14. Folstein MF, Folstein SE, McHugh PR. 'Mini-mental state'. A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975;12:189–98.
15. Kahn R, Goldfarb A, Pollack M, *et al*. Brief objective measures for the determination of mental status in the aged. *Am J Psychiatry* 1960;117:326–8.
16. Anthony JC, LeResche L, Niaz U, *et al*. Limits of the 'Mini-Mental State' as a screening test for dementia and delirium among hospital patients. *Psychol Med* 1982;12:397–408.
17. Perkins NJ, Schisterman EF. The inconsistency of 'optimal' cutpoints obtained using two criteria based on the receiver operating characteristic curve. *Am J Epidemiol* 2006;163:670–5.
18. Shinkai S, Watanabe S, Kumagai S, *et al*. Walking speed as a good predictor for the onset of functional dependence in a Japanese rural community population. *Age Ageing* 2000;29:441–6.
19. Tiedemann A, Shimada H, Sherrington C, *et al*. The comparative ability of eight functional mobility tests for predicting falls in community-dwelling older people. *Age Ageing* 2008;37:430–5.
20. Guralnik JM, Ferrucci L, Pieper CF, *et al*. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *J Gerontol A Biol Sci Med Sci* 2000;55:M221–31.
21. Cesari M, Kritchevsky SB, Penninx BW, *et al*. Prognostic value of usual gait speed in well-functioning older people—results from the Health, Aging and Body Composition Study. *J Am Geriatr Soc* 2005;53:1675–80.
22. Cesari M, Kritchevsky SB, Newman AB, *et al*. Added value of physical performance measures in predicting adverse health-related events: results from the Health, Aging and Body Composition Study. *J Am Geriatr Soc* 2009;57:251–9.
23. Onder G, Penninx BW, Ferrucci L, *et al*. Measures of physical performance and risk for progressive and catastrophic disability: results from the Women's Health and Aging Study. *J Gerontol A Biol Sci Med Sci* 2005;60:74–9.
24. Studenski S, Perera S, Wallace D, *et al*. Physical performance measures in the clinical setting. *J Am Geriatr Soc* 2003; 51:314–22.
25. Simonsick EM, Newman AB, Visser M, *et al*. Mobility limitation in self-described well-functioning older adults: importance of endurance walk testing. *J Gerontol A Biol Sci Med Sci* 2008;63:841–7.
26. Markides KS, Black SA, Ostir GV, *et al*. Lower body function and mortality in Mexican American elderly people. *J Gerontol A Biol Sci Med Sci* 2001;56:M243–7.
27. Studenski S, Perera S, Patel K, *et al*. Gait speed and survival in older adults. *JAMA* 2011;305:50–8.
28. Montero-Odasso M, Schapira M, Soriano ER, *et al*. Gait velocity as a single predictor of adverse events in healthy seniors aged 75 years and older. *J Gerontol A Biol Sci Med Sci* 2005;60:1304–9.
29. Dargent-Molina P, Favier F, Grandjean H, *et al*. Fall-related factors and risk of hip fracture: the EPIDOS prospective study. *Lancet* 1996;348:145–9.
30. Wang L, Larson EB, Bowen JD, *et al*. Performance-based physical function and future dementia in older people. *Arch Intern Med* 2006;166:1115–20.
31. Beauchet O, Kressig RW, Najafi B, *et al*. Age-related decline of gait control under a dual-task condition. *J Am Geriatr Soc* 2003;51:1187–8.
32. Rantanen T, Era P, Kauppinen M, *et al*. Maximal isometric muscle strength and socio-economic status, health and physical activity in 75-year-old persons. *Aging Phys Act* 1994;2:206–20.
33. Ishizaki T, Watanabe S, Suzuki T, *et al*. Predictors for functional decline among non-disabled older Japanese living in a community during a 3-year follow-up. *J Am Geriatr Soc* 2000;48:1424–9.
34. Rantanen T, Guralnik JM, Sakari-Rantala R, *et al*. Disability, physical activity, and muscle strength in older women: the Women's Health and Aging Study. *Arch Phys Med Rehabil* 1999;80:130–5.
35. Rantanen T, Masaki K, Foley D, *et al*. Grip strength changes over 27 yr in Japanese-American men. *J Appl Physiol* 1998;85:2047–53.
36. Rantanen T, Harris T, Leveille SG, *et al*. Muscle strength and body mass index as long-term predictors of mortality in initially healthy men. *J Gerontol A Biol Sci Med Sci* 2000;55:M168–73.
37. Fujita Y, Nakamura Y, Hiraoka J, *et al*. Physical-strength tests and mortality among visitors to health-promotion centers in Japan. *J Clin Epidemiol* 1995;48:1349–59.
38. Sletvold O, Tilvis R, Jonsson A, *et al*. Geriatric work-up in the Nordic countries. The Nordic approach to comprehensive geriatric assessment. *Dan Med Bull* 1996;43:350–9.
39. Okumiya K, Matsubayashi K, Nakamura T, *et al*. The timed 'up & go' test is a useful predictor of falls in community-dwelling older people. *J Am Geriatr Soc* 1998;46:928–30.
40. Bischoff HA, Stahelin HB, Monsch AU, *et al*. Identifying a cut-off point for normal mobility: a comparison of the timed 'up and go' test in community-dwelling and institutionalised elderly women. *Age Ageing* 2003;32:315–20.

Performance-based assessments and demand for personal care in older Japanese people: a cross-sectional study

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Leisure activities and cognitive function in elderly community-dwelling individuals in Japan: A 5-year prospective cohort study

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ABSTRACT

Objective: This study aimed to clarify the longitudinal relationship between leisure activities and cognitive decline among Japanese community-dwelling older adults, using a 5-year prospective cohort study design.
Methods: A total of 567 men and women, aged 70 years and over, participated in the study. The Mini-Mental State Examination was used in baseline and follow-up surveys to assess cognitive function. The change in cognitive function from baseline to follow-up was determined, and cognitive decline over 5 years was used as the outcome variable. Leisure activities (hobby, social activity, and physical activity) were assessed at baseline and used as independent variables. Age, gender, number of years of education, presence of chronic diseases, instrumental activities of daily living, depressive symptoms, smoking, hearing deficits, and level of cognitive function at baseline were used as covariates.
Results: Multivariate logistic regression analysis, adjusted for potential confounders, showed that non-participation in a hobby was significantly and independently associated with cognitive decline (odds ratio: 1.87, 95% confidence interval: 1.16–3.02, $p<0.01$). There were no significant relationships between social activity, physical activity and cognitive decline.
Conclusions: Our study found a longitudinal inverse relationship between hobby participation and cognitive decline among elderly Japanese community-dwelling individuals, suggesting that engaging in a hobby in later life can contribute to preserving cognitive function.

Introduction

Along with the aging of populations worldwide, the prevalence of dementia in later life will increase rapidly. In Japan, it has been estimated that the number of people with dementia will peak in 2036 at around 3,550,000 people, that is, 10.8% of subjects aged 65 years and older [1]. These predicted changes offer complex and intriguing challenges for geriatricians and gerontologists who endeavor to prevent older people from developing dementia and becoming bedridden.

It has been reported that frequently engaging in leisure activities is associated with a lower risk of dementia and deterioration in cognitive function among community-dwelling older adults [2–4]. The Japan Ministry of Health, Labour and Welfare has introduced a Dementia Prevention Program [5], which encourages community-dwelling elderly subjects to engage in various leisure activities that help to stimulate their cognitive function in daily life (e.g., reading books, watching TV shows, gardening, playing challenging board games such as go or shogi, walking, and light exercise). We focus on the Dementia Prevention Program developed by the Japan Ministry of Health, Labour and Welfare because it is appropriate for the very elderly living in a community setting, who have various everyday physical impediments and whose physical function gradually deteriorates.

The Dementia Prevention Program was developed on the basis of findings from European and American longitudinal studies [2–4], which found an association between participation in leisure activities and a reduction in the incidence of dementia. However, since lifestyles and preferred activities among elderly individuals in Western countries may be different from those of elderly Japanese, it is questionable whether the findings from Western countries are applicable to dementia prevention strategies for older Japanese adults. The Cabinet Office of the Japanese Government reported that elderly individuals in Japan frequently engaged in various leisure activities, including gardening (34.3%), watching TV (31.4%), traveling (27.9%), walking (20.8%), knitting or Japanese-style pursuits (tea ceremonies, Japanese dancing, flower arrangement) (17.5%), reading books (16.4%), drawing (15.9%), sports (14.8%), Karaoke (10.5%), theater (6.8%), and playing challenging board games such as go or shogi (4.7%) [6]. Some of these activities were particular to Japan, thus the association between leisure

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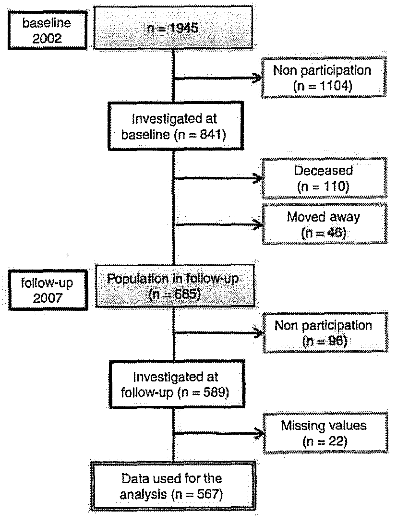

Fig. 1. Study sample in the analysis.

activity and cognitive decline should be re-examined among elderly Japanese subjects.

This study aimed to clarify a longitudinal relationship between leisure activities and cognitive decline among community-dwelling elderly Japanese, using a 5-year prospective cohort study design. Confirmation of a longitudinal relationship between leisure activities and cognitive decline could facilitate the development of specific strategies to prevent cognitive decline and dementia in older adults in Japan.

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Methods

Participants

The data for the present study was acquired from the mass health checkups for community-dwelling older adults ("Otasha-Kenshin") [7,8], conducted by the Tokyo Metropolitan Institute of Gerontology. "Otasha-Kenshin" means "health checkups for accomplishing successful aging" in Japanese. The study was administered in Itabashi ward in northern Tokyo, and we were granted access to the municipal resident registration files by the Itabashi ward authorities. Participants took part in a face-to-face interview at baseline and at 5-year follow-up with trained research assistants. The study was approved by the Ethics Committee of the Tokyo Metropolitan Institute of Gerontology. The study was explained to all participants, who were advised that: 1) their participation would be entirely voluntary; 2) they could withdraw from the study at any time; and 3) if they chose not to participate or to withdraw, then they would not be disadvantaged in any way. As of 2002, a sample of 1945 residents (aged 70–84 years) was obtained systematically from the municipal resident registration files. We acquired 841 completed sets of data (43.2% participation) in the baseline survey.

Of those who participated in the baseline survey, 589 participated in the follow-up survey 5 years later in 2007. Of the remaining 252 subjects, 110 had died during the 5-year follow-up period, 46 had moved to a different part of Japan, and 96 declined to participate. Of the 589 people who did participate in the follow-up survey, 22 were excluded from the analysis because they had missing cognitive performance data. In total, 567 participants (285 male, 282 female; mean age: 75.8 ± 3.5, age range: 70–84 at baseline) with a complete set of data were included in this analysis (see Fig. 1).

Those subjects who died or moved away during the follow-up period had a lower proportion of women (30.8% vs. 49.7%, $p<0.01$), were older (77.1 vs. 75.8 years, $p<0.01$) and had a similar number of years of education (10.8 vs. 10.7 years, $p=0.83$), an identical rate of depression (3.2% vs. 1.6%, $p=0.19$), a higher rate of chronic disease (48.7% vs. 35.9%, $p<0.01$), an identical rate of hearing deficits (9.6% vs. 7.8%, $p=0.45$), an identical rate of smoking (21.9% vs. 16.9%, $p=0.15$), lower instrumental activities of daily living score (IADL) [9], measured according to the Tokyo Metropolitan Institute of Gerontology Index of Competence (4.6 vs. 4.8 points, $p<0.01$), lower Mini-Mental State Examination [10] (MMSE) score (26.9 vs. 28.3 points, $p<0.01$) at baseline, exhibited a lower rate of engaging in hobbies (34.6 vs. 45.7, $p<0.01$), and similar rates of engagement in social activity (30.1 vs. 37.2, $p=0.11$) and physical activity (69.9 vs. 69.7, $p=0.96$) compared with subjects used in the analysis (Table 1).

