who watched television for >6 h/day (51). Although the reason for the inconsistency

between their result and ours remains unknown, the television viewing time in this study was possibly shorter than that of the previous study. In this study, only 13.1% participants watched television for more than 4 h/day, indicating that most of participants watched television for <4 h/day. Our short range of time for television viewing might have led to difficulty in detecting the association with SCC.

We found that reading books or newspapers for ≥10 min/day was associated with a lower risk of SCC than reading for <10 min/day, and that the OR for SCC decreased with increased reading time. Kesse-Guyot and colleagues examined the relationship between type of sedentary behavior and cognitive function among middle-aged people, and observed a non-significant association between reading and cognitive function (50). The most likely explanation for the difference in the results between the two studies might be due to the difference in lifestyle. The employment rate and number of social encounters in daily life are lower among older adults than among middle-aged adults, which induces higher potential ability for a biological response to stimulation among older adults. Older adults, therefore, might be more cognitively stimulated than middle-aged adults by reading books and newspapers. Then, differences in lifestyle or living condition could lead to different relationships between reading and cognitive function (52). However, the mechanism of the relationship between reading and cognitive function is largely unproven. A few hypotheses have been suggested regarding the mechanism of the relationship between reading and cognitive function. First, reading behavior has been hypothesized to stimulate brain activity and to increase brain-derived neurotrophic factor, which develops the brain's neural network. Second, reading has

been hypothesized to be helpful for obtaining information on health-care services from government or volunteer organizations. Those who can access health information tend to lead a healthy lifestyle that prevents them from developing diseases including dementia (51). Further research should be conducted to examine these causal relations.

This study is the first to investigate the combined relationship of physical activity and sedentary behavior on cognitive function. The results of the present study show that, for each reading time group, those who participate in high physical activity have a lower SCC risk than those who participate in low physical activity. Additionally, the combined group who reported ≥150 min/week of physical activity and ≥30 min/day of reading showed 60% lower SCC compared with the combined group who reported <150 min/week of physical activity and <10 min/day of reading. These results revealed that the high-risk group with SCC comprised physically and mentally less active older adults and that developing an intervention program aimed at increasing the amount of participation in physical and mental activities might contribute to decreased incidence of dementia in the future.

This study has some limitations. First, because this study was cross-sectional, the results do not show a cause-and-effect relationship and reverse causation may be possible. We concluded that higher physical activity and prolonged mentally active sedentary behavior may contribute to preventing SCC. However, individuals with poor cognitive function may not participate in high physical activity as a result of SCC. To examine the relationship between these factors, longitudinal studies or intervention studies are needed. Second, although individuals who had never received

long-term health-care insurance service benefits were enrolled in this study, subjects who developed dementia or mild cognitive impairment during the study were not necessarily completely excluded. Third, physical activity was assessed subjectively, which may have led to over-reporting. Physical activity should be evaluated using objective measurements in future research. Fourth, this study did not assess sedentary behavior using a device, such as a computer, tablet, or smartphone, because only few device users were enrolled in this study. However, the number of older adults using these devices is expected to increase in the future; thus, further research should examine the relationships between SCC and sedentary behavior using these devices.

In conclusion, high physical activity or long mentally active sedentary behavior is associated with a lower risk of SCC, and the combined effect of higher physical activity and cognitively active sedentary behavior showed the lowest risk of SCC among community-dwelling older adults. Further longitudinal studies are required to assess these relationships.

Chapter 3

An additive effect of leading role in the organization between social participation and dementia onset among Japanese older adults: The AGES cohort study.

1. Background

The number of dementia patients has increased dramatically because of the aging population worldwide. In 2010, more than 35 million people developed dementia and it is estimated that increase to 115 million people in 2050 (28). The population aging rate of Japan is 26.7% in 2015, and prevalence of dementia will increase from 2.8 million (9.5%) in 2010 to 4.7 million (12.8%) in 2025 (53).

Identifying factors related to dementia onset is fundamental for improving preventive strategies; several systematic reviews and meta-analyses have identified some modifiable factors related to cognitive function or dementia onset (5,7,8), and social participation is one of the factors related to dementia onset.(8). The following, which are promoted by social participation, decrease risk of dementia: increasing physical activity (leaving one's home), accessing emotional support by expanding social networks, and increasing frequency of cognitive activity by obtaining a social role (14); however, most of them only focused on absence of social participation and dementia onset or cognitive function, and the additive effect of leadership positions remains largely unknown.

Some observational studies investigated the relationship between leadership positions and

health status. According to Ishikawa et al.(21), holding leadership positions on the association was related to a 12 % risk reduction of mortality. Takagi et al. (20) suggested that performing leadership positions was significantly related to low odds ratio (OR) for depression for women (OR, 0.57; 95% CI, 0.37-0.88). Having leadership positions within civic groups may decrease the risk of dementia considerably; elderly people who manage the organization to which they belong perform various tasks or acquire roles that stimulate brain function or are beneficial to their health more so than compared with regular members, and this positively affects cognitive function.

The degrees of relationship between social participation and dementia onset may be different according to age group; in old-old (aged 75 or over), the age-related change has a greater effect on physical or mental health than in the young-old (aged 65–74) (54), and social participation can be a burden to the old-old. Therefore, to examine the relationship between social participation and dementia onset by age group is needed.

The purpose of the present study was to assess the additive effect of leadership positions in civic groups on the association between dementia onset and social participation among older adults in a local community, using data from a large cohort study (the Aichi Gerontological Evaluation Study: AGES).

2. Methods

Data

This study was based on data from the Aichi Gerontological Evaluation Study (AGES) project as a

part of the Japan Gerontological Evaluation Study (JAGES). JAGES is a largely Japanese prospective cohort study aiming to find out the details of related factors for major health problems among the older adults, such as depression, dementia, or functional deterioration (55).

Participants

Participants were chosen from within six municipalities in Aichi prefecture, consisting of urban, semi-urban, and rural settings. Out of 49,707 older adults aged 65 years and older in a local community who did not receive public long-term care insurance benefits, 29,374 individuals were selected using two methods: random sampling in two larger municipalities, and a complete survey in four semi-urban or rural municipalities. In October 2003, we conducted the baseline mail survey. A total of 15,313 individuals completed the baseline self-administrated questionnaire and followed up from November 2003 to March 2013. To identify the predictive factors for dementia onset, we involved relatively healthy older adults, and excluded individuals with any premonitory symptoms of dementia, such as being unable to walk, take a bath or use a toilet independently. Individuals who developed dementia within two years of the baseline were also excluded to clarify the relationship between dementia onset and initial conditions (Fig. 1).

The Ethics Committee on Research of Human Subjects at Nihon Fukushi University approved this study protocol.

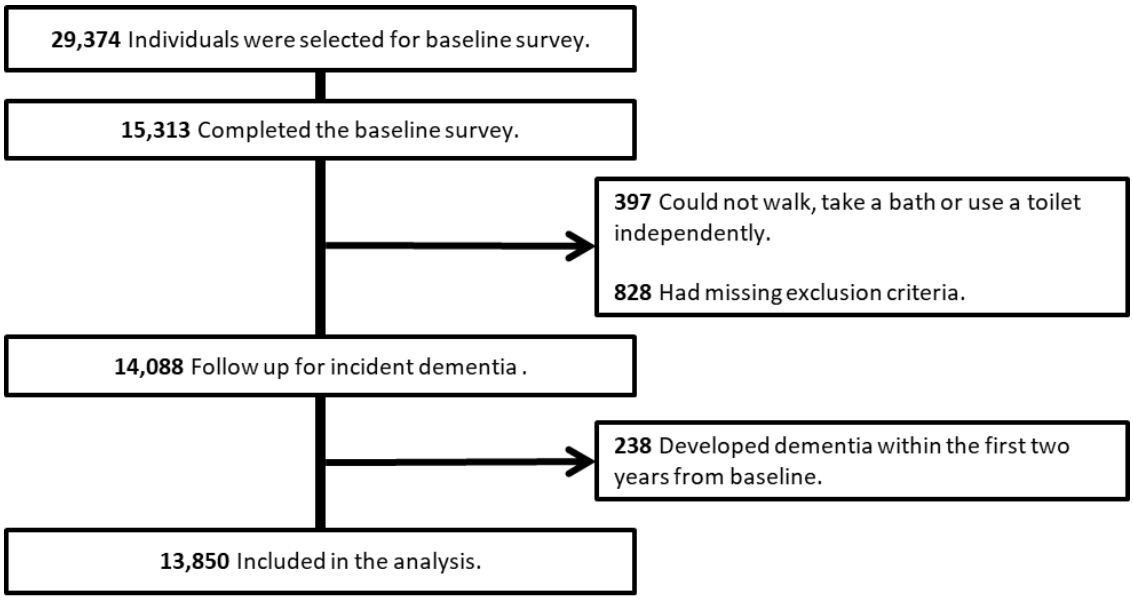

Figure 1. Flow of participants thorough the study.

