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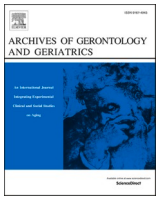

Social participation and functional disability trajectories in the last three years of life: The Japan Gerontological Evaluation Study

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HIGHLIGHTS

- Social participation and pre-death functional disability trajectories were evaluated.
- Older adults' social participation may maintain their last years' functional ability.
- Vertical social participation among men were not associated with trajectory patterns.
- The findings emphasize the importance of social participation among older adults.
- The findings can also shape policies for enhancing aging populations' quality of life.

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ABSTRACT

Background: Functional disability has various patterns from onset until death. Although social participation is a known protective factor against functional disability among older individuals, it is unclear whether social participation is associated with the trajectory patterns of functional disability prior to death. This study assessed the association between social participation, specifically in horizontal and vertical groups, and the trajectories of functional disability prior to death.

Methods: We used survey data from the 2010 Japan Gerontological Evaluation Study for functionally independent older adults combined with public long-term care insurance system data from 2010 to 2016 (n = 4,502). The outcome variables included five previously identified trajectory patterns using group-based trajectory modeling. As the explanatory variable, we used three definitions of social participation: any group, horizontal group (e.g., sports, hobbies), or vertical group (e.g., political, religious), at least once a month. We used a multinomial logistic regression analysis to calculate odds ratios with 95 % confidence intervals for the identified trajectory patterns.

Results: Participation in any groups was significantly less likely to belong to "Accelerated disability" (OR=0.74 [95 % CIs 0.60–0.92]), "Persistently mild disability" (0.68 [0.55–0.84]), and "Persistently severe disability" (0.67 [0.50–0.83]) compared to "Minimum disability." Although participation in horizontal groups was similarly associated with trajectories regardless of gender, vertical groups was not associated with trajectories among males.

Conclusions: Social participation among older adults may be associated with an extended period of living without disabilities before death. This association may differ by gender and social participation group and requires further research.

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1. Introduction

With the current trend of rapid population aging, the escalating burden of functional disability among older populations, particularly the persistence of severe functional disability, has emerged as a critical public health concern. Functional disability among older adults is defined as the acquired difficulty in performing fundamental daily tasks or more intricate activities essential for independent living (Rodrigues et al., 2009). While functional disability increases with age, distinct patterns of functional disability trajectories have been identified among older adults during the years preceding death (Edjolo et al., 2020; Gill et al., 2010; Lunney et al., 2018; Potente & Monden, 2018; Saito et al., 2022). These trajectories include "absence of disability until just prior to death," "gradual accumulation of disability," and "prolonged severe disability leading up to death."

Prior research has examined predictors of these functional disability trajectories, including socioeconomic status (e.g., income, wealth, educational gradient), sociodemographic variables (e.g., age, gender), specific diseases (e.g., advanced dementia, organ failure, cancer), and self-rated health (Edjolo et al., 2020; Gill et al., 2010; Lunney et al., 2018; Potente & Monden, 2018; Saito et al., 2022). The identification of these predictors concerning trajectory patterns preceding death has valuable implications for the development of preventive intervention programs for long-term care and for identifying priority populations for targeted strategies (Cohen-Mansfield et al., 2018; Gill et al., 2010; Lunney et al., 2018). Additionally, this knowledge enables approximating the associated long-term care costs for each trajectory pattern and facilitates the formulation of end-of-life policies that align with the principles of effectiveness, efficiency, and equity (Saito et al., 2022).

Social participation strongly affects older adults' health and well-being (Levasseur et al., 2010), making it a focal point for health-promoting interventions (Hikichi et al., 2015). Many studies have shown that social participation is positively associated with mortality and the onset of functional disability, dementia, and other health conditions (Ashida et al., 2016; James et al., 2011; Kanamori et al., 2014; Otsuka et al., 2018; Takahashi et al., 2019; Tomioka et al., 2017; Ukawa et al., 2020; Unger et al., 1997; Yamazaki et al., 2021; Zunzunegui et al., 2005). Aida et al. (Aida et al., 2009) classified social participation into two overarching categories based on its characteristics: horizontal groups (comprising volunteer, sports, hobby groups) characterized by egalitarian relationships, and vertical groups (comprising senior citizen clubs, neighborhood or residents' associations, political organizations, industry or trade associations, and religious groups) characterized by hierarchical relationships. Previous research has suggested that participation in horizontal groups is more positively associated with health outcomes than participation in vertical groups (Aida et al., 2009; Engström et al., 2008; Uchiyama & Kawabata, 2011; Ukawa et al., 2020). This finding suggests that the health benefits derived from social participation may vary according to the inherent characteristics of the group.