Those subjects who were excluded or declined to participate in the follow-up survey had an almost identical proportion of women (47.5 vs. 49.7, $p=0.65$), similar age (76.4 vs. 75.8 years, $p=0.15$), fewer years of education (10.1 vs. 10.7 years, $p<0.05$), a higher rate of depression (5.1% vs. 1.6%, $p<0.05$), an identical rate of chronic disease (37.3% vs. 35.9%, $p=0.79$), an identical rate of hearing deficits (11.9% vs. 7.8%, $p=0.15$), an identical rate of smoking (22.0% vs. 16.9%, $p=0.19$), a lower IADL score (4.6 vs. 4.8 points, $p<0.01$), a lower MMSE score (27.3 vs. 28.3 points, $p<0.01$) at baseline, exhibited a lower rate of engaging in hobbies (33.1 vs. 45.7, $p<0.01$), and exhibited almost the same rates of engagement in social activity (37.3 vs. 37.2, $p=0.99$) and physical activity (62.7 vs. 69.7, $p=0.14$) compared with subjects used in the analysis (Table 1).

Table 1
Characteristics of subjects.

	Participants ($n=576$)	Deceased/moved away ($n=156$)	Non-participants at follow-up ($n=118$)	Participants vs. deceased/moved away	Participants vs. non-participants
Gender (% women)	282 (49.7)	48 (30.8)	56 (47.5)	<0.01	0.65
Age (year)	75.8 ± 3.5	77.1 ± 3.7	76.4 ± 3.9	<0.01	0.15
Education (year)	10.7 ± 3.0	10.8 ± 3.5	10.1 ± 2.9	0.83	0.04
Depression (%)	9 (1.6)	5 (3.2)	6 (5.1)	0.19	0.02
Chronic disease (%)	204 (35.9)	76 (48.7)	44 (37.3)	<0.01	0.79
Hearing deficit (%)	44 (7.8)	15 (9.6)	14 (11.9)	0.45	0.15
Smoking (%)	96 (16.9)	34 (21.9)	26 (22.0)	0.15	0.19
IADL (points)	4.8 ± 0.6	4.6 ± 0.93	4.6 ± 0.9	<0.01	<0.01
MMSE (points)	28.3 ± 2.1	26.9 ± 3.2	27.3 ± 2.7	<0.01	<0.01
Hobby (yes %)	259 (45.7)	54 (34.6)	39 (33.1)	0.01	0.01
Social activity (yes %)	211 (37.2)	47 (30.1)	44 (37.3)	0.11	0.99
Physical activity (yes %)	395 (69.7)	109 (69.9)	74 (62.7)	0.96	0.14

Note: t tests for continuous measures and chi-square tests for categorical measures were used to clarify the significance of differences in these characteristics between the two groups (participants vs. deceased/moving away, participants vs. non-participants).

Outcome measure

MMSE was used to assess cognitive function at baseline and follow-up. The change in cognitive function during the 5 years (calculated by subtracting baseline MMSE score from follow-up MMSE score: a negative value signifying a decrease in MMSE score) was an outcome variable. In addition, we used a cutoff score of −3 (meaning that scores of −3 and below were classified as "cognitive decline") to judge whether participants had meaningful deteriorations in cognitive function over 5 years. Previous studies have pointed out that a change in MMSE score may reflect not only true improvement or decline with aging, but also may be a result of measurement error, regression to the mean, and a practice effect of the test [11,12], and showed that a change in MMSE score of at least 2 to 4 points was necessary to reliably measure a change in scores [12,13].

Independent variables (leisure activities)

Data collected at baseline were used as independent variables. Participants were interviewed regarding leisure activities: hobby, social activity, and physical activity. Subjects were asked whether they engaged in any hobbies (e.g., gardening, watching TV, traveling, knitting, reading books, Karaoke, and playing board games such as go or shogi) "never", "occasionally", or "frequently". In the analysis, these responses were dichotomized into two categories: "never/occasionally" and "frequently", the former being defined as "no" and the latter as "yes". Question regarding engagement in social activities (e.g., volunteering and group activities for the elderly) was answered "yes" or "no". The question regarding regular physical activities (e.g., jogging, walking, Japanese croquet, hiking, dance, swimming, and gymnastics) was answered with a "yes" or "no" response.

Covariates

Data collected at baseline were used as covariates in the analysis of an independent association between leisure activities and cognitive decline. Data for age, gender, number of years of education, presence of chronic diseases, IADL, depressive symptoms (measured according to Mini-International Psychiatric Interview (MINI) [14]), smoking, hearing deficit, and baseline MMSE score, were included. The presence of chronic diseases was defined as at least one disease among diabetes, heart disease, and stroke.

Statistical analyses

Chi-square tests were performed to test the univariate associations between leisure activities and cognitive decline according to each leisure activity (i.e., hobby, social activity, and physical activity). Logistic regression analyses were performed to test the multivariate associations between leisure activities and cognitive decline according to each leisure activity. Adjusted odds ratio estimates and confidence intervals for engagement in the leisure activities, controlled for the above-mentioned covariates, were calculated. All statistical procedures were performed using SAS version 9.1 software (SAS Institute Inc., Cary, NC, USA).

Results

Fig. 2 shows distributions of change in MMSE score between the baseline and follow-up survey. The mean change in MMSE score was −0.94 ± 2.61 (range: −16 to 7). The number (proportion) of participants with cognitive decline was 109 (19.2%).

Table 2 shows the associations between leisure activities and cognitive decline, as assessed by chi-square tests. Those who did not engage in a hobby were more likely to experience cognitive decline over 5 years, compared with participants who did (23.4% vs. 14.3%, $p<0.01$). Those who did not engage in social activities and physical activities had an almost identical proportion experiencing cognitive decline, compared with participants who did (20.5% vs. 17.1%, $p=0.31$; 19.8% vs. 18.9%, $p=0.83$, respectively).

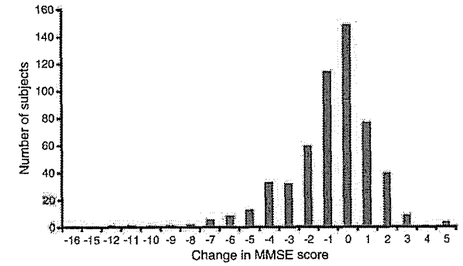

Fig. 2. Change in MMSE score over 5 years ($n=567$). Note: Change in cognitive function was calculated by subtracting baseline MMSE score from follow-up MMSE score: a negative value means a decrease in MMSE score during the 5-year period.

Multiple logistic regression analyses were carried out to examine the independent relationships between participation in leisure activities and cognitive decline. There was a significant relationship between lack of participation in a hobby and cognitive decline (odds ratio: 1.87, 95% confidence interval: 1.16–3.02, $p<0.01$) during the 5-year period. There were no significant relationships between participation in social and physical activities and cognitive decline (Table 3).

To examine whether the relationships between participation in leisure activities and cognitive decline were affected by cognitive impairment at baseline, we repeatedly performed the above analysis in subjects with no cognitive impairment according to MMSE scores at baseline. We used a cutoff MMSE score of 24, meaning that scores of 24 and above were classified as no cognitive impairment [15] ($n=541$). The results revealed that, in participants with a score of 24 or above, the association between hobby engagement and cognitive decline remained significant (odds ratio: 1.65, 95% confidence interval: 1.02–2.68, $p<0.05$), while the associations between social and physical activity and cognitive decline remained non-significant.

Discussion

This study aimed to clarify the longitudinal relationship between leisure activities (hobby, social activity, and physical activity) and cognitive decline among Japanese community-dwelling older adults, and found a significant and independent inverse relationship between hobby participation and cognitive decline, even when adjusting for potential confounding factors such as age, gender, number of years of education, presence of chronic diseases, IADL, depressive symptoms, smoking, hearing deficit, and level of cognitive function at baseline, indicating that older individuals who did not enjoy hobbies were more likely to experience cognitive decline during the 5-year period, compared to those who did. There were no significant

Table 2
The number (rate) of participants with cognitive decline over 5 years corresponding to engaging in leisure activities ($n=567$).

	Change in cognitive function		p^a
	Decline	Stable/improved	
Hobby			
Yes	37 (14.3)	222 (85.7)	<0.01
No	72 (23.4)	236 (76.6)	
Social activity			
Yes	36 (17.1)	175 (82.9)	0.31
No	73 (20.5)	283 (79.5)	
Physical activity			
Yes	75 (18.9)	320 (81.1)	0.83
No	34 (19.8)	138 (80.2)	

[a] Chi-square test. A cut-off score of −3 (meaning that scores of −3 and below were classified as "cognitive decline") was used to judge whether participants had significant deterioration over 5 years with respect to cognitive function.

Table 3
Longitudinal relationship between leisure activity and cognitive decline ($n = 567$).

	Odds ratio	95% Confidence interval	p^a
Hobby (no participation)	1.87	1.16–3.02	<0.01
Social activity (no participation)	1.45	0.89–2.34	0.14
Physical activity (no participation)	1.06	0.65–1.74	0.81

[a] Multiple logistic regression analyses adjusted for age, gender, number of years of education, presence of chronic disease, IADL (measured according to the Tokyo Metropolitan Institute of Gerontology Index of Competence [9]), depressive symptoms (measured according to MINI [14]), smoking, hearing deficit, and baseline MMSE score.

relationships between participation in social activities and cognitive decline, nor participation in physical activities and cognitive decline.

Our findings were similar to the results of previous studies. Wilson [2] reported that regular engagement in cognitive-stimulating activities (including viewing television, listening to radio, reading newspapers, reading magazines, reading books, playing games such as cards, checkers, crosswords, or other puzzles, and going to museums) was associated with a reduced risk of Alzheimer disease (AD) during a mean follow-up of 4.5 years. Verghese [4] found that regular engagement in cognitive activities (including reading books or newspapers, writing for pleasure, doing crossword puzzles, playing board games or cards, participating in organized group discussions, and playing musical instruments) was associated with a reduced risk of dementia during a mean follow-up of 5.1 years. The previous studies suggested that engaging in activities that demand relatively substantive cognitive resources may be effective in preserving cognitive function in the elderly. The previous studies also showed a significant relationship only between cognitive activities and incidence of dementia, but not a significant relationship between physical activity and incidence of dementia [2,4]. Thus, previous studies and ours suggest that enjoying a hobby (which is a cognitive stimulating activity) may have a protective effect in helping to preserve cognitive function in later life.

Meanwhile, the longitudinal relationship could be explained by "reverse causality", with which a loss of hobby participation would occur after an early stage of cognitive deficit developed owing to preclinical dementia. Quitting a hobby may constitute an early sign of dementia incidence [4], and such potential dementia cases are more likely to experience cognitive decline eventually. Because the current study did not conduct dementia discrimination at baseline, we cannot exclude the possibility that such potential dementia cases may have been included into the study cohort. However, the likelihood of this possibility occurring in the current study may be weakened, for two reasons. First, the multivariate analysis controlled for baseline cognitive function levels. Second, the association between hobby participation and cognitive decline remained significant when the analysis was restricted to subjects with no cognitive impairment [15] (defined by a cutoff MMSE score of 24 or above). Because, in the present findings, it is difficult to decide whether the longitudinal relationship ought to be explained by the protective effect or by reverse causality, further investigations with longer follow-up periods are needed in the future.