Measurements

Incident Dementia

Dementia onset was determined using disabling dementia, which is defined as incident functional disability with dementia. This was obtained from long-term care insurance data managed by local municipalities, as described previously (56). Briefly, the degree of functional disability was evaluated according to a two-step procedure: on-site assessment of physical and mental condition by an agent from the home care provider, and further assessment by the Long-term Care Approval Board, consisting of health care professionals (doctors, nurses, caseworkers, or others) that referenced the results of on-site assessment and the primary physician's report, which is a standard form for assessing medical conditions and physical functions by a home physician[2)]. Dementia was determined according to the Degree of Independence in Daily Living for Elderly with Dementia

(Dementia Scale) (57)~~,~~. This scale was developed by the Japanese Ministry of Health, Labour and Welfare, and health professionals in Japan use it to assess physical and cognitive function and classify individuals into levels~~:~~ I–IV and M. Level I means that the individuals have symptoms of dementia, but will be able to maintain an independent daily life. Level II indicates that the individuals show some symptoms and behaviors causing trouble in their daily life or some difficulties with communication, but could continue to live independently if monitored. Level III indicates that the individuals have the same symptoms as Level II patients, but more frequently, and sometimes require care to support their daily lives. Level IV indicates that the individuals have the same symptoms as in Level III, but more frequently, and always need care in their daily lives. Level M indicates individuals with severe mental or physical diseases and behavioral disorders, who require specialized medical care. We defined individuals scoring levels II to IV or M as having dementia. A previous study has shown that the Dementia Scale is well correlated with the Mini Mental State Exam score (58).

Social participation and leadership positions in an organization

The scale of social participation was taken from the Japanese General Social Survey (59), and categorized organizations into following eight types: neighborhood association, senior citizen club/fire-fighting team, religious group, political organization or group, industrial or trade association, volunteer group, citizen or consumer group, hobby group, and sports group or club. Participants were asked whether they were members of each association and their frequency of

participation; those who answered “I do not participate in any organization” and “participate in the organization” but “very little” for frequency of participation were classified as “non-members”. Therefore, the individuals who belonged to one or more associations were asked their position in the organization; those who serve as head, manager or treasurer were categorized as having “leadership positions”, while others were classified as “regular members”.

Covariates

In this study, demographic variables, health behavior, and health status were included as covariates.

Demographic variables consisted of sex, age (65–69, 70–74, 75–79, 80–84, 85 years and over), educational attainment (less than 10 years, 10 or more years), marital status (married, other), residential status (solitary, other), employment (worker, non-worker), health behavior including alcohol status (drinker, non-drinker), smoking status (smoker/ former smoker, never-smoker), walking time (less than 30 minutes/day, 30minutes/day and longer), health status included instrumental ADLs (IADLs) (the subscale of Tokyo Metropolitan Institute of Gerontology Index of Competence: TMIG-IC (60)), medical history (heart disease, stroke, hypertension, diabetes), depression (Geriatric Depression Scale−Short Version, GDS-SV (45)). Those who earned full score for TMIG-IC were categorized as “high”, the GDS-SV cut-off was 5, as in a previous study (46), and subjects who scored above the cut-off were categorized as “depressed”.

Statistical analysis

To handle missing data, we carried out multiple imputation with full conditional specification, and created 50 multiply imputed datasets (47). Imputed model included incident of dementia, social participation and leading positions, demographic variables, health behavior, and health status. Therefore, Cox proportional hazard models were used on these datasets. These estimates and their standard errors were combined using Rubin's rules (61), and Hazard Ratio (HR) or confidence interval (CI) was calculated. For comparison, Cox proportional hazards model was used on the subset of complete case data.

We calculated HRs for incident of dementia according to social participation and by age group (young-old, old-old) using the Cox proportional hazards model to examine the relationship between these factors, and carried out a similar analysis model that exchanged social participation and leading role variables to assess the additive effects of leading positions. We used a level of significance of less than 5% in all analyses. SAS 9.4 (SAS Institute, Cary, NC) was used for all calculations.

3. Results

Of 29,374 individuals, 15,313 completed the baseline survey (response rate, 52.1%). Non-responders were younger, and there was no difference between sexes. Of the 15,313 subjects, 13,850 were included in the analysis. A total of 1463 individuals were excluded from analysis; 397 could not walk, take a bath or use a toilet independently, 828 had missing exclusion criteria, and 238 developed dementia within the first two years from baseline (Fig.1). The mean follow-up period was

7.9 years (standard deviation, 2.4 years), and the number of missing values across each variable varied between 0 (0%) and 933 (10.1%) in young-old, 0 (0%) and 721 (15.6%) in old-old; the total number of individuals who had incomplete data among the all variables was 2629 (28.5%) in young-old and 1663 (36.0%) in old-old. The number of individuals who died during follow-up was 1611 (17.5%) in young-old and 1363 (29.5%) in old-old.

Of the 13,850 subjects of the analysis, 9234 (66.7%) were young-old and 4616 (33.3%) were old-old. Of these young-old, 708 (7.7%) developed dementia, 3003 (32.5%) were non-members, 2514 (27.2%) were regular members, 2784 (30.1%) were in leadership positions, whereas in old-old, 1289 (27.9%) developed dementia, 1774 (38.4%) were non-members, 1289 (27.9%) were regular members, and 832 (18.0%) were in leadership positions (Table. 1). Table 2 shows that the incidence of dementia onset increased with age. The incidence in each category of old-old individuals was much higher than in young-old participants.

Table 1. Initial characteristics of the participants.

		young-old（n=9234）		old-old（n=4616）	
		n	%	n	%
Dementia onset	No-dementia	8526	92.3	3327	72.1
	Dementia	708	7.7	1289	27.9
Sex	Male	4714	51.1	2080	45.1
	Female	4520	48.9	2536	54.9
Social participation	Non-participants	3003	32.5	1774	38.4
	Regular-members	2514	27.2	1289	27.9
	Leadership positions	2784	30.1	832	18.0
	Missing	933	10.1	721	15.6
Age	65－69	5082	55.0	-	-
	70－74	4152	45.0	-	-
	75－79	-	-	2827	61.2
	80－84	-	-	1269	27.5
	≧85	-	-	520	11.3
Educational attainment	<10 yrs	5286	57.2	2849	61.7
	≧ 10 yrs	3896	42.2	1712	37.1
	Missing	52	0.6	55	1.2
Marital status	Married	7343	79.5	2647	57.3
	Single	1766	19.1	1891	41.0
	Missing	125	1.4	78	1.7
Living arrangement	Living with others	8294	89.8	3900	84.5
	Living alone	779	8.4	569	12.3
	Missing	161	1.7	147	3.2
Occupational status	Employed	2806	30.4	608	13.2
	Not employed	6296	68.2	3916	84.8
	Missing	132	1.4	92	2.0
Walking time (per day)	< 30 min	2794	30.3	1586	34.4
	≧ 30 min	5523	59.8	2548	55.2
	Missing	917	9.9	482	10.4
Medical history					
Heart disease	No	8164	88.4	3809	82.5
	Yes	1070	11.6	807	17.5
Stroke	No	9119	98.8	4520	97.9
	Yes	115	1.2	96	2.1
Hypertention	No	6266	67.9	2905	62.9
	Yes	2968	32.1	1711	37.1
Diabetes	No	8168	88.5	4157	90.1
	Yes	1066	11.5	459	9.9
Alcohol consumption	Non-drinker	5535	59.9	3317	71.9
	Drinker	3582	38.8	1181	25.6
	Missing	117	1.3	118	2.6
Smoking	Never smoked	5312	57.5	2800	60.7
	Past smoker/smoker	3615	39.1	1601	34.7
	Missing	307	3.3	215	4.7
Depression	normal	6004	65.0	2591	56.1
	depressed	2304	25.0	1316	28.5
	Missing	926	10.0	709	15.4
IADL	High	7649	82.8	3196	69.2
	Low	1335	14.5	1182	25.6
	Missing	250	2.7	238	5.2