However, these studies defined the outcome as the occurrence of death or functional disability and did not consider the patterns of functional disability trajectory in the final stages of life. Consequently, this study aimed to evaluate the association between social participation and patterns of functional disability trajectories before death, focusing on differences in association by group characteristics.

2. Materials and methods

This study builds upon our previous work in which we identified the trajectory patterns of functional disability prior to death using the same combined databases of the Japan Gerontological Evaluation Study (JAGES) 2010 and individual Long-Term Care Insurance (LTCI) data of six years (Saito et al., 2022). While the previous study we refer to identified five trajectory patterns and proposed that individual health perception might be a predictor of trajectory patterns, the current study focuses on social participation.

2.1. Study population

We used a dataset from the 2010 JAGES, a research project that targets people aged 65 years or older who can perform activities of daily living (ADL) independently to provide a scientific basis for prevention policies for a healthy aging society. The JAGES 2010 survey was distributed to older adults residing in 22 cities and towns in Japan (n = 121,398). Of the older people who responded to the 2010 JAGES (n = 72,440, response rate: 59.7 %), respondents who were followed-up with through the LTCI system and death levy data of their local government for up to six years until 2016 (n = 70,697, follow-up rate: 97.6 %) were included in this study. Among the 7980 respondents who died, we excluded those who died within three years of the baseline survey (n = 3068) to mitigate potential reverse causation and severity bias. The rationale for this exclusion was that individuals who died shortly after the baseline might have had pre-existing health issues impacting their social participation and ability to derive benefit from it. The baseline survey and follow-up data were combined. Thus, 4875 respondents were considered eligible for the extraction of functional disability trajectories. The above definition of study participants was the same as that reported by previous researchers (Saito et al., 2022). In this study, we excluded individuals who reported that their ADLs were not independent at baseline (n = 373) to counter the reverse causation that unhealthy people cannot participate in social activities. Fig. 1 shows a flowchart of the inclusion and exclusion criteria. A total of 4502 participants were included in the final sample.

2.2. Trajectories of functional disability

Functional disability trajectories extracted in our previous study were used as outcomes in this study (Saito et al., 2022). We applied group-based mixture models with maximum likelihood estimation to identify the trajectory patterns of functional disability using 36 time points (monthly levels of functional disability during the 36 months before death). We constructed the trajectory models according to the number of groups (i.e., 2 to 5) and trajectory shapes (i.e., linear, quadratic, cubic). We then selected the best-fitting model considering Bayesian information criterion (BIC) and Akaike information criterion (AIC) as model fit statistics, a substantial number of participants in each group (at least 5 %), and the study objective (identification of comparable patterns of functional disability). Average posterior probabilities of each class of $\geq$0.70 were considered good discrimination in classifying individuals into different groups. There were no missing data for the group-based trajectory analysis because the functional disability information was collected from a public database (i.e., LTCI). In Japan, functional disability is reviewed and judged by the Long-Term Care Certification Board, which consists of academic experts in health, medicine, and welfare, based on the results of a survey of the physical and mental condition of older adults, as well as a computerized judgment (primary judgment) based on the attending physician's written opinion (Health & Welfare Bureau for the Elderly Ministry of Health LaW., n.d.). No nursing care certification was defined as independence, and support 1–2, and nursing care 1–5 were defined as disability because this is an objective measure of functional disability using LTCI data presented by the Japanese Ministry of Health, Labor, and Welfare (Ministry of Health, Labour & Welfare of Japan, n.d.). The trajectories, which reflect the progression of disability in the last three years of life, were classified into five categories: (1) persistently severe disability, characterized by a high level of disability that remains constant; (2) persistently mild disability, where individuals show a consistent but mild level of disability; (3) accelerated disability, which denotes a gradual increase in disability over time; (4) catastrophic disability, marked by a rapid and profound increase in disability, often near the end of life; and (5) minimum disability, indicating individuals with the

lowest degree of disability, suggesting significant independence. These categories provide a framework for understanding the different paths that functional disability can take in the final years of life. A visual representation of these trajectories can be found in Supplementary Fig. 1.