We speculate that there could be three mechanisms underlying the relationship between hobby participation and cognitive decline in the elderly. The first pathway may be related to the "use it or lose it" hypothesis [16], from a famous saying in English. Older individuals tend to experience deterioration in their cognitive and physical function if they physically and mentally receive little stimulus in everyday life (i.e., "disuse syndrome") [17]. Thus, since some hobbies demand use of cognitive resources and stimulate cognitive function, engagement in a hobby may have a beneficial effect in preventing older individuals from failing into the disuse syndrome, and consequently reduce the deterioration in cognitive function.

The second pathway underlying the relationship between hobby participation and cognitive decline may be related to the "cognitive reserve hypothesis" [18–20]. Previous studies have suggested that there are individual differences in tolerance to dementia pathology. Price [21] examined a relationship between neuropathological diagnosis at autopsy and clinical diagnosis of AD before death, and demonstrated that around 40% of non-demented individuals met at least some level of criteria for neuropathological AD, suggesting that there may be a lag between neuropathological states and manifestation of dementia symptoms (e.g., behavior disorders and cognitive decline), and that some non-demented older individuals may also have the potential for progression of cognitive dysfunction. Similarly, according to the Nun study [22], the lag may vary among individuals. The study found that those who showed a neuropathological state of AD at autopsy included not only individuals with dementia clinically manifest before death but also cognitively intact individuals. The findings indicate that there may be individual differences in cognitive reserve, which is an ability to tolerate dementia pathology. Previous studies assumed that cognitive reserve varied according to characteristics such as education and occupational attainment. Hence, those with higher education and career progression in earlier life are likely to have enhanced cognitive reserve in later life [18,19]. Previous studies demonstrated that older adults with higher education [23,24] and occupation attainment [23] were less likely to develop dementia. The results might be related to frequent engagement in cognitively challenging activities and consequent enhanced cognitive reserve. Thus, regularly engaging in a hobby may have a beneficial effect in preventing cognitive decline in later life by enhancing cognitive reserve.

The third pathway underlying the relationship between hobby participation and cognitive decline may be related to "the positive affect hypothesis". Engaging in a hobby brings a "positive affect" (including happiness, joy, enthusiasm, contentment, subjective well-being, self-esteem, and congenial mood) to older adults. A previous study [25] reviewed the relationships between these positive affects and health outcomes, including mortality, morbidity, physical functioning, and others (cardiovascular, endocrine, and immunological diseases), and suggested that a positive affect regulated the central nervous system and hypothalamic–pituitary–adrenal axis activity. Hyperactivity in the axis may be detrimental to health because it causes a loss of hippocampal neurons and hippocampus atrophy [3,26–28], and an increase in cardiovascular risk factors (e.g., elevated blood pressure, cardiac dysrhythmia, and elevated platelet activation) [3,25,29], which increase the risk of dementia. Hence, engaging in a hobby may preserve cognitive function by providing a positive affect.

The relationship between hobby participation and cognitive decline may be confounded by depressive symptoms. It is well known that quitting a hobby is an early sign of depressive symptoms. In fact, the Geriatric Depression Scale, which is widely used to assess depressive symptoms among older individuals, includes an item related to having quit their hobby (i.e., "Have you dropped many of your activities and interests?" [30]). Also, a previous study reported that older individuals with depressive symptoms tend to experience cognitive decline [31]. Thus, the presence of depressive symptoms can be a confounding factor that affects the association between engaging in hobbies and cognitive decline. Nevertheless, our study controlled for the confounding effect of depressive symptoms (assessed by the MINI [14]) and found an independent inverse relationship between participation in a hobby and cognitive decline.

Our findings were inconsistent with the results of previous studies, which showed a longitudinal relationship between social engagement and preserving cognitive function among older adults [32,33]. Wang [32] found a relationship between participation in social activities (including traveling, playing card games, group activities, and volunteer activities) and reduced risk of dementia. Ertel [33] found a relationship between participation in social activities (including marital status, volunteering, frequency of contact with children, parents, and neighbors) and preservation of cognitive function using a large, representative sample of American citizens. Meanwhile, Fabrigoule [34] did not find a significant association between participation in golden age clubs, which is one of the social activities of the elderly, and incidence of dementia, using a 3-year longitudinal study design in older individuals dwelling in Gironde (France). Further detailed explorations of the relationship are required to resolve the contradictions.

Our findings were inconsistent with the results of previous studies, which showed a longitudinal relationship between regular physical activity and preservation of cognitive function among older adults by observational study [35,36,37]. Larson [35] reported that older individuals who engaged in regular exercise (three or more times per week) were less likely to develop dementia during a mean follow-up of 6.2 years. Lindsay [37] reported that regular exercise ("regular" was not explicitly defined in the study) was associated with a reduced risk of AD in a 5-year prospective cohort study. According to the previous studies, regular physical activity brings biological benefits related to improved cerebral blood circulation [38] and oxygen delivery to regions of the brain [39], thus preserving cognitive function in later life. However, Wang [32] did not find any significant associations between physical activity (including swimming, walking, and gymnastics) and risk of dementia, in a 6.4-year longitudinal study among very old individuals living in Stockholm, Sweden. Wilson [2] also conducted a 4.5-year longitudinal study among older Catholic clergy in the USA and did not find a significant association. Further detailed examinations of the relationship are needed to resolve the contradictory results.

Generalization of our findings is limited in two ways. First, we did not assess which kinds of activities the participants engaged in as a hobby because of restricted procedures in this survey. Various kinds of activities are included in the hobbies that Japanese older individuals enjoy [6], and the extent of effectiveness of hobbies in preserving cognitive function, may vary with type of hobby. For example, hobbies such as the board games of go and shogi would demand relatively more cognitive resources than watching TV. Fishing and sports may demand few cognitive resources because these activities mostly use physical resources (e.g., physical fitness). Thus, which kinds of activities are most effective in preserving cognitive function should be examined in future studies. Second, the representativeness of the sample in this study may have been restricted. The participation rate at baseline was relatively low (43.2% participation) because we acquired the data by administering mass health checkups. In addition, those who were deceased/moved away differed in terms of the proportion of women, age, rate of chronic disease, IADL, cognitive functioning, and rate of engaging in hobbies compared with participants whose data were used in this study (Table 1). Also, those without follow-up data differed in terms of years of education, rate of depression, IADL, cognitive functioning, and rate of engaging in hobbies, compared with participants whose data were used in this study (Table 1), suggesting that a selection bias may have occurred. Therefore, we cannot exclude the possibility that the extent to which our findings are generalized may be limited because of the two reasons.

In conclusion, this study found an independent inverse relationship between hobby participation and longitudinal decline in cognitive function among community-dwelling older adults in Japan, suggesting that engaging in hobbies in later life can contribute to preserving cognitive function. Our results may help to facilitate the development of efficient strategies to prevent cognitive decline and reduce the incidence of dementia in older individuals in Japan.

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References

[1] Otsuka T. Future estimation of the number of demented individuals among the elderly in Japan. J Jpn Assoc Psychiatric Hosp 2001;20:841–5 [in Japanese].
[2] Wilson RS, Mendes De Leon CF, Barnes LL, Schneider JA, Bienias JL, Evans DA, et al. Participation in cognitively stimulating activities and risk of incident Alzheimer disease. JAMA 2002;287:742–8.
[3] Fratiglioni L, Paillard-Borg S, Winblad B. An active and socially integrated lifestyle in late life might protect against dementia. Lancet Neurol 2004;3:343–53.
[4] Verghese J, Lipton RB, Katz MJ, Hall CB, Derby CA, Kuslansky G, et al. Leisure activities and the risk of dementia in the elderly. N Engl J Med 2003;348:2508–16.
[5] Japan Ministry of Health Law. The revised-manual for prevention and support program for dementia; 2009.
[6] Cabinet Office, Government of Japan. The survey on health among the aged population in Japan; 1996 http://www8.cao.go.jp/kourei/ishiki/h08_sougou/a15_13.htm.
[7] Suzuki T, Kwon J, Kim H, Shimada H, Yoshida Y, Iwasa H, et al. Low serum 25-hydroxyvitamin D levels associated with falls among Japanese community-dwelling elderly. J Bone Miner Res 2008;23:1309–17.
[8] Iwasa H, Yoshida H, Kim H, Yoshida Y, Kwon J, Sugiura M, et al. A mortality comparison of participants and non-participants in a comprehensive health examination among elderly people living in an urban Japanese community. Aging Clin Exp Res 2007;19:240–5.
[9] Koyano W, Shibata H, Nakazato K, Haga H, Suyama Y. Measurement of competence: reliability and validity of the TMIG Index of Competence. Arch Gerontol Geriatr 1991;13:103–16.
[10] Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189–98.
[11] Park HL, O'Connell JE, Thomson RG. A systematic review of cognitive decline in the general elderly population. Int J Geriatr Psychiatry 2003;18:1121–34.
[12] Hensel A, Angermeyer MC, Riedel-Heller SG. Measuring cognitive change in older adults: reliable change indices for the Mini-Mental State Examination. J Neurol Neurosurg Psychiatry 2007;78:1298–303.
[13] Iverson GL. Interpretation of Mini-Mental State Examination scores in community-dwelling elderly and geriatric neuropsychiatry patients. Int J Geriatr Psychiatry 1998;13:661–6.
[14] Sheehan DV, Lecrubier Y, Sheehan KH, Amorim P, Janavs J, Weiller E, et al. The Mini-International Neuropsychiatric Interview (M.I.N.I.): the development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. J Clin Psychiatry 1998;59(Suppl 20):22–33.
[15] Tombaugh TN, McIntyre NJ. The mini-mental state examination: a comprehensive review. J Am Geriatr Soc 1992;40:922–35.
[16] Hultsch DF, Hertzog C, Small BJ, Dixon RA. Use it or lose it: engaged lifestyle as a buffer of cognitive decline in aging? Psychol Aging 1999;14:245–63.
[17] Yamaguchi H, Takahashi E, Maruoka K, Shimizu H, Yoshikawa H, Yamaji T, et al. Disuse dementia—a role of daily living activities on preventing mental decline in aged people. Jpn J Geriatr Psychiatry 1995;6:195–201 [in Japanese].
[18] Iwahara A, Hatta T. Lifestyle activities and cognitive reserve. Jpn Psychol Rev 2009;52:416–29 [In Japanese].
[19] Scarmeas N, Stern Y. Cognitive reserve and lifestyle. J Clin Exp Neuropsychol 2003;25:625–33.
[20] Stern Y. What is cognitive reserve? Theory and research application of the reserve concept. J Int Neuropsychol Soc 2002;8:448–60.
[21] Price JL, McKeel Jr DW, Buckles VD, Roe CM, Xiong C, Grundman M, et al. Neuropathology of nondemented aging: presumptive evidence for preclinical Alzheimer disease. Neurobiol Aging 2009;30:1026–36.
[22] Snowdon DA. Aging with grace: what the Nun Study teaches us about living longer, healthier and more meaningful lives. New York: Bantam books; 2001.
[23] Stern Y, Gurland B, Tatemichi TK, Tang MX, Wilder D, Mayeux R. Influence of education and occupation on the incidence of Alzheimer's disease. JAMA 1994;271:1004–10.
[24] Wilson RS, Li Y, Aggarwal NT, Barnes LL, McCann JJ, Gilley DW, et al. Education and the course of cognitive decline in Alzheimer disease. Neurology 2004;63:1198–202.
[25] Pressman SD, Cohen S. Does positive affect influence health? Psychol Bull 2005;131:925–71.
[26] Bremner JD. Does stress damage the brain? Biol Psychiatry 1999;45:797–805.
[27] McEwen BS. Sex, stress and the hippocampus: allostasis, allostatic load and the aging process. Neurobiol Aging 2002;23:921–39.
[28] Wilson RS, Evans DA, Bienias JL, de Leon CF Mendes, Schneider JA, Bennett DA. Proneness to psychological distress is associated with risk of Alzheimer's disease. Neurology 2003;61:1479–85.
[29] Rozanski A, Blumenthal JA, Davidson KW, Saab PG, Kubzansky L. The epidemiology, pathophysiology, and management of psychosocial risk factors in cardiac practice: the emerging field of behavioral cardiology. J Am Coll Cardiol 2005;45:637–51.
[30] Brink TL, Yesavage JA, Lum O, Heersema PH, Adey M, Rose TL. Screening tests for geriatric depression. Clin Gerontol 1982;1:37–43.
[31] Wilson RS, Mendes De Leon CF, Bennett DA, Bienias JL, Evans DA. Depressive symptoms and cognitive decline in a community population of older persons. J Neurol Neurosurg Psychiatry 2004;75:126–9.
[32] Wang HX, Karp A, Winblad B, Fratiglioni L. Late-life engagement in social and leisure activities is associated with a decreased risk of dementia: a longitudinal study from the Kungsholmen project. Am J Epidemiol 2002;155:1081–7.