Table 2. Incidence rates (1000 person-years) of dementia onset by sex, age, and educational attainment.

		young-old		old-old	
		Incidence rate	95%CI	Incidence rate	95%CI
Sex					
	Male	9.3	8.3 - 10.4	36.2	32.8 - 39.9
	Female	9.3	8.4 - 10.5	43.9	40.7 - 47.4
Age					
	65－69	5.5	4.8 - 6.4	-	-
	70－74	14.3	13.0 - 15.8	-	-
	75－79	-	-	31.3	28.8 - 34.1
	80－84	-	-	51.5	46.3 - 57.3
	≥ 85	-	-	83.3	71.8 - 96.8
Educational attainment					
	< 10 yrs	10.2	9.2 - 11.3	42.6	39.4 - 45.9
	≥ 10 yrs	8.9	7.8 - 10.1	36.2	32.6 - 40.1

The results of Cox proportional hazards model on the imputed data indicated that the crude HR for dementia onset for regular members or those holding leadership positions, compared with non-members, was 0.65 (95%CI, 0.55－0.75), and adjusted HR was 0.75 (95%CI, 0.64－0.88) in young-old, whereas crude HR was 0.73 (95%CI, 0.64－0.82), but adjusted HR was non-significant in old-old (Table 3).

Table 4 shows the relationship between having a leading role and dementia onset. In young-old, both crude HR and adjusted HR for dementia onset for non-members, relative to regular members, were significant (crude HR, 1.38; 95%CI, 1.15－1.65, adjusted HR, 1.22; 95%CI, 1.02－1.46), and crude HR or adjusted HR for leadership positions were also significant (crude HR, 0.76; 95%CI, 0.61－0.94, adjusted HR, 0.76; 95%CI, 0.65－0.99); however, in the old-old group, there

was not significant adjusted HR.

Table 3. Relationship between social participation and dementia onset.

	Crude		Adjusted	
	HR	95%CI	HR	95%CI
young-old（n=9234）				
social participation				
non-participants	reference		reference	
participants	0.64	0.55-0.75	0.75	0.64-0.88
old-old(n=4616)				
social participation				
non-participants	reference		reference	
participants	0.73	0.65-0.82	0.91	0.81-1.03

Note : Adjusted for sex, age, educational attainment, marital status, living arrangement, occupational status, walking time, medical history, alcohol consumption, smoking, depression, and IADL.

Table 4. Relationship between having a leadership positions and dementia onset

	Crude		Adjusted	
	HR	95%CI	HR	95%CI
young-old（n=9234）				
regular-members	reference		reference	
non-participants	1.38	1.15-1.64	1.22	1.02-1.46
leadership positions	0.76	0.64-0.94	0.81	0.65-0.999
old-old(n=4616)				
regular-members	reference		reference	
non-participants	1.30	1.15-1.48	0.99	0.86-1.13
leadership positions	0.86	0.72-1.02	0.98	0.83-1.14

Note : Adjusted for sex, age, educational attainment, marital status, living arrangement, occupational status, walking time, medical history, alcohole consumption, smoking, depression, and IADL.

4. Discussion

Present study showed that with the young-old group, the non-members of social group activity have

a greater risk for prevalence of dementia than the members, and that the members with leadership in the organization have a significantly lower risk for dementia compared with the non-leading members in both crude and adjusted analyses. However, with the old-old group, non-significant differences in dementia risk were observed between members and non-members, and among non-members, non-leading members, and leading members in adusted analysis. These findings seem to suggest that social participation might be effective for prevention of dementia, and this preventive effect could become stronger in the young-old group if leadership positions are taken.

Our findings are broadly consistent with those of previous studies. Kuiper et al. assessed the relationship between social participation and incidence of dementia through meta-analysis (8). The results of this analysis revealed that individuals with less social participation had a higher risk of dementia onset relative to subjects with higher levels of social participation (RR, 1.41; 95%CI, 1.13–1.75). Although the mechanism underlying the association between social participation and incidence of dementia was not identified, the following pathways were possible: 1) higher level of physical activity due to leaving the home may promote cognitive reserve (14), 2) frequent contact with others may cause positive emotional states such as increased self-esteem, social competence, and adequate mood, which lead to lower stress levels (15), 3) performing various activities (e.g., engaging in a hobby, calculating the scores of games) that stimulate cognitive function serves to prevent a cognitive decline (“use it or lose it” theory) (16). The present study implies that social participation might have a suppressive effect on the incidence of dementia, but the effect may be different based on participation in social activities. Although the reasons for the additive effect of a

leadership role on incidence of dementia are not fully understood, one reason might be the difference in the frequency of social participation. Compared with regular members, individuals who take on leadership roles such as president, facilitator or treasurer have more frequent opportunities for social participation, and also take responsibility for actions to manage group activities (e.g., holding meetings, planning activities, and communicating with regular members). In this study, the proportion of individuals engaging in group activities more than once a month was higher among those in leadership positions than regular members (81.7% vs 64.8%, data not shown). Higher frequency of social participation may help to strengthen the health benefits of social participation (62), or enable individuals to obtain information that supports a healthy lifestyle (63). Socially-responsible activities may improve the quantity or quality of stimulation of the brain's cognitive function, or maintain better mental health (20). However, we did not investigate the type of activity, or use laboratory data, so this is only speculation. As little is known about the mechanism behind the increased positive effect of leadership on cognitive function, further investigation is needed.

In contrast to the young-old group, there were no significant relationships between social participation or leadership and dementia onset in the old-old group. These results support the findings of previous studies (19,64). Iwasa et al.suggested that social participation was not attributed to the prevention of cognitive decline among Japanese community-dwelling elderly aged 70 years and over, based on the data from a five-year prospective cohort study (19). One possible explanation is that as the prevalence of individuals with health problems is much higher in this group than in the

young-old group, the relationship between social participation and dementia onset in old-old elderly may be relatively weaker than that in the young-old group. In the present study, health status such as diabetes, depression, and Independent Activity of Daily Living were strongly related to dementia onset (Appendix 1); therefore, these health problems may be the major correlated factors of incidence of dementia in old-old elderly. However, we may have underestimated this relationship in the old-old group for several reasons. First, the percentage of individuals who had died or moved out during follow-up period was much higher (29.5%) among the old-old than young-old (17.5%), which means that about 30% of the old-old participants had died or moved out before developing dementia. Secondly, the presence or absence of social participation and leadership were assessed at baseline, but prior experience was not assessed; therefore, old-old participants who had experienced social participation or leadership before the assessment but had already retired from these activities at the time of baseline assessment were categorized as non-members. Thus, in this study, the category of non-member in the old-old group contained those who were non-members later in life and those who were members before the study period. These reasons can be attributed to underestimation of the association between social participation and incidence of dementia. Further studies of the association of social participation with dementia onset in old-old elderly people are needed.

This study has several limitations. First, the incidence of dementia in this study was obtained from the results of an examination and judgment by the Certification Committee of Needed Long-Term Care in the participant's municipality. Therefore, underestimation of dementia incidence

might have occurred, because every dementia patient does not necessarily submit an application to the Certification Committee. Second, as the type of dementia was not assessed, such as Alzheimer disease, vascular dementia, or Lewy body dementia, the effect of social participation or leadership on each type of dementia remained unclear. Third, the response rate of the baseline survey was 52.1%, meaning that non-responders may have induced selection bias. In this study, the characteristics of non-responders were unknown, but we think it is possible that old-old people or those with lower health status may have been less likely to respond to the survey. There may therefore have been differences in baseline characteristics between study participants and non-participants. Fourth, as the experience of social participation or leadership before the baseline survey was not assessed, the relationship between social participation and dementia onset may be affected by the results of these factors, especially among old-old participants. Future studies evaluating this association should take into account the subject's experience of social participation and leadership before the baseline survey. Fifth, this study could not identify which types of social activity or leadership were related to the incidence of dementia. Further studies are needed to examine this issue, especially qualitative studies that assess the influence of social participation or a leadership role on older adults' daily lives. Finally, as the assessment of social participation and leadership were carried out only at the baseline survey, the influence of change in status of participation during the follow-up period on the relationship was not clear.