2.3. Social participation

In the JAGES 2010 questionnaire, respondents were asked about the frequency of their participation in activities related to various groups, including volunteer groups, sports clubs, leisure activities, senior citizen clubs, neighborhood or residents' associations, political organizations, industrial or trade associations, and religious organizations. Based on previous research (Aida et al., 2009; Yazawa et al., 2016), we defined social participation as participation in one of the groups at least once a month. Following Aida et al. (Aida et al., 2009), horizontal social participation was defined as participation in any of the volunteer, sports, or leisure groups, whereas vertical social participation referred to participation in any of the remaining five groups (i.e., senior citizen clubs, neighborhood or residents' associations, political organizations, industrial or trade associations, and religious organizations or groups).

2.4. Covariates

We considered several covariates in our analysis, including gender and baseline age categorized into three groups (65−75, 75−84, or ≥85 years); years of education (less than 10 or 10 years or more); annual household equivalent income (less than 2 or 2 million yen or more); history of previous treatment for cancer, heart disease, and stroke, each considered as separate binary variables; the number of days from the survey until death (a continuous variable); and residential population density at baseline categorized into four groups (<999, 1000−1499, 1500−3999, or ≥4000 people/km^2). These covariates were chosen based on previous studies that explored the relationship between social participation and incidents of functional disability and other relevant outcomes (Ashida et al., 2016; Hikichi et al., 2015; James et al., 2011; Kanamori et al., 2014; Otsuka et al., 2018; Saito et al., 2022; Takahashi et al., 2019; Tomioka et al., 2017; Ukawa et al., 2020; Unger et al., 1997; Yamazaki et al., 2021; Zunzunegui et al., 2005).

2.5. Statistical analysis

We summarized the baseline characteristics of deceased participants by functional disability trajectory patterns, presenting counts and proportions for binary or categorical variables, and means with standard deviations for continuous variables, applying appropriate *t*-tests or chi-squared tests as needed. We then performed a multinomial logistic regression analysis to calculate the odds ratio (OR) with 95 % confidence intervals (CIs) for each trajectory for older people who participated in the groups (i.e., any group, horizontal group, and vertical group). Furthermore, subgroup analyses stratified according to gender were performed. Additionally, we conducted an age-stratified analysis by categorizing participants into three baseline age groups (65–74 years, 75–84 years, and ≥85 years). To address missing values, we used Markov chain Monte Carlo imputation under the assumption that missing data were random and subsequently evaluated the effect estimates using Rubin's rule (Rubin, 1996). In addition to the multiple imputation approach, we performed a sensitivity analysis through complete case analysis to evaluate the robustness of our findings. This process entailed analyzing only the cases with no missing values for any of the variables included in our models. We performed all statistical analyses using Stata 17.0 MP (StataCorp. LLC, College Station, TX, USA), and the threshold for significance was set at $p < 0.05$.

Ethical approval for this study was obtained from the Ethics Committee for Research on Human Subjects at Nihon Fukushi University (No. 10–05) and University of Tokyo (No. 10555).

3. Results

Table 1 summarizes the participants' characteristics according to their functional disability trajectories. The mean age of the participants was 78.2 years, with a standard deviation of 6.8, and 62.8 % identified as male. The highest proportion of social participation at baseline was observed in the "Minimum disability" trajectory pattern (participation