[33] Ertel KA, Glymour MM, Berkman LF. Effects of social integration on preserving memory function in a nationally representative US elderly population. Am J Public Health 2008;98:1215–20.
[34] Fabrigoule C, Letenneur L, Dartigues JF, Zarrouk M, Commenges D, Barberger-Gateau P. Social and leisure activities and risk of dementia: a prospective longitudinal study. J Am Geriatr Soc 1995;43:485–90.
[35] Larson EB, Wang L, Bowen JD, McCormick WC, Teri L, Crane P, et al. Exercise is associated with reduced risk for incident dementia among persons 65 years of age and older. Ann Intern Med 2006;144:73–81.
[36] Abbott RD, White LR, Ross GW, Masaki KH, Curb JD, Petrovitch H. Walking and dementia in physically capable elderly men. JAMA 2004;292:1447–53.
[37] Lindsay J, Laurin D, Verreault R, Hebert R, Helliwell B, Hill GB, et al. Risk factors for Alzheimer's disease: a prospective analysis from the Canadian Study of Health and Aging. Am J Epidemiol 2002;156:445–53.
[38] Colcombe SJ, Kramer AF, Erickson KI, Scalf P, McAuley E, Cohen NJ, et al. Cardiovascular fitness, cortical plasticity, and aging. Proc Natl Acad Sci U S A 2004;101:3316–21.
[39] Rogers RL, Meyer JS, Mortel KF. After reaching retirement age physical activity sustains cerebral perfusion and cognition. J Am Geriatr Soc 1990;38:123–8.

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RESEARCH ARTICLE

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Global cognition and 8-year survival among Japanese community-dwelling older adults

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Objective: We sought to examine the longitudinal relationship between cognitive function and all-cause mortality among Japanese community-dwelling older adults, using an 8-year prospective cohort study design with mortality surveillance.

Methods: A total of 454 men and 386 women, aged 70 years and older, participated in the study. The Mini Mental State Examination (MMSE) was administered to assess global cognition. The total MMSE score and subscale scores were used as independent variables, and age, gender, education level, chronic disease, sensory deficit, depressive symptoms, and instrumental activities of daily living were used as covariates.

Results: During the follow-up period, 191 subjects (139 men and 52 women) died, and 64 subjects (31 men and 33 women) moved to a different region of Japan and were lost to follow-up. Use of the multivariate Cox proportional hazards model, adjusted for potential confounders, showed that global cognition was significantly and independently associated with mortality (hazard ratio [HR] = 1.59, 95% confidence interval [CI]: 1.14–2.23 and HR = 2.81, 95% CI: 1.77–4.36 for the middle [24–27 points] and lowest [0–23 points] categories, respectively). Among the MMSE subscales, *place orientation* (HR = 1.57, 95% CI: 1.09–2.25), *calculation* (HR = 1.67, 95% CI: 1.18–2.35), and *delayed recall* (HR = 1.42, 95% CI: 1.03–1.96), were also significantly and independently associated with mortality.

Conclusions: Our study suggests that among older individuals, those with lower levels of cognitive function are more likely to have a shorter lifespan compared with those with higher cognitive functioning.

Key words: all-cause mortality; cognition; community older adults; Mini Mental State Examination (MMSE)
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Introduction

Cognitive function is an important contributor to health among older adults. A number of recent studies have examined the longitudinal association between cognitive function and mortality among older adults. Among the different domains of cognitive function, episodic memory (Small and Backman, 1997; Portin *et al.*, 2001), executive function (Johnson *et al.*, 2007; Lavery *et al.*, 2009), and information processing speed (Smits *et al.*, 1999; Rosano *et al.*, 2008; Lavery *et al.*, 2009) have been shown to predict mortality among older adults living in a community setting. Global cognition measured by the Mini Mental State Examination (MMSE) (Folstein *et al.*, 1975) also predicts mortality (Kelman *et al.*, 1994; Bruce *et al.*, 1995; Gussekloo *et al.*, 1997; Fredman *et al.*, 1999; Korten *et al.*, 1999; Andersen *et al.*, 2002; Nguyen *et al.*, 2003). The MMSE is the most widely used test for objectively measuring cognitive function, and its validity and reliability have been confirmed (Tombaugh and McIntyre, 1992).

Only a few studies have examined the association between MMSE subscales and mortality. A study (Villarejo *et al.*, 2011) reported a longitudinal association between the three-word delayed recall task of the MMSE and all-cause mortality among non-demented older individuals. However, longitudinal associations between the other MMSE subscales and mortality are unclear. A careful examination of the relationship between MMSE subscales and mortality should help facilitate the prediction of early death among older adults in epidemiological surveys in the community and in clinical settings.

In this study, we examined the longitudinal relationship between cognitive performance, based on the MMSE, and all-cause mortality among Japanese community-dwelling older adults, using an 8-year surveillance of mortality.

Methods

Participants

The data for the present study were acquired from mass health checkups for community-dwelling older adults (*Otasha-Kenshin*) (Iwasa *et al.*, 2007; Suzuki *et al.*, 2008), conducted in 2002 by the Tokyo Metropolitan Institute of Gerontology. The Japanese term *Otasha-Kenshin* translates into "health checkups for accomplishing successful aging." The study was conducted in Itabashi ward in northern Tokyo, Japan, and we were granted access to the municipal resident registration files by the Itabashi ward authorities. Participants took part in a face-to-face interview, to establish the baseline, with trained research assistants. The study was approved by the Ethics Committee of the Tokyo Metropolitan Institute of Gerontology. As of 2002, a sample of 1945 residents (aged 70–84 years) was randomly obtained from the municipal resident registration files. We sent a letter asking them to participate in checkups. Eight hundred forty-seven individuals agreed to participate (43.5% participation rate). There was a lower proportion of women compared with men who participated in the baseline survey (46.2% *vs.* 51.9%, respectively, $p = 0.012$). Participants and non-participants were almost identical in age (76.2 *vs.* 76.4 years, respectively, $p = 0.233$).

Of those who participated in the baseline survey, seven were excluded from the analysis: one subject had missing educational information and six had missing MMSE scores. In total, 840 participants (454 men and 386 women, mean age of 76.2 ± 3.6 years at baseline) with complete data sets were included, and their data
F1 were used for the 8-year mortality surveillance (Figure 1).

Mortality follow-up

Because the survey was completed at the end of 2002, we defined January 1, 2003 as the baseline for the follow-up period in the present study. Thus, we carried out an 8-year mortality surveillance, from January 1, 2003 to January 1, 2011.

Current residency in Itabashi ward on January 1, 2011 was determined using the municipal resident registration files for Itabashi ward. The dates on which residents moved away or died were identified from the registration files and used to calculate survival times. The certifications and dates of all decedents and those moving away were obtained from the Itabashi ward authorities.

The dependent variable in the analyses was survival time, calculated as the number of days between the baseline (i.e., January 1, 2003) and the date of death or censoring (including survivors and dropouts due to migration from Itabashi ward). Survivors were censored on January 1, 2011. Dropouts were censored on the date of migration from Itabashi ward.

We used all-cause mortality as the dependent variable because we did not have any data regarding the cause of death among the decedents.

Measurements of cognitive performance

We used the MMSE (Folstein *et al.*, 1975) to assess cognitive function among older adults. The MMSE is the most widely used test of global cognitive function and has been used in numerous studies (Tombaugh and McIntyre, 1992; Dewey and Saz, 2001; Xu *et al.*, 2002; Inagaki *et al.*, 2009). The MMSE includes 12 test items that objectively assess different cognitive domains: (1) *time orientation* (5 points); (2) *place orientation* (5 points); (3) *registration* of three words (3 points); (4a) *calculation* (mentally subtracting seven iteratively from 100, 5 points); (4b) *reverse spelling* (mentally spelling backwards a word presented auditorily); (5) *delayed recall* of the three words presented earlier (3 points); (6) *naming objects* (2 points); (7) *repeating a sentence* (1 point); (8) *listening and obeying* (following a three-stage mmand, 3 points); (9) *reading and obeying* (following a message printed on a card, 1 point); (10) *writing sentences* (1 point); and (11) *copying figures* (copying figures on a sheet of paper, 1 point). Item scores were summed to give the total MMSE score (ranging between 0 and 30), with higher scores reflecting a higher level of global cognitive performance. Although in the original MMSE procedure (Folstein *et al.* 1975), item 4b, *reverse spelling*, was conducted only if participants refused to perform item 4a, *calculation*, both items were implemented in this study. As previously reported (Holtsberg, *et al.* 1995),

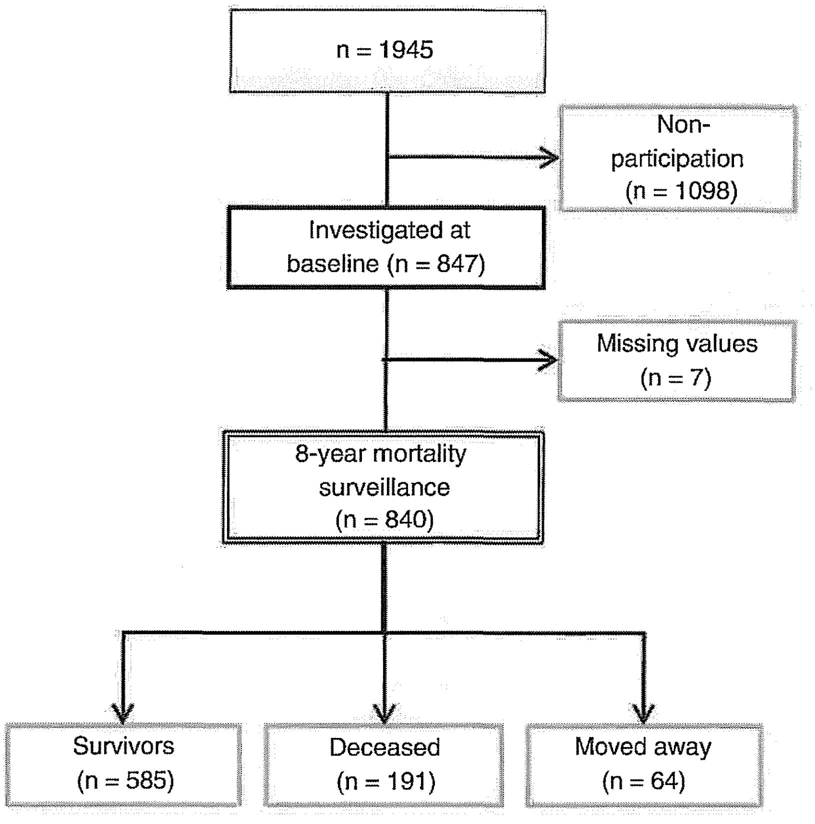

Figure 1 Study sample in the analysis.

the higher of the two scores from item 4a, *calculation*, and item 4b, *reverse spelling*, was used for computing the total MMSE score. Thus, in this study, the number of participants for item 4a differed from those of other items because some subjects refused to perform this task ($n = 25$).

We divided the MMSE total score into the following three categories: low (0–23 points), middle (24–27points), and high (28–30 points), based on a previous protocol (Gussekloo *et al.*, 1997; Xu *et al.*, 2002). Subjects obtaining 0–23 points were considered to possibly have a cognitive impairment (Tombaugh and McIntyre, 1992).