In summary, despite the above-mentioned limitations, this study revealed that social participation might have a repressive effect on the incidence of dementia and also leadership within

the activity group might have stronger positive effect on dementia incidence among young-old adults. These finding should be used to encourage young-old adults to participate in and take leadership positions in social activity organizations.

5. Conclusion

In young-old elderly people, social participation might have a positive effect on the prevention of dementia onset, and leadership within a group may lead to a reduction of risk of dementia onset of almost 20%, compared with regular members.

Appendix. Relationship between having a leadership positions and dementia onset in old-old.

	Crude			Adjusted		
	HR	95%CI		HR	95%CI	
Social participation						
Regular-members	reference			reference		
Non-participants	1.30	1.15	- 1.48	0.99	0.86	- 1.13
Leadership positions	0.86	0.72	- 1.02	0.98	0.83	- 1.14
Sex						
Female				reference		
Male				0.92	0.76	- 1.10
Age						
75－79				reference		
80－84				1.62	1.43	- 1.84
≧85				2.56	2.16	- 3.04
Educational attainment						
≧ 10 yrs				reference		
<10 yrs				1.03	0.91	- 1.16
Medical history						
Heart disease						
No				reference		
Yes				0.90	0.78	- 1.04
Stroke						
No				reference		
Yes				0.83	0.58	- 1.18
Hypertention						
No				reference		
Yes				1.28	1.14	- 1.44
Diabetes						
No				reference		
Yes				0.79	0.66	- 0.94
IADL						
High				reference		
Low				1.49	1.32	- 1.69
Alcohol consumption						
Non-drinker				reference		
Drinker				0.96	0.83	- 1.12
Smoking						
Never smoked				reference		
Past smoker/smoker				1.11	0.93	- 1.32
Walking time (per day)						
< 30 min				reference		
≧ 30 min				0.99	0.88	- 1.12
Marital status						
Married				reference		
Single				1.11	0.96	- 1.28
Living arrangement						
Living alone				reference		
Living with others				0.92	0.77	- 1.09
Occupational status						
Not employed				reference		
Employed				0.94	0.79	- 1.12
Depression						
normal				reference		
depressed				1.37	1.20	- 1.56

Chapter 4

Factors that promote new or continuous participation in social group activity among Japanese community-dwelling older adults: a 2-year longitudinal study

1. Background

Engaging in social group activities, including hobbies, sports, or volunteer programs, contributes to a better health status. Previous studies have reported that social participation decreases stress levels (15). provides access to health related information for help in making better health behavior (65), and performing the activity that stimulate cognitive function serves to prevent a cognitive decline (16). Altogether,, social participation appears to play a role in preventing dementia onset and functional decline (8,14,66); and so social participation may greatly improve quality of life in older people (67).

According to a Japanese national survey (24), a substantial number of individuals who are currently non-participants in social groups are willing to engage in social group activities. To promote engagement in social group activities, it may be necessary to identify factors that influence initiation of participation and develop interventions targeted at predictive these factors. Our previous long-term intervention study demonstrated that intergenerational volunteering was associated with maintained levels of physical function, intellectual activity, social network involvement (68), and

brain atrophy (69). Therefore, the factors that influence continuation in group activity may also important in maintaining functional health.

Previous studies have revealed associated a number of factors that influence involvement in volunteer work (25), sports groups (26), and motivation to participate in volunteer work (70). Most of these studies investigated group activities that comprised specific activities in which participants were interested, but did not examine less specialized types of social groups, such as neighborhood associations or senior citizen clubs in Japanese local communities.

Throughout Japan, many local residents are members of their neighborhood association. Such organizations aim to improve social relationships or advocate for common goals in the local community, with membership extending to local residents regardless of their gender, age, or nationality. These organizations coordinate a broad range of activities, including patrolling streets to watch over children, cleaning up the neighborhood, and organizing events to develop relationships among local residents. While joining an association is not mandatory, non-participants may find it difficult to build relationships with local residents, or to obtain information about the local community. As a result, most people enter the association via their household unit.

Senior citizen clubs are also widespread across Japan. There are over 100,000 clubs with approximately 5.9 million Japanese older adults (13.9%) as members (71). Most of these clubs receive government grants, and a nationwide federation has been established. Community-dwelling older adults aged >60 years are invited to join the club based in their residential area. The aim of these organizations is to promote the health of members and to encourage members to help one

another. They offer activities that improve quality of life (e.g., group physical activity, traveling, or hobby group activities) and altruistic contribute to the local community (e.g., cleaning and managing public spaces).

Engaging in a neighborhood association or a senior citizen club has been found that related to the instrumental activities of daily living (IADL) (72) and cognitive decline (18). However, the factors that influence participation in such organizations have not been defined. A previous study (27) indicated that volunteer workers have more social support, are better educated, and are healthier than non-volunteer workers. Yet, the factors that influence participation in social groups may vary according to the group purpose and organizational structure.

The aim of this study was to identify the factors that promote new or continuous participation in social group activities, according to activity type.

2. Methods

Sample and study design

We conducted a 2-year community-based longitudinal study that included a follow-up period. The study took place from 2013 to 2015. Individuals who could independently complete a self-administrated questionnaire were recruited among all residents aged ≥65 years in a section of the Ota ward, Tokyo, Japan. Over 700,000 residents live in the Ota ward, and the population density is over 10,000 residents per km^2. Those who were institutionalized or were certified as requiring level four or five long-term care, which indicates a severe functional disability, were excluded at a

baseline survey. We enrolled 7608 older adults at the baseline survey, which was conducted in July 2013. A total of 5166 individuals completed the baseline survey (response proportion, 67.9%). We conducted a follow-up investigation in July 2015, and 3732 participants responded to the questionnaire. Of these, we were missing baseline social group activity values for 352 individuals, and they were thus subsequently excluded. Finally, 3380 participants were included in the analysis (Figure 1).

The questionnaire was accompanied by a document that indicated the purpose of the study, stated that cooperation was voluntary, and described how personal information would be handled. The act of returning the questionnaire indicated consent to participate in the study. The study protocol was approved by the Ethics Committee of the Tokyo Metropolitan Institute of Gerontology.

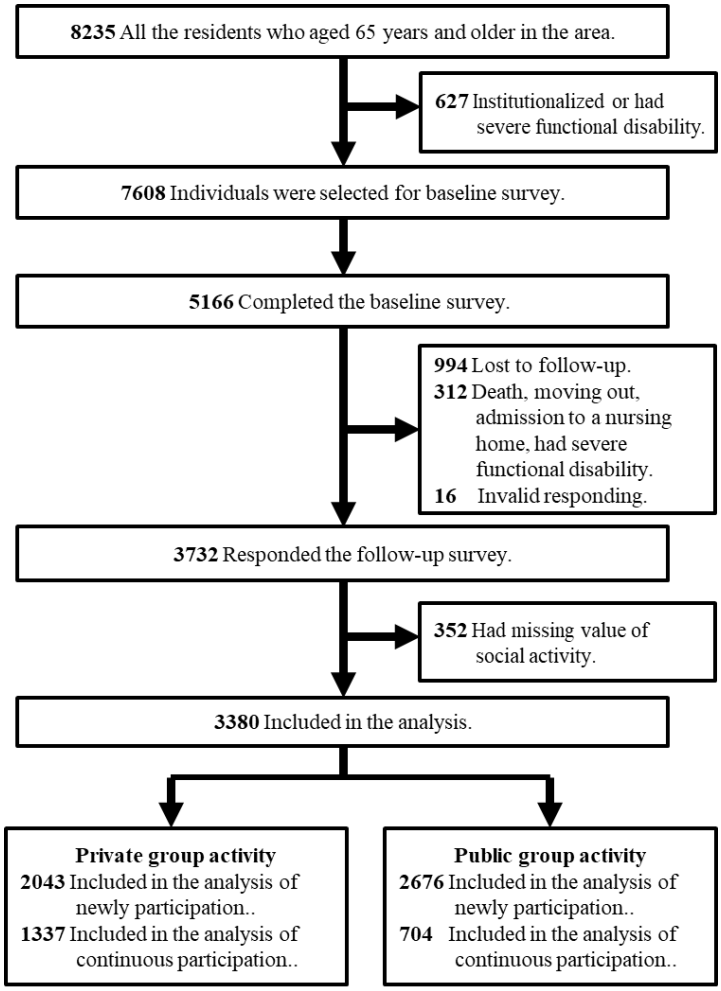

Figure 1. Flow diagram of this study.