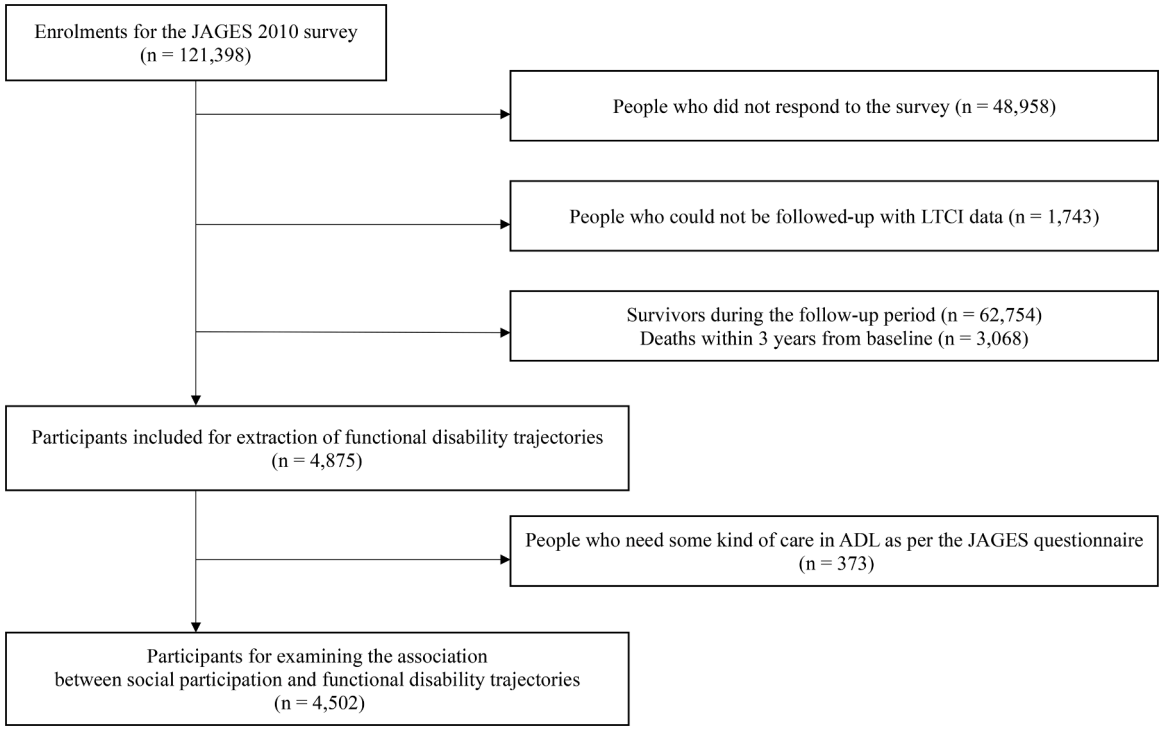

Fig. 1. Flowchart showing the selection of the study population.

in any group: 906 [49.9 %]; horizontal group participation: 644 [37.1 %]; and vertical group participation: 583 [32.9 %]). Among individuals younger than 75 years at baseline, the "Minimum disability" trajectory pattern accounted for the highest percentage (877; 42.0 %), while this was not the case for those aged 75 years and above. Furthermore, older individuals belonging to the "Minimum disability" pattern had the youngest mean age at the time of death (80.3; SD= 6.3). Among individuals with a "minimum disability" trajectory pattern, 178 (10.6 %) reported a history of previous cancer treatment at baseline. In the "catastrophic disability" group, 76 (10.5 %) reported a similar history.

Table 2 showed that those who participated in any group was more likely to belong to the "Minimum disability" pattern compared to other trajectories (Persistently severe disability: OR = 0.67 [95 % CIs 0.53–0.85]; Persistently mild disability: OR = 0.67 [95 % CIs 0.55–0.83]; Accelerated disability: OR = 0.74 [95 % CIs 0.60–0.91]; Catastrophic disability: OR = 0.87 [95 % CIs 0.73–1.03]). In terms of types of social participation, each type of social participation did not show a consistent trend in point estimates or 95 % CIs.

Tables 3 and 4 present the results of gender-stratified analysis. Among women, regardless of the type of group, participation was associated with a higher likelihood of belonging to the "Minimum disability" pattern, aligning with the main analysis. However, for men, the 95 % CI for those participating in the vertical group was wider than that for those who participated in the horizontal group (Table 4). Furthermore, Supplementary Tables 1–3 present the estimated results stratified by age groups. For the age groups 65–74 and 75–84 years, the estimated results were similar to those of the overall analysis. However, in the age group of ≥85, the 95 % CIs were wider, and no significant results were observed. Moreover, complete case analyses in Supplementary Tables 4–6 show that despite wider 95 % CIs, the trends of the estimates did not significantly change. Furthermore, Supplementary Tables 7–9 detail the ORs and 95 % CIs for all covariates used in our model.