When analyzing the MMSE subscales, all subscale scores were dichotomized as either completely correct or incorrect according to the score in each subscale. This method was based on a previous protocol (Ishizaki *et al.*, 1998). For example, for the *time orientation* subscale (max = 5 points), participants who scored 5 were considered to have responded correctly and were given 1 point. Those who scored 4 or lower were classified as being incorrect and were given 0 point.

Other measurements

Data for baseline characteristics were used as covariates in the analysis to identify independent associations between cognitive performance and mortality, and to describe the characteristics of the study participants. Data for age, gender, education level, chronic disease, sensory deficit, depressive symptoms (Sheehan, *et al.*, 1998), instrumental activities of daily living (IADL, measured according to the Tokyo Metropolitan Institute of Gerontology Index of Competence [Koyano, *et al.*, 1991]), and self-rated health were included. Chronic disease was self-reported by the participants. Chronic disease was defined as experiencing at least one of the following diseases: history of stroke, heart disease, or diabetes mellitus. Sensory deficit was self-reported by the participants and was defined as experiencing at least one of the following: hearing loss or eyesight problems. To assess IADL, participants were asked to judge whether they were independent with respect to the five daily IADL tasks (e.g., using public transportation and preparing meals) (Koyano *et al.*, 1991). Higher scores reflect a higher level of functioning in IADL. In this study, a cut-off score of 4/5 (meaning that scores of 4 and below were classified as IADL dependent) was used to judge whether participants were dependent with respect to IADL (Ishizaki *et al.*, 2006).

Statistical analysis

We carried out χ^2 tests for categorical variables and analysis of variance for continuous variables to examine differences in baseline characteristics between groups (i.e., survivors *versus* deceased *versus* dropouts). We also carried out χ^2 tests to examine differences in the MMSE subscale scores between the groups. Cox proportional hazards models, controlling for age, gender, education level, chronic disease, sensory deficit, depressive symptoms, and IADL, were used to test the independent relationships between each cognitive performance and all-cause mortality. All statistical procedures were
Q2 performed using SPSS 19.0 for Windows.

Results

During the 8-year follow-up, of the 840 adults, 191 (139 men and 52 women) died and 64 (31 men and 33 women) moved to a different region of Japan and were lost to follow-up.

T1 Table 1 shows the characteristics of the members in the follow-up cohort, collected in 2002, including age, gender, education level, chronic disease, sensory deficit, depressive symptoms, IADL, the distribution of MMSE scores, and mean duration of follow-up. Deceased individuals were more likely to be older ($p < 0.001$), men ($p < 0.001$), and have chronic diseases ($p = 0.012$). They were also more likely to have a lower IADL score ($p < 0.001$), exhibit lower health status ($p = 0.002$), display lower sensory function ($p < 0.001$), and have lower MMSE scores ($p < 0.001$), compared with survivors/dropouts.

Table 2 shows the MMSE subscale scores. Deceased T2
individuals had lower scores in the seven tasks—*time orientation, place orientation, calculation, reverse spelling, delayed recall, repeated sentences*, and *copying figures*. Because the number who answered items incorrectly in subscales 6 (*naming objects*) and 9 (*reading and obeying*) was so small, we did not conducted any analysis on those subscales.

Figure 2 shows the Kaplan–Meier survival curves F2
corresponding to the relationship between global cognition and mortality. The risk of mortality was significantly higher for lower functioning individuals than for higher functioning individuals (log-rank test: $p < 0.001$).

Table 3 shows the independent association between T3
global cognition and mortality. Following multivariate Cox regression analysis, adjusted for the potential confounders cited earlier, global cognition (hazard ratio [HR] = 1.59, 95% confidence interval [CI] = 1.14 to 2.23 and HR = 2.81, 95% CI = 1.77 to 4.36 for the middle [24–27 points] and lowest [0–23 points] categories, respectively) was significantly and independently associated with mortality.

Table 4 shows the independent associations between T4
MMSE subscale scores and mortality. Following multivariate Cox regression analysis, adjusted for the potential confounders cited earlier, *time orientation* (HR = 1.56, 95% CI: 1.12 to 2.18), *place orientation* (HR = 1.87, 95% CI: 1.37 to 2.56), *calculation* (HR = 1.81, 95% CI: 1.30 to 2.52), *reverse spelling* (HR = 1.42, 95% CI: 1.06 to 1.90), *delayed recall*

Table 1 Distribution of participants' characteristics at baseline ($N = 840$)

	Survivors ($n = 585$)	Deceased ($n = 191$)	Dropouts ($n = 64$)	p-value[b]
Age, mean ± SD (years)	75.6 ± 3.4	77.6 ± 3.8	76.5 ± 4.0	<0.001
Gender (women), *n* (%)	301 (51.5)	52 (27.2)	33 (51.6)	<0.001
Number of years of education, mean ± SD (years)	10.6 ± 2.9	10.9 ± 3.4	10.1 ± 3.7	0.235
Chronic diseases (present), *n* (%)[a]	206 (35.2)	86 (45.0)	31 (48.4)	0.012
Instrumental activities of daily living (dependent), *n* (%)	72 (12.3)	52 (27.2)	9 (14.1)	<0.001
Self-rated health (fair/poor), *n* (%)	108 (18.5)	58 (30.7)	15 (23.4)	0.002
Sensory deficit, *n* (%)	62 (10.6)	42 (22.0)	4 (6.3)	<0.001
Depressive symptoms, *n* (%)	12 (2.1)	7 (3.7)	1 (1.6)	0.404
MMSE, mean ± SD (scores)	28.3 ± 2.1	26.9 ± 3.2	27.9 ± 2.5	<0.001
Duration of follow-up, mean ± SD (years)[c]	8.0	4.7 (2.0)	3.8 (2.2)	–

MMSE, Mini Mental State Examination.

[a]Chronic disease was defined as having at least one of the following diseases: stroke, heart disease, or diabetes mellitus.

[b]χ^2 tests for categorical variables and analysis of variance for continuous variables were used to examine differences in baseline characteristics between groups (survivors *versus* deceased *versus* dropouts).

[c]All survivors were followed up for 8 years (i.e., from January 1, 2003 to January 1, 2011).

Table 2 Number of participants who answered incorrectly on each subscales of the MMSE ($N = 840$)[a]

	Survivors ($n = 585$)	Deceased ($n = 191$)	Dropouts ($n = 64$)	p-value[b]
1. Time orientation, n (%)	81 (13.8)	50 (26.2)	13 (20.3)	<0.001
2. Place orientation, n (%)	103 (17.6)	63 (33.0)	16 (25.0)	<0.001
3. Registration (immediate recall), n (%)	10 (1.7)	7 (3.7)	2 (3.1)	0.256
4a. Calculation, n (%)[c]	330 (57.8)	134 (73.2)	32 (52.5)	<0.001
4b. Reverse spelling, n (%)	205 (35.0)	89 (46.6)	25 (39.1)	0.017
5. Delayed recall, n (%)	257 (43.9)	120 (62.8)	41 (64.1)	<0.001
6. Naming objects, n (%)	3 (0.5)	1 (0.5)	3 (4.7)	–
7. Repeating a sentence, n (%)	40 (6.8)	29 (15.2)	5 (7.8)	0.002
8. Listening and obeying, n (%)	5 (0.9)	5 (2.6)	1 (1.6)	0.174
9. Reading and obeying, n (%)	3 (0.5)	3 (1.6)	1 (1.6)	–
10. Writing sentences, n (%)	32 (5.5)	15 (7.9)	6 (9.4)	0.289
11. Copying figures, n (%)	30 (5.1)	19 (9.9)	6 (9.4)	0.041

MMSE, Mini Mental State Examination.
[a]When analyzing the MMSE subscales, all MMSE subscale scores were dichotomized as either correct or incorrect, according to the score for each subscale.
[b]χ^2 tests were used to examine differences in number (%) of participants who answered MMSE subscale items incorrectly. Because the number who answered items incorrectly in subscales 6 and 9 was so small, we did not conducted any analysis on those subscales.
[c]The number of participants for item 4a (*calculation*) ($n = 815$) differed from those for other items because some subjects refused to perform this task ($n = 25$).

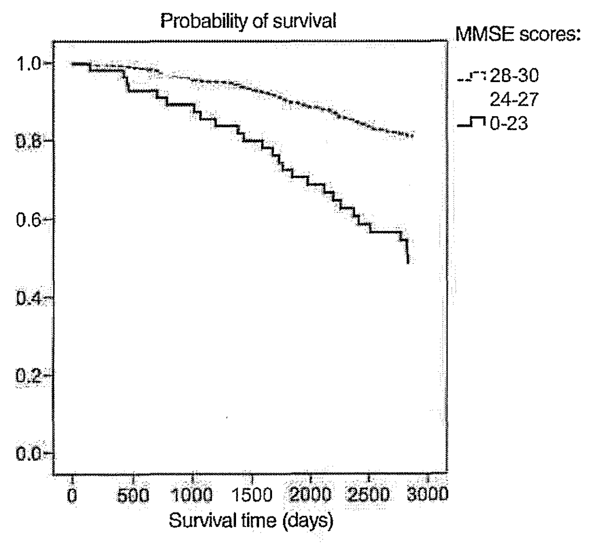

Figure 2 Unadjusted Kaplan–Meier survival curves exploring differences in all-cause mortality between levels of global cognition (measured by Mini Mental State Examination [MMSE]) at baseline over the 8-year follow-up period. Risk of mortality significantly varied according to the level of global cognition (log-rank test: $p < 0.001$). The vertical axis indicates probability of survival. The horizontal axis indicates survival time (days).

(HR = 1.65, 95% CI: 1.22 to 2.25), *repeating a sentence* (HR = 1.53, 95% CI: 1.02 to 2.30), and *copying figures* (HR = 1.95, 95% CI: 1.20 to 3.15) were significantly and independently associated with mortality. Among the subscales, *registration, naming objects, listening and obeying, reading and obeying,* and *writing sentences* were not analyzed because these subscale scores were not associated significantly with mortality in the univariate analyses (Table 3).

To examine whether the relationships between cognitive performance on the MMSE subscales and mortality were affected by cognitive impairment at baseline, we performed the aforementioned analysis excluding possible cases of cognitive impairment based on the MMSE total score. We used a cut-off score of 24, meaning that scores of 23 and below were classified as possible cognitive impairment (Tombaugh and McIntyre 1992) ($n = 57$). The results revealed that, after excluding subjects with a score of 23 or below, the association of *place orientation* (HR = 1.57, 95% CI: 1.09 to 2.25), *calculation* (HR = 1.67, 95% CI: 1.18 to 2.35), and *delayed recall* (HR = 1.42, 95% CI: 1.03 to 1.96) with mortality remained significant.

Table 3 Adjusted hazard ratios of all-cause mortality by MMSE total score ($N = 840$)[a]

MMSE total score	N	Deceased	Hazard ratio (95% confidence interval)	p-value
28–30 (ref.)	588	107	1	
24–27	195	57	1.59 (1.14–2.23)	0.007
0–23	57	27	2.81 (1.79–4.36)	<0.001

MMSE, Mini Mental State Examination.
[a]Adjusted for baseline characteristics (including age, gender, education level, chronic disease, sensory deficit, depressive symptoms, and instrumental activities of daily living).