Measurements

Social group activity

We investigated social group activity using a scale from the Japan Gerontological Evaluation Study (66). The scale examines engagement in the following types of organizations: neighborhood associations in local communities, senior citizen clubs, volunteer groups, hobby groups, and sports groups.

Although several studies have proposed methods for classifying different types of social

group activities (73), consensus has not been reached. In this study, we divided the organizations into two categories according to the degree of variety of activities (single, multiple), membership style (limited to local members, non-limited), and by referencing a previous study (74). First, volunteer, hobby, and sports groups were classified as private groups (PrG), as they comprise members who conduct specific activities and share common interests. According to previous studies, private groups have similar factors that influence participation (25,26). Second, neighborhood associations and senior citizen clubs were categorized as public groups (PuG), as they are organized by local community members and offer multiple activities to enhance the lives of members. We evaluated the degree of duplication among these groups and found that 53% of senior citizen club members belonged to a neighborhood association.

Participants reported the groups to which they belonged and the frequency of participation. Those who had not participated in any organization within the past year were classified as 'non-participants'.

Explanatory variables

To identify the factors that influence social group participation, we selected variables that were previously reported as being significantly related to social participation in Japanese community-dwelling older adults. Yamakita and colleagues (26) conducted a large cross-sectional study investigating the factors that influence sports group participation. They found that demographic, social, health status, and environmental factors were related to participation. As we

sought to identify the factors that influence social group participation with the ultimate goal of developing individual or community-level interventions for potential social group participants, we excluded environmental factors in this study. Therefore, demographic variables, social relationships, and health status were adopted as explanatory variables.

Demographic variables comprised gender, age (<75 and ≥75 years), educational attainment (<10 years, 10–12 years, >12 years), marital status (married, other), living with their children (yes, no), and subjective economic status (having leeway, generality, being tight on money).

Social relationships included relationships with individuals in the neighborhood (Alienation, Familiarity), and employment (>35 hours per week: full-time worker, <35 hours per week: part-time worker, and non-worker).

Health status included self-rated health (SRH) (good, poor), mental health (World Health Organization-Five Well-being Index: WHO-5) (75), IADL (the subscale of the Tokyo Metropolitan Institute of Gerontology Index of Competence: TMIG-IC (60)), and medical history (stroke, cardiac disease, chronic back pain, or neuralgia). The WHO-5 is a widely used questionnaire that assesses subjective psychological well-being. The validity of the scale has been confirmed as a screening tool for depression (75). The scale comprises five items, and a score under 13 indicates poor mental health. Those who scored full points on the TMIG-IC were categorized as ‘non-disability’.

Statistical analysis

First, we used a chi-square test to assess differences between participants and non-participants in

each group. Second, to examine the factors that influenced new or continuous participation in social group activity, we conducted logistic regression analysis. This analysis included social group participation at the follow-up assessment as a dependent variable, and demographic variables, social relationships, and health status as explanatory variables. All explanatory variables were included in the single analysis. Analyses were conducted separately for PrG and PuG, and for participants and non-participants. Therefore, we used four analysis models. The number of participants included in each analysis differed according to the model, as follows: new participation in a PrG (n = 2043), continuous participation in a PrG (n = 1337), new participation in a PuG (n = 2676), and continuous participation in a PuG (n = 704). We evaluated model calibration using C-statistics. For analysis of the imputed data, we calculated the mean value of the C-statistics in 50 datasets. All four models showed moderate C-statistics ranging from 0.65 to 0.71.

The proportion of participants for whom values were missing across each variable ranged from 0 to 15.2%, and the proportion of individuals for whom values were missing in the analysis model ranged from 29.3 to 34.6%. In this study, missing values were imputed by multiple imputation with full conditional specification. We estimated 50 imputed datasets, carried out logistic regression analysis on each dataset, and combined these estimates and standard errors to calculate the odds ratio (OR) or 95% confidence interval (CI). The estimation model of the missing values included all demographic, social relationships, health status, and social group activity variables. For comparison, we used a logistic regression model to analyze the subset of the complete case data.

$P<0.05$ was considered to indicate statistical significance, and SAS 9.4 (SAS Institute,

Cary, NC) was used for all statistical analyses.

3. Results

The baseline characteristics of the study participants are shown in Table 1. A total of 1337 individuals (39.6%) participated in PrGs, 704 (20.8%) engaged in PuGs, and 415 (12.3%) were members of groups of both types. PrG and PuG participants had common interests, were more likely to have a leeway status, more likely to have close relationships with neighbors, had a better SRH, had better mental health, were considered non-disabled according to the IADL, had no medical history of stroke, and were engaged in another group activity. In addition, those who participated in PrGs had completed more years of education, and were more likely to be female, married, and non-workers compared with non-participants. We found an inverse relationship between age and living status between the participants in the PrG and PuG groups.

Table 1. Demographic characteristics of study participants.

		Private group activity					Public group activity				
		Non-participants (n=2043)		Participants (n=1337)			Non-participants (n=2676)		Participants (n=704)		
		n	%	n	%	P value	n	%	n	%	P value
Sex	Female	1080	52.9	896	67.0	<0.01	1542	57.6	434	61.6	0.05
	Male	963	47.1	441	33.0		1134	42.4	270	38.4	
Age	≥75 years	934	45.7	529	39.6	<0.01	1133	42.3	330	46.9	0.04
	<75 years	1048	51.3	778	58.2		1468	54.9	358	50.9	
	Missing	61	3.0	30	2.2		75	2.8	16	2.3	
Educational attainment	>12 years	660	32.3	606	45.3	<0.01	981	36.7	285	40.5	0.13
	10 - 12 years	854	41.8	575	43.0		1137	42.5	292	41.5	
	<10 years	453	22.2	129	9.6		474	17.7	108	15.3	
	Missing	76	3.7	27	2.0		84	3.1	19	2.7	
Marital status	Married	1194	58.4	843	63.1	0.02	1599	59.8	438	62.2	0.31
	Other	799	39.1	475	35.5		1019	38.1	255	36.2	
	Missing	50	2.4	19	1.4		58	2.2	11	1.6	
Living with their child	Yes	852	41.7	479	35.8	<0.01	1030	38.5	301	42.8	0.045
	No	1149	56.2	838	62.7		1595	59.6	392	55.7	
	Missing	42	2.1	20	1.5		51	1.9	11	1.6	
Subjective economic status	Tight	604	29.6	217	16.2	<0.01	677	25.3	144	20.5	0.02
	Generality	748	36.6	496	37.1		976	36.5	268	38.1	
	Leeway	597	29.2	583	43.6		912	34.1	268	38.1	
	Missing	94	4.6	41	3.1		111	4.1	24	3.4	
Relationship with neighborhood	Alienation	990	48.5	409	30.6	<0.01	1244	46.5	155	22.0	<0.01
	Familiarity	1032	50.5	917	68.6		1408	52.6	541	76.8	
	Missing	21	1.0	11	0.8		24	0.9	8	1.1	
Employment	Non-worker	1265	61.9	929	69.5	<0.01	1742	65.1	452	64.2	0.76
	Part time worker	301	14.7	211	15.8		399	14.9	113	16.1	
	Full time worker	345	16.9	133	9.9		377	14.1	101	14.3	
	Missing	132	6.5	64	4.8		158	5.9	38	5.4	
Self-rated health	Low	540	26.4	156	11.7	<0.01	599	22.4	97	13.8	<0.01
	High	1391	68.1	1143	85.5		1956	73.1	578	82.1	
	Missing	112	5.5	38	2.8		121	4.5	29	4.1	
Mental health	Poor	936	45.8	293	21.9	<0.01	1048	39.2	181	25.7	<0.01
	Healthy	964	47.2	969	72.5		1451	54.2	482	68.5	
	Missing	143	7.0	75	5.6		177	6.6	41	5.8	
IADL	Disability	338	16.5	61	4.6	<0.01	352	13.2	47	6.7	<0.01
	Non-disability	1634	80.0	1250	93.5		2241	83.7	643	91.3	
	Missing	71	3.5	26	1.9		83	3.1	14	2.0	
Medical history											
Stroke	Yes	89	4.4	29	2.2	<0.01	105	3.9	13	1.8	0.02
	No	1709	83.7	1105	82.6		2209	82.5	605	85.9	
	Missing	245	12.0	203	15.2		362	13.5	86	12.2	
Cardiac disease	Yes	297	14.5	170	12.7	0.27	371	13.9	96	13.6	0.76
	No	1501	73.5	964	72.1		1943	72.6	522	74.1	
	Missing	245	12.0	203	15.2		362	13.5	86	12.2	
Choronic back pain	Yes	461	22.6	257	19.2	0.07	578	21.6	140	19.9	0.23
or Neuralgia	No	1337	65.4	877	65.6		1736	64.9	478	67.9	
	Missing	245	12.0	203	15.2		362	13.5	86	12.2	
Engagement of another social group activity	Participant	289	14.1	415	31.0	<0.01	922	34.5	289	41.1	<0.01
	Non-participant	1754	85.9	922	69.0		1754	65.5	415	58.9	