4. Discussion

Our study suggested that, compared to the older adults not participating in any group activities, older adults who participated in groups were less likely to belong to the "Accelerated disability," "Persistently mild disability," or "Persistently severe disability" trajectories than the "Minimum disability" trajectory, and this association was also true for the older adults who participated in each of the horizontal and vertical groups. The gender-stratified analysis showed that men who participated in vertical groups were not associated with the "Minimum disability" pattern, however, women who participated in vertical groups were more likely to have "Minimum disability" pattern.

Table 1
Characteristics of deceased participants at baseline according to functional disability trajectory groups.

	Total *N* = 4502	Persistently severe disability *n* = 424	Persistently mild disability *n* = 569	Accelerated disability *n* = 557	Catastrophic disability *n* = 866	Minimum disability *n* = 2086	p-value
participants in any groups	1774 (45.7 %)	142 (39.0 %)	188 (39.4 %)	195 (40.9 %)	343 (45.7 %)	906 (49.9 %)	<0.001
participants in horizontal groups	1209 (32.8 %)	95 (27.7 %)	123 (27.2 %)	114 (25.7 %)	233 (32.9 %)	644 (37.1 %)	<0.001
Participants in vertical groups	1164 (30.6 %)	97 (27.1 %)	128 (27.4 %)	128 (27.4 %)	228 (30.9 %)	583 (32.9 %)	0.025
Gender (Male)	2827 (62.8 %)	224 (52.8 %)	299 (52.5 %)	352 (63.2 %)	541 (62.5 %)	1411 (67.6 %)	<0.001
Age of baseline	78.2 (6.8)	81.9 (7.0)	81.3 (6.1)	79.8 (6.4)	78.6 (6.5)	76.0 (6.3)	<0.001
Age group of baselines							<0.001
<74	1394 (31.0 %)	65 (15.3 %)	77 (13.5 %)	119 (21.4 %)	256 (29.6 %)	877 (42.0 %)	
75−84	2270 (50.4 %)	203 (47.9 %)	315 (55.4 %)	298 (53.5 %)	445 (51.4 %)	1009 (48.4 %)	
≥85	838 (18.6 %)	156 (36.8 %)	177 (31.1 %)	140 (25.1 %)	165 (19.1 %)	200 (9.6 %)	
Age at death	82.6 (6.8)	86.7 (7.0)	85.9 (6.0)	84.2 (6.3)	83.0 (6.4)	80.3 (6.3)	<0.001
Years of education, <10 years	2470 (57.3 %)	236 (59.9 %)	307 (57.3 %)	326 (60.8 %)	462 (55.9 %)	1139 (56.3 %)	0.27
Equivalent income, <2million yen	1793 (51.3 %)	162 (53.3 %)	211 (51.1 %)	225 (51.7 %)	335 (49.2 %)	860 (51.8 %)	0.76
History of previous treatment for cancer	346 (9.3 %)	16 (4.4 %)	35 (7.0 %)	41 (8.7 %)	76 (10.5 %)	178 (10.6 %)	0.001
History of previous treatment for heart disease	804 (21.5 %)	67 (18.5 %)	119 (23.9 %)	115 (24.4 %)	150 (20.8 %)	353 (21.0 %)	0.18
History of previous treatment for stroke	111 (3.0 %)	11 (3.0 %)	19 (3.8 %)	18 (3.8 %)	22 (3.0 %)	41 (2.4 %)	0.40
Number of days from the survey until death	1660.0 (324.0)	1790.3 (310.1)	1725.7 (313.6)	1647.1 (335.9)	1648.6 (320.2)	1623.7 (318.9)	<0.001
Population density							0.008
< 1000	1306 (29.0 %)	120 (28.3 %)	157 (27.6 %)	170 (30.5 %)	293 (33.8 %)	566 (27.1 %)	
1000−1499	1437 (31.9 %)	138 (32.5 %)	165 (29.0 %)	176 (31.6 %)	246 (28.4 %)	712 (34.1 %)	
1500−3999	1175 (26.1 %)	121 (28.5 %)	172 (30.2 %)	140 (25.1 %)	213 (24.6 %)	529 (25.4 %)	
≥ 4000	584 (13.0 %)	45 (10.6 %)	75 (13.2 %)	71 (12.7 %)	114 (13.2 %)	279 (13.4 %)	