Table 4 Adjusted hazard ratios of all-cause mortality for each subscale of the MMSE[a,b]

	Total ($n = 840$)				Individuals with no cognitive impairment ($n = 783$)[c]			
	N	Deceased	Hazard ratio (95% confidence interval)	*p*-value	*N*	Deceased	Hazard ratio (95% confidence interval)	*p*-value
1. Time orientation								
Correct (ref.)	696	141	1		679	135	1	
Incorrect	144	50	1.56 (1.12–2.18)	0.009	104	29	1.24 (0.82–1.87)	0.303
2. Place orientation								
Correct (ref.)	658	128	1		637	122	1	
Incorrect	182	63	1.87 (1.37–2.56)	<0.001	146	42	1.57 (1.09–2.25)	0.013
4a. Calculation[d]								
Correct (ref.)	319	49	1		314	47	1	
Incorrect	496	134	1.81 (1.30–2.52)	<0.001	456	111	1.67 (1.18–2.35)	0.004
4b. Reverse spelling								
Correct (ref.)	521	102	1		511	96	1	
Incorrect	319	89	1.42 (1.06–1.90)	0.002	272	68	1.34 (0.97–1.87)	0.079
5. Delayed recall								
Correct (ref.)	422	71	1		417	71	1	
Incorrect	418	120	1.65 (1.22–2.25)	<0.001	366	93	1.42 (1.03–1.96)	0.034
7. Repeating a sentence								
Correct (ref.)	766	162	1		733	145	1	
Incorrect	74	29	1.53 (1.02–2.30)	0.037	50	19	1.44 (0.88–2.38)	0.148
11. Copying figures								
Correct (ref.)	785	172	1		742	154	1	
Incorrect	55	19	1.95 (1.20–3.15)	0.007	41	10	1.31 (0.68–2.50)	0.416

MMSE, Mini Mental State Examination.
[a]Adjusted for baseline characteristics (including age, gender, education level, chronic disease, sensory deficit, depressive symptoms, and instrumental activities of daily living).
[b]All MMSE subscale scores were dichotomized into either completely correct or incorrect, according to the score in each subscale.
[c]Individuals with possible cognitive impairment (MMSE < 24) were excluded.
[d]The number of participants for the item 4a (*calculation*) differed from those for other items because some subjects refused to perform this task. Total sample analysis, $n = 815$; analysis excludes individuals with cognitive impairment ($n = 770$).

Discussion

In this study, we examined the relationship between cognitive performance and all-cause mortality among community-dwelling older people in Japan. Our findings indicate that global cognitive function (measured using the MMSE) predicts mortality after adjusting for potential confounders, such as age, gender, education level, chronic disease, sensory deficit, depressive symptoms, and IADL. In addition, among the MMSE subscales, *place orientation*, *calculation*, and *delayed recall* were significantly and independently associated with mortality. Our study suggests that older individuals with lower levels of cognitive function are more likely to have shorter lives, based on the 8-year follow-up, compared with those with higher cognitive functioning.

Our findings are similar to the results of previous studies showing a relationship between global cognition (measured using the MMSE) and mortality among community-dwelling older adults (Kelman *et al.*, 1994; Bruce *et al.*, 1995; Gussekloo *et al.*, 1997; Fredman *et al.*, 1999; Korten *et al.*, 1999; Andersen *et al.*, 2002; Nguyen *et al.*, 2003). The findings of these studies and our present report suggest that global cognition is a predictor of mortality among community-dwelling older adults. In addition, the association between global cognition and mortality was significant not only in individuals with possible cognitive impairment (i.e., MMSE total score of 0–23 points) but also in individuals exhibiting a mild deficit in global cognition (i.e., MMSE score of 24–27 points), which is consistent with the previous study (Gussekloo *et al.*, 1997). Previous studies indicate that individuals with cognitive impairment are more likely to have shorter lives, compared with those who are not cognitively impaired (Dewey and Saz, 2001). Our study also confirmed that older individuals who exhibit a mild deficit in global cognition are more likely to have a shorter lifespan, compared with those who are cognitively intact.

We speculate that there are four possible reasons why individuals who exhibited a mild deficit in global cognition (i.e., MMSE score of 24–27 points) were more likely to have shorter lives in this study. The first possible reason is the presence of potential cases of dementia. We divided participants into two groups, using a cut-off score of 24 in the MMSE, and regarded those who had 23 points or lower as having a possible cognitive impairment. A meta-analytic study for the accuracy of the MMSE for the detection of dementia (Mitchell, 2009) reported that the sensitivity and specificity were 79.8% and 81.3% in memory clinic settings, respectively, and that the sensitivity and specificity were 85.1% and 85.5% in non-clinical community settings, respectively. This indicates that the MMSE alone has modest accuracy for dementia diagnosis. As dementia diagnosis was not conducted by a specialist in our study, we cannot exclude the possibility that potential cases of dementia, who generally have poor survival rates (Dewey and Saz, 2001), may have been accidentally included in the group exhibiting a mild deficit in global cognition.

The second possible reason is that individuals who exhibit a mild deficit in global cognition may represent individuals with *mild cognitive impairment* (MCI) (Petersen *et al.*, 2001). Because individuals with MCI are prone to develop dementia (Kluger *et al.*, 1999), they may also be more likely to have a shorter lifespan. In addition, recent studies have demonstrated that individuals with MCI *per se* are more likely to have a shorter lifespan (Guehne *et al.*, 2006).

The third possible reason is physical health status. Cognitive performance among older adults is prone to be affected by physical health status (Tombaugh and McIntyre, 1992), such as functional disability, hearing loss, and chronic disease, which are all closely related to mortality (Korten *et al.*, 1999; Ostbye *et al.*, 1999; Kattainen *et al.*, 2004; Spiers *et al.*, 2005; Takata *et al.*, 2007; Lee *et al.*, 2008). Thus, individuals who exhibited a mild deficit in global cognition (MMSE scores of 24–27) may be likely to have poor physical health, and consequently, they may be more likely to have shorter lives as well. However, because we conducted a multivariate analysis, adjusted for such confounders (including, IADL, sensory function, and chronic disease), to examine the independent associations between cognition and mortality, this possibility is unlikely.

The fourth possible reason may be related to *health literacy*. Individuals who exhibit a mild deficit in global cognition may be less likely in their everyday life to seek appropriate medical care and health information to promote and maintain good health. Thus, they may tend to have a shorter lifespan, especially among older adults. Recent public health studies have focused on health literacy, which are skills that determine the motivation and ability of individuals to gain access to, understand, and use health information (Nutbeam, 1998). Health literacy was reportedly positively associated with cognitive function among older adults (McDougall *et al.*, 2012). In addition, older adults who have low cognitive function were less likely to take part in health surveys (Launer *et al.*, 1994) and checkups (Yoshida *et al.*, 2008) conducted in the community, suggesting that they are less likely to be motivated to keep fit. Therefore, it is possible that because of poor health literacy, individuals who exhibit a mild deficit in global cognition may be more likely to have a shorter lifespan.

The MMSE subscale scores including *time orientation*, *place orientation*, *calculation*, *reverse spelling*, *delayed recall*, *repeating a sentence*, and *copying figures* were significantly and independently associated with mortality, suggesting that these subscales individually can predict early death among older adults. The associations of the MMSE subscales *place orientation*, *calculation*, and *delayed recall* with mortality remained statistically significant after excluding subjects with possible cognitive impairment, defined by a cut-off MMSE score of 23 (Tombaugh and McIntyre, 1992). This finding suggests that these items predict mortality independently of cognitive impairment. In contrast, the associations of the subscales *time orientation*, *reverse spelling*, *repeating a sentence*, and *copying figures* with mortality diminished when subjects who had possible cognitive impairment were excluded from the analyses. These findings suggest that the associations between these four tasks and mortality are significantly affected by cognitive impairment. That is, performance in the four tasks may predict mortality among older adults, but apparently, only in combination with cognitive impairment. As mentioned earlier, because we did not conduct dementia diagnosis at baseline in this study, we cannot completely exclude the influence of possible cases of dementia. Therefore, our preceding interpretations need to be further investigated.

The generalization of our findings may also be limited for two reasons: First, the representativeness of the sample in this study may have been restricted. The participation rate at baseline was relatively low (43.2% participation) because we acquired the data by administering mass health checkups. Therefore, participants in our study may differ in health characteristics from non-participants because of self-selection bias (Iwasa *et al.*, 2007). Second, the relationship between cognitive performance on the MMSE items and mortality found in this study might differ from those in Western countries. Although the validity of the Japanese version of the MMSE has already been confirmed and its mean scores are remarkably similar to those of the Westerners (Ishizaki, *et al.*, 1998), a recent study pointed out differences in performance on subscales of the MMSE between Japanese and a US cohort

(Dodge *et al.*, 2009). We therefore should attend to these previous findings when considering the generalizability of our findings.

Conclusions

In this study, we examined the relationship between cognitive performance and all-cause mortality among community-dwelling older individuals in Japan. Our findings indicated that global cognition (assessed using the MMSE) predicted mortality after adjusting for potential confounders. Among the MMSE subscales, *place orientation*, *calculation*, and *delayed recall* were significantly and independently associated with mortality. Given that the MMSE is relatively easy to administer, it could be of value during annual health checkups and in primary care settings to detect risk of early death in the community older population. Our results may thus help to facilitate the development of longevity-promoting strategies, and they underscore the importance of early detection and treatment of cognitive decline in older adults. Future research using a longer continuous follow-up survey would be of value to elucidate the relationship between cognition and mortality more clearly, with accompanying data regarding cause of death and professional diagnosis of possible dementia.

Conflicts of interest

None declared.

Author contributions

HI engaged in study conceptualization, data collection, data analysis, and interpretation of results, in addition to writing and editing the manuscript. YY, TS, HK, and HY contributed to data collection, interpretation of results, and discussions on the manuscript. IK contributed to interpretation of results and discussions on the manuscript.

Key points

- This study found the longitudinal relationship between global cognition (measured by the MMSE) and all-cause mortality among community older adults.
- Among the MMSE subscales, *place orientation*, *calculation*, and *delayed recall* were also associated with mortality.

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References

Andersen K, Nybo H, Gaist D, *et al.* 2002. Cognitive impairment and mortality among nonagenarians: the Danish 1905 cohort survey. *Dement Geriatr Cogn Disord* 13: 156-163.

Bruce ML, Hoff RA, Jacobs SC, Leaf PJ. 1995. The effects of cognitive impairment on 9-year mortality in a community sample. *J Gerontol B Psychol Sci Soc Sci* 50: P289-P296.

Dewey ME, Saz P. 2001. Dementia, cognitive impairment and mortality in persons aged 65 and over living in the community: a systematic review of the literature. *Int J Geriatr Psychiatry* 16: 751-761.

Dodge HH, Meguro K, Ishii H, *et al.* 2009. Cross-cultural comparisons of the Mini-mental State Examination between Japanese and U.S. cohorts. *Int Psychogeriatr* 21:113-122.

Folstein MF, Folstein SE, McHugh PR. 1975. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 12: 189-198.

Fredman L, Magaziner J, Hebel JR, Hawkes W, Zimmerman SI. 1999. Depressive symptoms and 6-year mortality among elderly community-dwelling women. *Epidemiology* 10: 54-59.

Guehne U, Angermeyer MC, Riedel-Heller S. 2006. Is mortality increased in mildly cognitively impaired individuals? A systematic literature review. *Dement Geriatr Cogn Disord* 21: 403-410.

Gussekloo J, Westendorp RG, Remarque EJ, *et al.* 1997. Impact of mild cognitive impairment on survival in very elderly people: cohort study. *BMJ* 315: 1053-1054.

Holtsberg PA, Poon LW, Noble CA, Martin P. 1995. Mini-Mental State Exam status of community-dwelling cognitively intact centenarians. *Int Psychogeriatr* 7: 417-427.

Inagaki H, Gondo Y, Hirose N, *et al.* 2009. Cognitive function in Japanese centenarians according to the Mini-Mental State Examination. *Dement Geriatr Cogn Disord* 28: 6-12.

Ishizaki J, Meguro K, Ambo H, *et al.* 1998. A normative, community-based study of Mini-Mental State in elderly adults: the effect of age and educational level. *J Gerontol B Psychol Sci Soc Sci* 53: P359-P363.

Ishizaki T, Yoshida H, Suzuki T, *et al.* 2006. Effects of cognitive function on functional decline among community-dwelling non-disabled older Japanese. *Arch Gerontol Geriatr* 42: 47-58.

Iwasa H, Yoshida H, Kim H, *et al.* 2007. A mortality comparison of participants and non-participants in a comprehensive health examination among elderly people living in an urban Japanese community. *Aging Clin Exp Res* 19: 240-245.