IADL = instrumental activities of daily living

Of the 2043 non-participants at baseline, 520 (25.5%) had newly participated in PrG activities during the 2-year study period. Additionally, of 1337 participants at baseline, 127 (9.5%)

withdrew from PrGs during the follow-up period. Of 2676 PuG non-participants 290 (10.8%) had initiated participation at the follow-up assessment, while 222 of 704 (31.5%) left PuGs during the follow-up period (Table 2).

Table 2. The transitional change of individuals' group engagement.

	Private group activity		Public group activity	
	n	**%**	**n**	**%**
Non-participants at baseline				
Continuous non-participation	1338	65.5	2133	79.7
Newly participation	520	25.5	290	10.8
Missing	185	9.1	253	9.5
Participants at baseline				
Withdrawal	127	9.5	222	31.5
Continuous participation	1169	87.4	438	62.2
Missing	41	3.1	44	6.3

The percentages of continuous non-participants and new participants were calculated by dividing the number of these variables by the number of non-participants at baseline. The percentages of those who dropped out and continuous participation were caluculated by dividing the number of these variables by the number of participants at baseline.

The factors that influenced PrG participation are shown in Table 3. Better mental health (OR, 1.88; 95% CI, 1.48–2.38), better SRH (OR, 1.58; 95% CI, 1.18–2.10), being a non-worker (OR for full-time workers compared with that for non-workers, 0.69; 95% CI, 0.51–0.94), having established relationships with neighbors (OR, 1.52; 95% CI, 1.21–1.91), having a higher subjective economic status (OR for leeway compared with tight finances, 1.47; 95% CI, 1.09–1.97), more years

of education (OR for <10 years compared with that for >12 years, 0.55; 95% CI, 0.39–0.77), and being a member of PuG (OR, 3.04; 95% CI, 2.29–4.02) were significantly related to a higher OR for new participation. However, better mental health (OR, 2.07; 95% CI, 1.37–3.12), being a non-worker (OR for full-time workers compared with that for non-workers, 0.46; 95% CI, 0.25–0.84), and having established relationships with neighbors (OR, 1.63; 95%CI, 1.09-2.44) were significantly related to a higher OR for continuous participation.

Table 4 exhibits the factors related to involvement in a PuG. Logistic regression analysis showed that better mental health (OR, 1.40; 95% CI, 1.05–1.87), being male (OR, 1.67; 95% CI, 1.25–2.22), and having established relationships with neighbors (OR, 2.35; 95% CI, 1.78–3.10) were significantly related to a higher OR for new participation. Similarly, being male (OR, 1.99; 95% CI, 1.31–3.02), having established relationships with neighbors (OR, 2.43; 95% CI, 1.58–3.71), and fewer years of schooling (OR for 10–12 years, 2.02; 95% CI, 1.38–2.95: OR for >12 years, 2.01; 95% CI, 1.17–3.44) were independently related to a higher OR for continuous participation.

We found differences between the results obtained from the complete case data and that obtained from the imputed data. However, most of the effect sizes obtained from the imputed data were smaller than those from the complete data. Therefore, we did not expect our data to lead to overestimation of the relationships.

Table 3. Logistic regression analysis of related factors of private group activity.

		New participation during 2 years								Continuous participation for 2 years							
		Complete data analysis (n=1340)				Imputed data analysis (n=2043)				Complete data analysis (n=936)				Imputed data analysis (n=1337)			
		OR	95%CI		P value	OR	95%CI		P value	OR	95%CI		P value	OR	95%CI		P value
Sex	Female	reference				reference				reference				reference			
	Male	1.31	0.98	1.75	0.07	1.06	0.83	1.35	0.64	1.06	0.61	1.83	0.84	1.12	0.71	1.77	0.62
Age	≥75 years	reference				reference				reference				reference			
	<75 years	0.92	0.70	1.22	0.57	0.99	0.78	1.25	0.93	1.45	0.89	2.36	0.13	1.47	0.99	2.19	0.06
Educational attainment	>12 years	reference				reference				reference				reference			
	10 - 12 years	0.95	0.71	1.27	0.73	0.86	0.67	1.10	0.22	0.88	0.53	1.46	0.61	0.94	0.62	1.44	0.79
	<10 years	0.49	0.33	0.74	<0.01	0.55	0.39	0.77	<0.01	0.70	0.32	1.53	0.37	0.69	0.38	1.27	0.24
Marital status	Married	reference				reference				reference				reference			
	Other	0.69	0.52	0.93	0.01	0.80	0.63	1.02	0.07	0.77	0.47	1.27	0.31	0.78	0.52	1.18	0.24
Living with their child	Yes	reference				reference				reference				reference			
	No	0.84	0.65	1.10	0.20	0.88	0.70	1.09	0.24	0.92	0.57	1.47	0.72	1.03	0.70	1.53	0.87
Subjective economic status	Tight	reference				reference				reference				reference			
	Generality	1.23	0.88	1.72	0.22	1.27	0.96	1.68	0.09	0.86	0.45	1.67	0.66	0.91	0.53	1.55	0.73
	Leeway	1.59	1.12	2.26	<0.01	1.47	1.09	1.97	0.01	0.79	0.40	1.55	0.50	0.98	0.57	1.71	0.95
Relationship with	Alienation	reference				reference				reference				reference			
neighborhood	Familiarity	1.51	1.15	2.00	<0.01	1.52	1.21	1.91	<0.01	1.78	1.09	2.92	0.02	1.63	1.09	2.44	0.02
Employment	Non-worker	reference				reference				reference				reference			
	Part time worker	0.99	0.70	1.42	0.97	1.05	0.78	1.41	0.77	0.64	0.36	1.14	0.13	0.66	0.41	1.09	0.10
	Full time worker	0.67	0.46	0.97	0.03	0.69	0.51	0.94	0.02	0.56	0.27	1.18	0.13	0.46	0.25	0.84	<0.01
Self-rated health	Low	reference				reference				reference				reference			
	High	1.58	1.13	2.21	<0.01	1.58	1.18	2.10	<0.01	1.61	0.85	3.03	0.14	1.60	0.94	2.72	0.08
Mental health	Poor	reference				reference				reference				reference			
	Healthy	1.64	1.24	2.17	<0.01	1.88	1.48	2.38	<0.01	1.88	1.15	3.10	0.01	2.07	1.37	3.12	<0.01
IADL	Disability	reference				reference				reference				reference			
	Non-disability	1.57	1.03	2.41	0.04	1.42	0.98	2.07	0.07	1.70	0.72	4.03	0.23	1.46	0.68	3.14	0.33
Medical history																	
Stroke	Yes	reference				reference				reference				reference			
	No	0.62	0.31	1.23	0.17	0.66	0.37	1.15	0.14	1.04	0.28	3.84	0.96	0.87	0.25	3.10	0.83
Cardiac disease	Yes	reference				reference				reference				reference			
	No	0.79	0.55	1.14	0.21	0.84	0.60	1.17	0.30	0.79	0.40	1.59	0.51	0.92	0.52	1.65	0.79
Choronic back pain	Yes	reference				reference				reference				reference			
or Neuralgia	No	0.71	0.53	0.97	0.03	0.78	0.59	1.02	0.07	1.06	0.61	1.84	0.84	1.03	0.65	1.64	0.90
Public group activity	Non-participants	reference				reference				reference				reference			
	Participants	3.28	2.35	4.59	<0.01	3.04	2.29	4.02	<0.01	1.10	0.65	1.86	0.72	1.33	0.85	2.07	0.21

The analysis included participation at follow-up as a dependent variable, with explanatory variables (age, sex, residential status, educational attainment, marital status, subjective economic status, employment attainment, and relationship with neighborhood, self-rated health, medical distory, instrumental activities of daily living [IADL], and mental health) analyzed simultaneously.