This table presents the dataset before imputing missing values.
Data are presented as n (%) for binary or categorical measures, and mean (SD) for continuous measures: age of baseline age of death, number of days from the survey until death.
Abbreviations: SD, Standard deviation.

Table 2
Association of social participation with trajectory of functional disability in the last three years of life ($n = 4502$).

	Any social participation				Horizontal social participation				Vertical social participation			
	Crude		Adjusted model		Crude		Adjusted model		Crude		Adjusted model	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Persistently severe disability	**0.66***	**[0.52–0.83]**	**0.67***	**[0.53–0.85]**	**0.66***	**[0.51–0.85]**	**0.71***	**[0.55–0.93]**	**0.76***	**[0.59–0.98]**	**0.71***	**[0.54–0.93]**
Persistently mild disability	**0.66***	**[0.54–0.81]**	**0.67***	**[0.55–0.83]**	**0.64***	**[0.52–0.80]**	**0.69***	**[0.54–0.87]**	**0.76***	**[0.61–0.95]**	**0.72***	**[0.57–0.90]**
Accelerated disability	**0.71***	**[0.58–0.87]**	**0.74***	**[0.60–0.91]**	**0.65***	**[0.51–0.82]**	**0.69***	**[0.55–0.88]**	**0.78***	**[0.62–0.97]**	**0.76***	**[0.61–0.95]**
Catastrophic disability	0.86	[0.72–1.01]	0.87	[0.73–1.03]	0.84	[0.70–1.02]	0.87	[0.72–1.05]	0.92	[0.77–1.10]	0.90	[0.75–1.08]
Minimum disability	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	

Data are shown as odds ratios and 95 % confidence intervals.
*$p < 0.05$.
Abbreviations: OR, Odds ratio; CI, Confidence interval.
Adjusted model: adjusted for gender, age at baseline, educational attainment, equivalent income, history of previous treatment for cancer, heart disease or stroke, residential population density at baseline, and number of days from the survey until death.

Table 3
Association of social participation with trajectory of functional disability in the last three years among older adult women ($n = 1675$).

	Any social participation				Horizontal social participation				Vertical social participation			
	Crude		Adjusted model		Crude		Adjusted model		Crude		Adjusted model	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Persistently severe disability	**0.53***	**[0.38–0.76]**	**0.57***	**[0.39–0.82]**	**0.51***	**[0.34–0.76]**	**0.62***	**[0.41–0.96]**	**0.61***	**[0.42–0.90]**	**0.57***	**[0.37–0.86]**
Persistently mild disability	**0.63***	**[0.46–0.85]**	**0.64***	**[0.46–0.88]**	**0.60***	**[0.43–0.84]**	**0.68***	**[0.47–0.97]**	**0.64***	**[0.46–0.90]**	**0.59***	**[0.42–0.84]**
Accelerated disability	**0.71***	**[0.51–0.98]**	**0.70***	**[0.51–0.98]**	**0.66***	**[0.46–0.94]**	0.69	[0.47–1.01]	**0.69***	**[0.48–0.99]**	**0.64***	**[0.44–0.93]**
Catastrophic disability	0.79	[0.60–1.05]	0.81	[0.61–1.07]	**0.69***	**[0.50–0.95]**	**0.71***	**[0.51–0.99]**	0.84	[0.62–1.12]	0.81	[0.60–1.09]
Minimum disability	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	

Data are shown as odds ratios and 95 % confidence intervals.
*$p < 0.05$.
Abbreviations: OR, Odds ratio; CI, Confidence interval.
Adjusted model: adjusted for age at baseline, educational attainment, equivalent income, history of previous treatment for cancer, heart disease or stroke, residential population density at baseline, and number of days from the survey until death.