Johnson JK, Lui LY, Yaffe K 2007. Executive function, more than global cognition, predicts functional decline and mortality in elderly women. *J Gerontol A Biol Sci Med Sci* 62: 1134-1141.

Kattainen A, Reunanen A, Koskinen S, *et al.* 2004. Disability predicted mortality in men but not women with coronary heart disease. *J Clin Epidemiol* 57: 513-521.

Kelman HR, Thomas C, Kennedy GJ, Cheng J 1994. Cognitive impairment and mortality in older community residents. *Am J Public Health* 84: 1255-1260.

Kluger A, Ferris SH, Golomb J, Mittelman MS, Reisberg B. 1999. Neuropsychological prediction of decline to dementia in nondemented elderly. *J Geriatr Psychiatry Neurol* 12: 168-179.

Korten AE, Jorm AF, Jiao Z, *et al.* 1999. Health, cognitive, and psychosocial factors as predictors of mortality in an elderly community sample. *J Epidemiol Community Health* 53: 83-88.

Koyano W, Shibata H, Nakazato K, Haga H, Suyama Y. 1991. Measurement of competence: reliability and validity of the TMIG Index of Competence. *Arch Gerontol Geriatr* 13: 103-116.

Launer LJ, Wind AW, Deeg DJ. 1994. Nonresponse pattern and bias in a community-based cross-sectional study of cognitive functioning among the elderly. *Am J Epidemiol* 139: 803-812.

Lavery LL, Dodge HH, Snitz B, Ganguli M. 2009. Cognitive decline and mortality in a community-based cohort: the Monongahela Valley Independent Elders Survey. *J Am Geriatr Soc* 57: 94-100.

Lee SJ, Go AS, Lindquist K, Bertenthal D, Covinsky KE. 2008. Chronic conditions and mortality among the oldest old. *Am J Public Health* **98**: 1209-1214.

McDougall GJ, Jr., Mackert M, Becker H 2012. Memory performance, health literacy, and instrumental activities of daily living of community residing older adults. *Nurs Res* **61**: 70-75.

Mitchell AJ. 2009. A meta-analysis of the accuracy of the mini-mental state examination in the detection of dementia and mild cognitive impairment. *J Psychiatr Res* **43**: 411-431.

Nguyen HT, Black SA, Ray LA, Espino DV, Markides KS. 2003. Cognitive impairment and mortality in older mexican americans. *J Am Geriatr Soc* **51**: 178-183.

Nutbeam D. 1998. Health promotion glossary. *Health Promot Int* **13**: 349-364.

Ostbye T, Steenhuis R, Wolfson C, Walton R, Hill G. 1999. Predictors of five-year mortality in older Canadians: the Canadian Study of Health and Aging. *J Am Geriatr Soc* **47**: 1249-1254.

Petersen RC, Doody R, Kurz A, *et al.* 2001. Current concepts in mild cognitive impairment. *Arch Neurol* **58**: 1985-1992.

Portin R, Muuriaisniemi ML, Joukamaa M, *et al.* 2001. Cognitive impairment and the 10-year survival probability of a normal 62-year-old population. *Scand J Psychol* **42**: 359-366.

Rosano C, Newman AB, Katz R, Hirsch CH, Kuller LH. 2008. Association between lower digit symbol substitution test score and slower gait and greater risk of mortality and of developing incident disability in well-functioning older adults. *J Am Geriatr Soc* **56**: 1618-1625.

Sheehan DV, Lecrubier Y, Sheehan KH, *et al.* 1998. The Mini-International Neuropsychiatric Interview (M.I.N.I.): the development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *J Clin Psychiatry* **59**(Suppl 20): 22-33.

Small BJ, Backman L. 1997. Cognitive correlates of mortality: evidence from a population-based sample of very old adults. *Psychol Aging* **12**: 309-313.

Smits CH, Deeg DJ, Kriegsman DM, Schmand B. 1999. Cognitive functioning and health as determinants of mortality in an older population. *Am J Epidemiol* **150**: 978-986.

Spiers NA, Matthews RJ, Jagger C, *et al.* 2005. Diseases and impairments as risk factors for onset of disability in the older population in England and Wales: findings from the Medical Research Council Cognitive Function and Ageing Study. *J Gerontol A Biol Sci Med Sci* **60**: 248-254.

Suzuki T, Kwon J, Kim H, *et al.* 2008. Low serum 25-hydroxyvitamin D levels associated with falls among Japanese community-dwelling elderly. *J Bone Miner Res* **23**: 1309-1317.

Takata Y, Ansai T, Akifusa S, *et al.* 2007. High-level functional capacity and 4-year mortality in an 80-year-old population. *Gerontology* **53**: 46-51.

Tombaugh TN, McIntyre NJ. 1992. The mini-mental state examination: a comprehensive review. *J Am Geriatr Soc* **40**: 922-935.

Villarejo A, Bermejo-Pareja F, Trincado R, *et al.* 2011. Memory impairment in a simple recall task increases mortality at 10 years in non-demented elderly. *Int J Geriatr Psychiatry* **26**: 182-187.

Yoshida Y, Iwasa H, Kwon J, *et al.* 2008. Characteristics of non-participants in comprehensive health examinations ("Otasha-kenshin") among an urban community dwelling elderly: basic research for prevention of the geriatric syndrome and a bed-ridden state. *Nihon Koshu Eisei Zasshi* **55**: 221-227. (In Japanese)

Xu G, Meyer JS, Thornby J, Chowdhury M, Quach M. 2002. Screening for mild cognitive impairment (MCI) utilizing combined mini-mental-cognitive capacity examinations for identifying dementia prodromes. *Int J Geriatr Psychiatry* **17**: 1027-1033.

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RESEARCH ARTICLE Open Access

Community-based intervention to improve dietary habits and promote physical activity among older adults: a cluster randomized trial

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Abstract

Background: The fastest growing age group globally is older adults, and preventing the need for long-term nursing care in this group is important for social and financial reasons. A population approach to diet and physical activity through the use of social services can play an important role in prevention. This study examined the effectiveness of a social health program for community-dwelling older adults aimed at introducing and promoting physical activity in the home at each individual's pace, helping participants maintain good dietary habits by keeping self-check sheets, and determining whether long-standing unhealthy or less-than-ideal physical and dietary habits can be changed.

Method: This cluster randomized trial conducted at 6 community centers in an urban community involved 92 community-dwelling older adults aged 65–90 years. The intervention group (3 community centers; n = 57) participated in the social health program "Sumida TAKE10!" which is an educational program incorporating the "TAKE10!® for Older Adults" program, once every 2 weeks for 3 months. The control group (3 community centers; n=35) was subsequently provided with the same program as a crossover intervention group. The main outcome measures were changes in food intake frequency, food frequency score (FFS), dietary variety score (DVS), and frequency of walking and exercise. The secondary outcome measures were changes in self-rated health, appetite, and the Tokyo Metropolitan Institute of Gerontology (TMIG) Index of Competence score.

Results: Compared to baseline, post-intervention food intake frequency for 6 of 10 food groups (meat, fish/shellfish, eggs, potatoes, fruits, and seaweed), FFS, and DVS were significantly increased in the intervention group, and interaction effects of FFS and DVS were seen between the two groups. No significant differences were observed between baseline and post-intervention in the control group. Frequency of walking and exercise remained unchanged in both groups, and no significant difference in improvement rate was seen between the groups. Self-rated health was significantly increased in the intervention group. Appetite and TMIG Index of Competence score were unchanged in both groups.

Conclusions: The social health program resulted in improved dietary habits, as measured by food intake frequency, FFS, and DVS, and may improve self-rated health among community-dwelling older adults.

Trial registration number: UMIN000007357

Keywords: Social health program, Community-dwelling older adults, Dietary variety, Physical activity, Self-rated health

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Background

The fastest growing age group globally is older adults, and in Japan the percentage of older adults has increased fourfold since 1960, from 5.7% in 1960 to 23.3% in 2011 [1]. Health promotion for older adults and the prevention of long-term care are important factors in maintaining a sound society. A population approach to diet and physical activity through the use of social services can play an important role in prevention, reach a large portion of the population, and be cost effective [2]. The health benefits of physical activity have been scientifically confirmed in older adults [3,4], and many community-based interventions on physical activity have shown improved physical function [5,6], improved cognitive function [7], reduced risk of falling [8,9], reduced decline in health-reported quality of life [10], and reduced healthcare costs [11]. Based on the scientific evidence available, the World Health Organization (WHO) [12], the American College of Sports Medicine, the American Heart Association [13], and other health related organizations have published specific recommendations on physical activity for older adults. However, the number of community-based interventions on diet has been relatively small, and nutritional intervention commonly consists of individual nutritional checkups and individual dietary counselling, or nutritional education from professionals on specific nutrients and supplements [14-17]. However, in a super-aging society like Japan, too few resources are available to provide professional advice for every individual and therefore simple health programs that promote a healthy diet are needed for community-dwelling older adults.

Against this background, we developed the "TAKE10!® for Older Adults" program for community-dwelling older adults to introduce and promote physical activity in the home at each individual's pace and to help participants maintain good dietary habits by keeping self-check sheets, even in the absence of professional advice [18]. The purpose of this study was to examine the effectiveness of a social program held at community centers that used the TAKE10!® for Older Adults program, and determine whether it could change long-standing unhealthy or less-than-ideal physical and dietary habits. We conducted a cluster randomized trial to avoid contamination across individuals and to eliminate any access barriers to participation in this intervention program [19-21].

TAKE10!® for Older Adults

"TAKE10" stands for eating regularly from 10 food groups and taking 10 min of physical activity at least 2–3 times per day. The program was developed in order to help community-dwelling older adults introduce physical activity into their lives and encourage their intake of a variety of foods. Physical capability, dietary habits, health status, and living environment among older adults vary greatly among individuals, and the program was designed to help older adults adjust the strength and frequency of their exercise as well as their food intake to correspond to individual capabilities and preferences. The contents of the TAKE10!® booklet are shown in Additional file 1: Appendix 1.

The program for physical activity recommends walking, stretching, muscle strengthening, and balance training in the home environment at the individual's own pace. There are 10 simple stretching exercises in total (e.g., upward, side, hamstring, hip, Achilles tendon, and quadriceps stretching) as well as 8 muscle strengthening exercises (e.g., plantar flexions, knee flexions, side leg raises, squats, and sit-ups). None of the exercises require equipment and therefore can easily be performed at home. WHO recommends at least 150 minutes of moderate-intensity aerobic physical activity throughout the week. TAKE10!® sets the initial goal slightly lower for older adults who have no established physical activity habits. We prepared a "TAKE10!® Calendar" record to enable participants to engage in physical activity by themselves (Additional file 2: Appendix 2).

The dietary program focuses on dietary variety. Some studies have shown that dietary variety is associated with health status in older adults and therefore can be used to indicate nutritional status [22-24]. One of the simple ways to promote a balanced intake of nutrients is having dietary variety, and such variety may be a good indicator of healthy dietary habits. Over consumption of energy-dense foods, which are nutrient-poor and high in fat, sugar, and salt, and inadequate consumption of fruits and vegetables are risk factors associated with an increased incidence of non-communicable diseases [2]. Moreover, inadequate protein intake causes adverse changes in the morphology and function of skeletal muscle in older adults [25,26]. We define a healthy diet for older adults as a well-balanced diet, and promote their intake of a variety of foods using a table of 10 food groups that correspond to the 10 main food groups of the Japanese diet without rice, namely meat, fish and shellfish, eggs, milk, soybean products, green and yellow vegetables, potatoes, fruits, seaweed, and fats and oils. For this purpose, we developed the "TAKE10!® Check Sheet"(Additional file 3: Appendix 3) to allow older adults to check the variety of foods in their diet quickly and easily, and ultimately improve their dietary habits, with an overall goal of maintaining good dietary habits.

In addition, information for older adults on subjects such as oral care, incontinence, and food safety are included in the TAKE10!® booklet (Additional file 1: Appendix 1).