The model of new participation included non-participants at baseline, whereas participants at baseline were included in the model of continuous participation.

An odds ratio higher than 1 indicates an increased likelihood for participation in private group activity at follow-up.

Table 4. Logistic regression analysis of related factors of public group activity.

		New participation during 2 years								Continuous participation for 2 years							
		Complete data analysis (n=1751)				Imputed data analysis (n=2676)				Complete data analysis (n=493)				Imputed data analysis (n=704)			
		OR	95%CI		P value	OR	95%CI		P value	OR	95%CI		P value	OR	95%CI		P value
Sex	Female	reference				reference				reference				reference			
	Male	1.77	1.25	2.49	<0.01	1.67	1.25	2.22	<0.01	2.42	1.48	3.96	<0.01	1.99	1.31	3.02	<0.01
Age	≥75 years	reference				reference				reference				reference			
	<75 years	0.98	0.70	1.35	0.88	0.85	0.65	1.11	0.23	1.09	0.70	1.67	0.71	1.06	0.73	1.54	0.75
Educational attainment	>12 years	reference				reference				reference				reference			
	10 - 12 years	0.71	0.51	1.00	0.05	0.94	0.71	1.26	0.70	2.64	1.68	4.16	<0.01	2.02	1.38	2.95	<0.01
	<10 years	0.76	0.47	1.23	0.26	1.21	0.83	1.77	0.32	2.42	1.25	4.69	<0.01	2.01	1.17	3.44	0.01
Marital status	Married	reference				reference				reference				reference			
	Other	0.91	0.65	1.29	0.60	0.95	0.72	1.26	0.75	0.81	0.52	1.28	0.37	0.84	0.58	1.23	0.37
Living with their child	Yes	reference				reference				reference				reference			
	No	1.07	0.79	1.47	0.65	1.22	0.95	1.57	0.12	1.32	0.88	1.99	0.18	1.32	0.94	1.87	0.11
Subjective economic status	Tight	reference				reference				reference				reference			
	Generality	0.92	0.62	1.37	0.68	1.01	0.71	1.43	0.96	1.13	0.65	1.97	0.67	0.92	0.57	1.48	0.73
	Leeway	0.80	0.53	1.23	0.31	0.92	0.65	1.32	0.66	1.21	0.69	2.13	0.50	0.97	0.60	1.57	0.90
Relationship with neighborhood	Alienation	reference				reference				reference				reference			
	Familiarity	2.40	1.71	3.36	<0.01	2.35	1.78	3.10	<0.01	2.27	1.37	3.79	<0.01	2.43	1.58	3.71	<0.01
Employment	Non-worker	reference				reference				reference				reference			
	Part time worker	1.22	0.82	1.81	0.32	1.16	0.83	1.62	0.38	0.82	0.47	1.43	0.49	0.90	0.56	1.42	0.64
	Full time worker	0.78	0.49	1.26	0.32	0.77	0.52	1.15	0.20	0.92	0.51	1.65	0.77	0.94	0.56	1.56	0.81
Self-rated health	Low	reference				reference				reference				reference			
	High	0.95	0.63	1.44	0.82	1.16	0.80	1.66	0.43	1.77	0.97	3.23	0.06	1.53	0.91	2.60	0.11
Mental health	Poor	reference				reference				reference				reference			
	Healthy	1.47	1.03	2.10	0.03	1.40	1.05	1.87	0.02	0.81	0.50	1.30	0.38	0.82	0.55	1.23	0.33
IADL	Disability	reference				reference				reference				reference			
	Non-disability	1.24	0.72	2.13	0.44	1.02	0.66	1.59	0.91	1.17	0.54	2.55	0.69	1.01	0.51	2.01	0.98
Medical history																	
Stroke	Yes	reference				reference				reference				reference			
	No	0.61	0.30	1.23	0.17	0.88	0.47	1.67	0.70	0.97	0.25	3.80	0.97	1.06	0.31	3.63	0.93
Cardiac disease	Yes	reference				reference				reference				reference			
	No	0.88	0.58	1.33	0.54	0.92	0.63	1.33	0.65	0.55	0.30	1.01	0.05	0.78	0.47	1.29	0.33
Choronic back pain or Neuralgia	Yes	reference				reference				reference				reference			
	No	1.04	0.72	1.50	0.85	1.05	0.76	1.45	0.78	0.65	0.39	1.09	0.10	0.72	0.45	1.14	0.16
Private group activity	Non-participants	reference				reference				reference				reference			
	Participants	1.11	0.80	1.55	0.53	1.22	0.93	1.61	0.14	0.97	0.63	1.50	0.89	1.09	0.76	1.57	0.63

The analysis included participation at follow-up as the dependent variable, with explanatory variables (age, sex, residential status, educational attainment, marital status, subjective economic status, employment attainment, and relationship with neighborhood, self-rated health, medical history, instrumental activities of daily living [IADL], and mental health) analyzed simultaneously.

The model of new participation included non-participants at baseline, whereas participants at baseline were included in the model of continuous participation.

An odds ratio higher than 1 indicates an increased likelihood for participation in a public group activity at follow-up.

4. Discussion

We evaluated the frequency of new or continuous participation in social group activities over a 2-year period, along with the factors that influenced such participation. Our findings suggest that differences exist between social group types. To the best of our knowledge, this is the first study to examine the factors that influence participation in social groups according to social group type. Our findings might contribute to the identification of individuals who are likely to be non-participants of social groups, and accordingly, to the development of intervention programs to enhance social participation among community-dwelling older adults.

We found that the new or continuous PrG participation rate was higher than that for the PuG. These findings are consistent with previous work (39). According to a Japanese national survey (24), a higher proportion of older adults want to participate in hobby groups (31.5%) or sports groups (29.7%) as compared with those who want to join neighborhood associations (20.6%), or senior citizen clubs (10.1%). Therefore, our study population might have included a substantial number of potential PrG participants, who then became new or continuous PrG participants during the follow-up period.

Previous studies have reported that participation in_PrGs and PuGs can have common benefits, such as improved mental health for those who are new participants and more intimate relationships with neighbors for those participating in activities as new or continuous members. For example, a cross-sectional study suggested that health status and social relationships were strongly related to sports group participation among Japanese older people (26), and other longitudinal

studies (27,76) have indicated that social capital and social function affect continuous engagement in volunteer work. Individuals who have good relationships with their neighbors are more likely to obtain information about private or public group activities and to receive encouragement from neighbors to participate in such activities.

We identified several different factors that influenced participation in social group activities. For PrGs, a higher SRH was related to a higher OR for new participation, and better mental health was related to a higher OR for continuous participation. However, these factors were not related to participation in PuGs. PrG members have common interests, but PrGs are not limited to local members. Conversely, PuGs comprise local residents, and they may receive support for their activities from the neighborhood. Our previous study found that PuG participation (active vs. inactive) had no impact on functional decline (66).

Compared with women, men had a higher OR for new participation in activities or continuous engagement in PuGs. However, we did not observe a gender difference for PrGs. Although the relationship between gender and social participation has been reported to be inconsistent (25), some Japanese cross-sectional studies (26,39) have reported that women are more likely to participate in social groups compared with men. Indeed, we observed a similar tendency in the baseline characteristics in this study. Men might more frequently play leadership roles in PuGs, such as planning events to develop relationships among local residents, or managing groups, since most of men could have ability which was developed by similar experiences at work. Therefore, older men might obtain satisfaction by applying this ability in retirement. Stukas and colleagues

suggested the motivations to volunteer is consisted of six prominent motivations (e.g., volunteering makes me feel better about myself) (77). These have been found to be significantly related to participation in social services (70). Taken together, these findings indicate that older men who were given the opportunity to exert their abilities in PuGs may have acquired the motivation to participate in a PuG.