Table 4
Association of social participation with trajectory of functional disability in the last three years among older adult men ($n = 2827$).

	Any social participation				Horizontal social participation				Vertical social participation			
	Crude		Adjusted model		Crude		Adjusted model		Crude		Adjusted model	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Persistently severe disability	0.77	[0.56–1.04]	0.76	[0.55–1.03]	0.80	[0.57–1.11]	0.81	[0.57–1.15]	0.85	[0.60–1.19]	0.82	[0.58–1.16]
Persistently mild disability	**0.66***	**[0.51–0.87]**	**0.69***	**[0.52–0.90]**	**0.66***	**[0.50–0.89]**	**0.70***	**[0.52–0.95]**	0.82	[0.61–1.09]	0.81	[0.60–1.08]
Accelerated disability	**0.71***	**[0.55–0.92]**	**0.75***	**[0.58–0.97]**	**0.63***	**[0.48–0.85]**	**0.69***	**[0.52–0.93]**	0.82	[0.62–1.09]	0.82	[0.62–1.09]
Catastrophic disability	0.89	[0.72–1.10]	0.89	[0.72–1.10]	0.95	[0.75–1.19]	0.98	[0.77–1.23]	0.95	[0.75–1.19]	0.94	[0.75–1.19]
Minimum disability	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	

Data are shown as odds ratios and 95 % confidence intervals.
*$p < 0.05$.
Abbreviations: OR, Odds ratio; CI, Confidence interval.
Adjusted model: adjusted for age at baseline, educational attainment, equivalent income, history of previous treatment for cancer, heart disease or stroke, residential population density at baseline, and number of days from the survey until death.

Our findings are consistent with recent research (Kanamori et al., 2014; Takahashi et al., 2019) that investigated the association between social participation and functional disability. They are also consistent with a prior study indicating an association between social withdrawal among older individuals and a trajectory pattern characterized by persistent severe functional disabilities (Saito et al., 2019). Moreover, we consider the mechanism behind our research findings to be feasible. Interpersonal connections created by participation may serve as vital

sources of essential social support (Hosseingholizadeh et al., 2019; Iizuka et al., 2023; Levasseur et al., 2015). An existing longitudinal study indicated that support received from friends and neighbors reduces the risk of functional impairment, even when social support from co-residing family members was absent (Murata et al., 2017). Furthermore, an existing study's mediation analysis revealed that social support accounts for a portion of the association between social participation and the development of functional disabilities (Otsuka et al., 2018). While the primary focus of these studies was the development of functional disability as an outcome measure, we anticipate that social relationships established by providing or receiving support will persist after the onset of functional disability. This persistence of social ties may, in turn, mitigate the progression of functional disabilities through the provision of advice and assistance from social networks.

In an analysis adjusted for gender variables as covariates, the relationship between participation in each of the horizontal and vertical groups and the trajectory of functional disability was similar to the association of any social participation with the trajectories (Table 2). Prior studies have suggested that horizontal groups tend to facilitate the exchange of social support, while participation in vertical groups can bolster norms and trust within the group more (Aida et al., 2009; Ferlander, 2007; Harpham et al., 2002). Our findings suggest that both resources may contribute to alleviating functional disability. Although we addressed the foundational significance of social support in the preceding paragraph, the precise role of the reinforcement of trust and norms within vertical groups remains ambiguous. In future, further investigation of the mechanisms underlying the relationship between participation in each group and the mitigation of functional disability is needed.

The gender-stratified analysis showed that women participating in groups exhibited a higher likelihood of belonging to the "Minimum disability" pattern regardless of whether their involvement was in horizontal or vertical groups. However, among older male participants engaged in vertical groups, the same results were not replicated. This observation suggests the potential for different resources to be acquired through participation in vertical groups based on gender. Previous research indicates that vertical connections may yield diverse outcomes based on an individual's hierarchical position (Ferlander, 2007). Specifically, individuals situated at the lower rungs of the hierarchy, such as newcomers, may encounter limited access to group resources. The vertical groups observed in this study might have exhibited salient hierarchical structures, particularly in males. This could have potentially hindered their comprehensive access to the preventive effects related to caregiving and exacerbation of identified functional disability.