Methods

Participants

The study was conducted at 6 community centers, each with >90 m^2 of floor space and air-conditioning, in

Sumida Ward in the Tokyo metropolitan area. Inclusion criteria were (1) participation in the "Sumida TAKE10" social health program conducted by Sumida Ward, (2) age ≥65 years; (3) understanding of the main study objectives and provision of informed consent, and (4) ability to travel independently to the closest participating community center. Exclusion criteria were (1) heart attack or stroke within the previous 6 months; (2) acute hepatic dysfunction or chronic active viral hepatitis, (3) fasting blood glucose >200 mg/dl, (4) diastolic blood pressure >180 mmHg and/or systolic blood pressure >100 mmHg, and (5) medical advice prohibiting exercise. Candidates were recruited by Sumida Ward through notifications printed in the Sumida Ward Bulletin delivered to all homes. A questionnaire on demographic, dietary, physical, and lifestyle characteristics was administered to all participants by researchers and program staff before and after intervention at each community center. Body weight and height were measured at the community centers by researchers and staff.

Sample size

Because a clinically meaningful difference in our main outcome measures could not be determined, only a provisional sample size was used. We estimated that individual randomization would require 36 participants per group for a trial with 80% power to detect a 10% difference between groups, with a 5% significance level. We assumed an intracluster correlation of 0.02 and 20 participants for each community center. Under these assumptions, we increased the sample size to 50 per group (design effect, 1.38) and cluster size was determined to be 3 per group.

Randomization

Randomization was conducted at the community center level to avoid contamination and to eliminate access barriers to participation in this program [19-21]. The 6 community centers in Sumida Ward (total area 13.75 km2) were randomized into the intervention group (3 centers) and control group (3 centers) using opaque envelopes by a public officer who was not involved in this study. Environmental factors such as access to transportation, public services, facilities, and basic culture around each of the 6 community centers did not differ substantially and all 6 centers are within a 2-kilometer radius of each other.

Effective blinding was not possible because both the subjects and researchers clearly understood the differences between the two groups.

Participant flow

The flow of participants is shown in Figure 1. From the 141 candidates for this study who were community-dwelling older adults living in Sumida Ward and

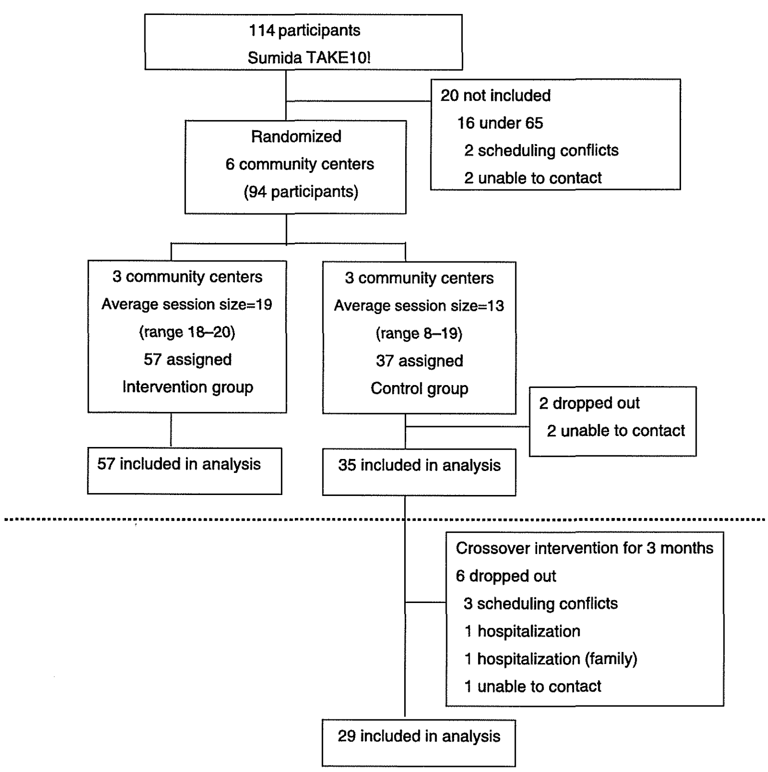

Figure 1 Participant flow.

participating in Sumida TAKE10!, 20 did not satisfy the following inclusion criteria: aged <65 years (n = 16), scheduling conflicts (n = 2), and unable to contact (n = 2). The remaining 94 participants were assigned to the intervention group (3 community centers; n = 57) or control group (3 community centers; n = 37) according to their home addresses. Baseline data was collected in October 2005 post-intervention data in January 2006. Two participants dropped out of the control group and 2 could not be contacted. Eventually, complete data were obtained for 57 participants in the intervention group and 35 participants in the control group.

Intervention

Six community centers were randomized to 3 community centers for the intervention group and 3 community centers for the control group. Participants in the intervention group participated in the Sumida TAKE10! program held from October 2005 to December 2006. Participants in the control group were required only to answer the questionnaire at the same time as the intervention group, and following the intervention, the control group was provided with the same Sumida TAKE10! program as a crossover intervention group to avoid any disadvantage and also to confirm whether the effect of the program could be verified.

The Sumida TAKE10! educational social health program was aimed at helping to prevent or delay the need for long-term nursing care. It consisted of a general lecture by a researcher on the importance of dietary variety and 5 educational sessions (1.5 hours each, held once every 2 weeks) lead by researchers and staff and held at each community center. The same researchers and staff conducted the same intervention program at each community center. The sessions, which were based on the TAKE10!® program, were comprised of approximately a 30-minute lecture on practicing good dietary habits followed by 1 hour of exercise. At the first session, each participant received an explanation on how to use the TAKE10!® Check Sheet and were then required to check their diet for the following 10 days so they could gain a better understanding of their dietary habits. At the second session, participants brought the check sheets with them and analyzed the sheets themselves in the lecture to determine which food groups were not well represented and they were encouraged to increase their intake from these food groups. The check sheet was submitted every session and returned the following session with simple comments such as "Good!" "Better than before!" and "Keep up the good work!"

During the exercise program, participants were instructed in the proper way to perform each stretching and muscle strengthening exercise and the reasoning behind each exercise. After instruction, each stretching exercise was performed 2 times to the right and to the left, and muscle strengthening exercises were each performed 3–5 times at a slow pace. Researchers and staff assisted all participants who did not currently have any physical activity habits. Exercise at home by walking at a self-determined pace, stretching daily, and doing muscle strength training once every two days was recommended. Participants recorded their daily TAKE10! exercise, or lack of exercise, on the TAKE10!® Calendar and submitted it once a month. After review, we returned the Calendar with basic comments as for the TAKE10!® Check Sheet. In all sessions, priority was placed on following any instructions from the participant's primary physician.

In this study, we aimed to determine whether decades-long habits of community-dwelling older adults could be changed by means of the TAKE10!® for Older Adults program, without receiving detailed individualized professional advice.

Main outcomes: dietary and physical activity habit outcomes

We evaluated changes in food intake (frequency of intake of the 10 food groups) and physical activity (frequency of walking and exercise). Food intake was assessed using a questionnaire on food intake frequency covering 1 week and covering the main 10 food groups in the Japanese diet mentioned above. There were 4 choices for food intake frequency for each food group: 1) eat almost every day (3 points), 2) eat 3 or 4 days a week (2 points), 3) eat 1 or 2 days a week (1 point), and 4) eat hardly ever (0 point). We then calculated a food frequency score (FFS) as the sum of scores for each of the 10 food groups to evaluate dietary habits (range 0–30). Dietary variety score (DVS) was also calculated to evaluate dietary habits [27] and was the sum of the number of times each respondent answered "eat almost every day" for the 10 food groups (maximum score 10).

In a previous study, a higher DVS was associated with a reduced risk of higher-level functional decline [27], as determined using the Tokyo Metropolitan Institute of Gerontology (TMIG) Index of Competence score [28]: relative to a reference group with a DVS of 1–3, groups with a DVS of 4–8 or 9–10 showed significantly lower declines TMIG Index of Competence scores over a period of 5 years [27].

Frequency of physical activity was assessed using the questionnaire to determine the frequency of walking and of stretching and muscle strengthening exercise over a 1-week period.

Secondary outcomes: health and health practice outcomes

Data on self-rated health, appetite, and higher-level functional capacity were obtained with the questionnaire. Higher-level functional capacity was measured using the TMIG Index of Competence, a multidimensional 13-item index comprising 3 subscales of instrumental self-maintenance (IADL, 5 items), intellectual activity (4 items), and social roles (4 items). Each item was scored 1 for 'yes '(able to do) and 0 for 'no'. The TMIG Index of Competence has been verified for validity and reliability, and it is widely accepted in Japan [28].

Data analysis

Data were analyzed on an intention-to-treat basis. Mean and standard deviation (SD) was calculated for each variable. We compared the baseline characteristics of the intervention and control groups (between-group) using Student's t-test for continuous variables, a Chi-square test, and Fisher's exact test for proportional variables and Mann-Whitney's U-test for categorical variables. Baseline and post-intervention data were compared as follows: FFS, DVS, and the TMIG Index of Competence within each group using a paired t-test; frequency of intake of each food group, walking and exercise frequency, and self-rated health within each group using the Wilcoxon signed-rank test; and appetite within each group using

Table 1 Demographic characteristics and functional capacities of participants

Characteristics	Intervention (n = 57)	Control (n = 35)	*P*
Sex, n (%)			
Men	9 (15.8)	8 (22.9)	0.419[a]
Women	48 (84.2)	27 (77.1)	
Age in years, mean ± SD	74.3 ± 5.9	74.3 ± 5.0	0.969[c]
BMI, mean ± SD	24.3 ± 2.7	24.3 ± 3.1	0.941[c]
Preexisting conditions, n (%)	20 (35.1)	11 (31.4)	0.718[a]
Hypertension	16 (28.1)	9 (25.7)	0.805[a]
Diabetes mellitus	4 (7.0)	2 (5.7)	1.000[b]
Joint pain (arthritis)	3 (5.3)	2 (5.7)	1.000[b]
Heart disease	4 (7.0)	4 (11.4)	0.474[b]
Cerebrovascular disease	1 (1.8)	0 (0.0)	1.000[b]
Have experienced falls, n (%)	7 (12.3)	5 (14.3)	0.762[b]
Lifestyle			
Ability to walk 1 km (yes, n (%))	52 (91.2)	31 (88.6)	0.727[b]
Hobby activity (yes, n (%))	48 (84.2)	28 (80.0)	0.605[a]
Volunteer activity (yes, n (%))	49 (86.0)	30 (85.7)	1.000[b]
Older adult's group activity (yes, n (%))	47 (82.5)	29 (82.6)	0.961[a]
Friendly conversation with neighbors (2 days or more/w, n (%))	45 (78.9)	27 (77.1)	0.839[a]
Going out (2 days or more/w, n (%))	56 (98.2)	34 (97.1)	1.000[b]
Appetite (yes, n (%))	55 (96.5)	32 (91.4)	0.365[b]
Food Frequency Score (FFS), mean ± SD	21.5 ± 3.7	21.1 ± 5.3	0.690[c]
Dietary Variety Score (DVS), mean ± SD	4.2 ± 2.3	3.9 ± 2.9	0.577[c]
TMG-Index of competence, mean ± SD	12.4 ± 1.1	11.9 ± 1.4	0.062[c]
Instrumental self-maintenance, mean ± SD	4.9 ± 0.2	4.9 ± 0.3	0.538[c]
Intellectual activity, mean ± SD	3.7 ± 0.6	3.8 ± 0.5	0.792[c]
Social roles, mean ± SD	3.8 ± 0.5	3.3 ± 1.1	0.014[c]
Self-rated health, n (%)			0.657[d]
Very good	7 (12.3)	3 (8.6)	
Good	41 (71.9)	26 (74.3)	
Not good	9 (15.8)	6 (17.1)	

SD Standard deviations.
Chi-square test[a] or Fisher's exact test[b] for proportional variables.
Student's t-test[c] for continuous variables.
Mann-Whitney's U test[d] for categorical variables.