Lower educational attainment was related to a lower OR for new participation in PrGs. This finding is generally consistent with the results of previous studies. It is possible that individuals with lower educational attainment have lower health literacy (78), therefore impeding their ability to obtain detailed information about PrGs, such as location or dates of activities. In contrast, lower educational attainment was negatively related to a higher OR for continuous participation in PuGs. This unexpected finding may indicate that individuals with a higher educational level feel a needs-discrepancy towards PuGs. Indeed, a previous study indicated that more highly educated older adults tend to feel that participation is unnecessary at senior centers, which provide educational seminars or group hobby activities for community-dwelling older adults (79). This may explain the negative relationship found between educational attainment and continuous PuG participation in this study. However, of the 118 highly educated participants who withdrew from PuGs, 81 (68.6%) had participated in PrGs at the follow-up assessment. Therefore, over two thirds of these participants engaged in continued social participation (data not shown).

Several previous studies have reported that employed older adults are more likely to participate in volunteer work compared with those who are unemployed, and that part-time workers

report the highest volunteer rates (80). However, the relationship between social participation and employment is complicated (25), and our findings indicated that full-time work was related to a lower OR for new or continuous participation compared with non-workers. Indeed, full-time workers may not have enough time to engage in group activities. Cultural differences might also affect participation in social group activities. Choi reported that individuals who prioritize religion in their life are more likely to engage in volunteer work (80). However, 57% of Japanese citizens are unaffiliated with a particular religion (81). In addition to employment status, culture-related factors may affect the social participation rate among Japanese older adults. Further studies evaluating these relationships are required.

While engagement in PuGs at baseline was significantly related to a higher OR for new participation in PrGs, we did not observe the opposite relationship. PuG participants could strengthen social relationships and obtain PrG-relevant information. However, it is less likely that PrG members would acquire information about their local community or PuGs, because the members were not limited by their area of residence. Conversely, promoting participation in PuGs might indirectly affect new participation in PrGs.

The present study has several limitations that should be considered. First, we conducted a complete survey in an urban area and obtained a relatively high response proportion at baseline (67.8%). As there are likely regional differences between the prevalence of different types of group activities, future studies should consider several municipalities to examine factors associated with group activity participation according to region. Second, individuals who initiated group activity

after the baseline survey but resigned before the follow-up period were classified as having engaged in continuous non-participation. Thus, we could not calculate the actual frequency of new participation in each group during the follow-up period. Future studies should investigate group participation at multiple time points and with greater frequency. Future studies may also benefit from examining participant experiences about their group activities. Third, the duration of the follow-up period might have been insufficient to observe changes in engagement status. In this study, the withdrawal rate for PrGs was low (9.5%). Further studies should employ a longer follow-up period to examine factors related to continuous participation in PrGs. Fourth, because our results revealed a high incidence rate (>10%) for new or continuous participation, ORs calculated via logistic regression analysis might have overestimated the risk (82). Fifth, the rate of loss to follow-up was 27.7%. This could have biased the results (83).

The rate of new and continuous participation in PrGs, such as hobbies, sports, and volunteering, was higher than that of PuGs, such as neighborhood associations and senior citizen clubs. Although participation in public vs. private social groups was related to different factors, relationships with neighbors was found to be a relevant factor for participation in both group types. Because the complete survey responses were retrieved from older adults who lived in an urban area, our findings may only apply to Japanese older adults living in areas with similar characteristics.

A future study should collect observations at multiple time points and include a longer follow-up period to examine predictive factors. Interventions that focus on predictors of participation may promote social group activity involvement and long-term participation.

Chapter 5

General discussion

In the Study 1, physical activity and reading books or newspapers were associated with SCC among community-dwelling older adults, moreover, the combined group who reported ≥150 min/week physical activity and ≥30 min/day reading showed 60% lower SCC than the combined group who reported <150 min/week physical activity and <10 min/day reading. The findings from Study 1 suggested that being physically active might be important for preventing cognitive decline among Japanese older adults, and mentally active sedentary brhavior such as reading book or newspaper could contribute to maintaining the cognitive function in older adults. Althouth some previous studies reported that sedentary behavior might be a risk factor of congnitive impairment, the relationship between sedentary behavior and cognitive function may be different by types.

For the conclusion of the Study 1, promoting physical activity and the mental activities which stimulate the cognitive function may be efficient for preventing dementia onset or congnitive decline.

In the Study 2, with young-old adults, participants in social group activity showed significantly lower hazard ratio of dementia onset in both crude and adjusted analyses. Additionaly, young-old social group members having leading role in the organization had a better effect on decreasing the risk for dementia onset in comparison with non-leading role members. These findings suggest that participation in social group activity has positive effect on preventing dementia onset and its effect is different due to how to involve in the social group activity in young-old adults.

Conversely, with the old-old adults, although significant preventive effect of social participation on dementia onset was observed in crude analysis, same result was no more observed in adjusted anlysis for covariates.These results suggest that social participation is not enough to prevent dementia onset for old-old adults. This seems to be due to the health status of the subjects in this generation. Many of the old-old adults have health problems such as diabetes, depression, and low functional fitness level. These health problems are strong risk factors of stroke which is a major causal factor of dementia onset and also these physical and mental health status are major factors enabling social participation(14,17,62). Therefore, social participation in old-old adults is directly and strongly affected by their physical and mental health status, which are directly and indirectly related to the incidence of dementia.

For the conclusion of the Study 2, participating in social group activity in young-old ages is important approach for the prevention of dementia, moreover, having leadership in the organization is more effective for dementia prevention. These findings, for the next step, suggest that implimenting the appropriate measure to promote social group participation for older-adults, especialy for young-older adults, is important for the prevention of dementia.

In the Study 3, the factors promoting social participation among community-dwelling older adults, based on the type of group activities,were examined. The results of this study showed that relevant factors of social participation are different by the type of group activities,viz PuG or PrG, and also that an intimate relationship with neighbors is a common factor for promoting participation in both types of group activity.

Sex is one of the promoting factors for initiating and continuing participation in PuG. Previous studies which enrolled Japanese community-dwelling older adults reported that the social group participation rate of female is higher than that of male (26,39), but male showed the higher participation than female in both new and continuous members of the PuG. This result seem to be due to that PuG is popular social participation for older males, because there are many roles in the social group organization which needs their ability such as managing the group or planning the events.

The older adults having a higher social economic status, better health status, being a non-worker, and a member of PuG are likely to become new participant in PrG activity. Although it is difficult to intervene in social economic factors or health status, inviting the non-worker or PuG member to join the PrG activity would be practical and efficient to increase PrG participants. Additionally, as full-time workers or individuals with poor mental health are likely to resign from the social group activity, taking care of these participants are important for preventing withdrawal from social participation. However, individuals with higher educational attainment could feel needs-discrepancy between their need and contents of PuG activities, and then they tend to resign from the social group. Therefore, improving the contents of activities to match the needs of the member is important for maintaining to be member of PuG .

For the conclusion of the Study 3, there are different and common relevant factors for participation in social activity between private group and public group and between new and continuous parcipations. With private group activity, the significantly and positively related factors

are educational attainment, subjective economical status, relationship with neighborhood, self-rated health, and mental health for new participation and relationship with neighborhood and mental health for continous participation. With public group activity, sex, relationship with neighborhood, and mental health are positively related with new participation, and sex, educational attainment, and relationship with neighborhood with continuous participation.These findings provide useful information to develop the measure for promoting and maintaining participation in social group activity for older adults.

For the general conclusion of this study, higher physical activity and mentally active sedentary behavior were related with lower risk of cognitive decline. Also participating in social group activity and having leadership in the organization could be important approach for the prevention of dementia in young-old ages. Therefore, developing and implementing the measure for promotiong physical activity and social participation based on the relevant factors shoud be important practical approaches for prevention of dementia among young-older adults in a community.

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