Supplementary Tables 1–3 suggest that the preventive effects of social participation are potentially greater among relatively younger seniors within a larger sample. Conversely, in the older adults within a smaller sample, many point estimates also below 1 were consistent with the main analysis (Table 2). The reason for the wider 95 % CI may include factors beyond the reduced power due to the small sample size. This may encompass survival bias in individuals aged $\geq$85 who are still independent in their ADLs, which could mean that the benefits of social participation are less pronounced compared to younger cohorts.

This study has several strengths. To our knowledge, this is the first study to examine the relationship between social participation and functional disability trajectories prior to death. While certain predictive factors for the trajectory of functional disability among older adults were identified in earlier studies, encompassing variables such as educational status, income, and assets (Edjolo et al., 2020; Potente & Monden, 2018), social participation presents a more practical avenue for intervention in later life (Hikichi et al., 2015, 2017). Secondly, this study used a robust definition of functional disability. In Japan, functional disabilities are reviewed and judged by the Long-Term Care Certification Board, which comprises academic experts in health, medicine, and welfare (Health & Welfare Bureau for the Elderly Ministry of Health LaW., n.d.). Older individuals or their families must be re-certified before the due date and can apply for re-evaluation even during the validity period. Thus, we used an objectively assessed robust measure of change in functional disability, which is key to this study.

However, this study has some limitations. First, our data did not include information regarding the causes of death, which can significantly affect the process of functional disability in individuals (Lunney et al., 2003). Table 1 shows that those in the minimum disability pattern tend to be younger at the time of death. The reason for this may be that those belonging to the "minimum disability" pattern may have had diseases leading to a relatively early death. Notably, a history of cancer treatment was more prevalent among individuals with "minimum disability" and "catastrophic disability" trajectories. On the other hand, having minimal functional disability suggests a higher quality of life (QOL) (Bowling et al., 2003; Netuveli et al., 2006). Regrettably, our study lacked the specific data on causes of death and QOLs needed to fully explore these hypotheses. Further research is crucial to better understanding the implications of these relationships. Second, we measured social participation at baseline in the 2010 survey, while we measured deaths between 2013 and 2016, and measured functional disability three years prior to death. Although we considered the number of days from the survey before death in our multivariate analysis, there was a range of 3–6 years from social participation to death. Third, the baseline functional abilities might not have been accurately assessed through long-term care certification or self-reporting. If such underlying impairments hindered social participation at baseline, this might have influenced the study's results by reversing the presumed causality. Finally, it is possible that older people who have developed functional disabilities during the follow-up period but have not applied to LTCI were included in the target population. In the Japanese LTCI system, older adults or their family members must apply to the municipality for evaluation of their functional disability to utilize long-term care insurance. Therefore, older adults with functional disabilities who have not been evaluated are not included in the LTCI database, which may lead to an underestimation of functional disability in the population.

5. Conclusions

Participation in group activities may help older adults maintain their functional ability and prevent them from experiencing several patterns of functional disability trajectories, including rapid and continuous severe disability among deceased individuals. Building a community environment that encourages the participation of older adults in groups, particularly horizontal groups among men, may make older people more likely to belong to groups with short periods of reduced functional ability in the years prior to death. Further research is needed to understand the social impact of changes in belonging trajectory patterns due to social participation on well-being, differences in nursing care costs, and quality-adjusted life years.

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CRediT authorship contribution statement

Takayuki Ueno: Writing – review & editing, Visualization, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Junko Saito:** Writing – review & editing, Visualization, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Hiroshi Murayama:** Writing – review & editing, Methodology, Conceptualization. **Masashige Saito:** Writing – review & editing, Resources, Project administration, Investigation. **Maho Haseda:** Writing – review & editing, Methodology, Conceptualization. **Katsunori Kondo:** Writing – review & editing, Supervision, Resources, Investigation, Funding acquisition, Conceptualization. **Naoki Kondo:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors have no conflicts of interest directly relevant to the content of this article.

Data availability

In our analysis, we used a dataset from 2010 JAGES and LTCI data. We retrieved the data on August 24, 2022 and can submit it through the project's website (https://www.jages.net/). Usage of this dataset is subject to the terms and conditions specified on the project's website.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.archger.2024.105361.

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