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Cognitive activity in a sitting position is protectively associated with cognitive impairment among older adults

Satoshi Kurita,[1] Takehiko Doi,[1] Kota Tsutsumimoto,[1,2] Ryo Hotta,[1] Sho Nakakubo,[1] Minji Kim[1] and Hiroyuki Shimada[1]

[1]Department of Preventive Gerontology, Center for Gerontology and Social Science, National Center for Geriatrics and Gerontology, Obu, Japan
[2]Japan Society for the Promotion of Science, Japan

Correspondence
Satoshi Kurita, Section for Health Promotion, Department of Preventive Gerontology, Center for Gerontology and Social Science, National Center for Geriatrics and Gerontology, 7-430 Morioka-cho, Obu City, Aichi Prefecture, 474-8511 Japan.
Email: kuritoshi@ncgg.go.jp

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Aim: Previous studies have obtained inconsistent results regarding the association between sedentary behavior and cognitive impairment. The present study aimed to examine the association between cognitive activity in a sitting position (CAS) and cognitive impairment among older adults.

Methods: Community-dwelling older adults, from Obu or Nagoya in Japan, participated in a survey in 2013. A total of 5300 participants (mean age 75.0 ± 5.1 years; women 52.9%) met the criteria for the present study. We assessed the frequency and variety of CAS composed of six activities, including reading books or newspapers, writing a diary or letters, solving crossword puzzles, playing board games, using a computer and maintaining housekeeping records. The frequency of engagement in CAS was one or more time(s)/week. The variety of CAS was assessed by the number of engagements in CAS. Cognitive impairment was defined by two or more tests at least 1.5 standard deviations below the reference threshold in four neuropsychological tests. Logistic regression analysis was carried out to examine the associations between the frequency and variety of CAS and cognitive impairment, adjusted for covariates.

Results: The proportion of participants engaging in each CAS varied from 12.3% (playing board games) to 93.6% (reading books or newspaper). After adjustment, five CAS were significantly associated with cognitive impairment (OR 0.33–0.65, all $P < 0.001$). The variety of CAS was significantly associated with the reduced OR of cognitive impairment (OR 0.61, 95% confidence interval 0.55–0.68).

Conclusions: Almost every CAS and a greater variety of CAS are associated with cognitive impairment among older people. **Geriatr Gerontol Int 2019; 19: 98–102.**

Keywords: cognitive activity, dementia, older adults, sedentary behavior.

Introduction

Suppressing cognitive impairment is important to prevent dementia, which is a serious worldwide health issue among older adults.[1] Among the factors related to dementia,[2] physical and cognitive activity are modifiable factors.[3] Although a physically and cognitively active lifestyle is thought to contribute to brain health, older adults are reportedly inclined to be sedentary for approximately 10 h/day.[4] A sedentary lifestyle might increase the risk of dementia, but the influence of sedentary behavior with cognitive activity on cognitive impairment remains unclear.

Sedentary behavior is a risk factor for chronic diseases, such as cardiovascular diseases and type 2 diabetes, and mortality.[5,6] As for the impact of sedentary behavior on cognitive impairment, a prospective cohort study found that excessive sedentary behavior led to worse cognitive function.[7] In contrast, objectively measured sedentary time had no significant association with cognitive impairment.[8] This might be partially because sedentary behavior has various forms. Among sedentary behavior, there were activities that are beneficial for cognitive function. For example, reading books and solving crossword puzzles, despite being sedentary behaviors, contributed to the reduced risk of dementia,[9] and longer sedentary time, including reading books and internet use, is associated with greater cognitive function.[10,11] However, it remains unclear as to which of these cognitive activities in a sitting position (CAS) are associated with cognitive impairment. Furthermore, whether there is an association between the variety or accumulation of CAS and cognitive function is still unclear. In addition, most previous studies that reported the effect of CAS on dementia did not consider the influence of physical activity and sitting time.[9,12,13]

The present study aimed to investigate whether there are associations between the frequency and variety of CAS and cognitive impairment among older adults, with respect to physical activity and sitting time. Although no study has developed an assessment tool for the duration of CAS, assessing the frequency of engaging in CAS, and including physical activity and sitting time into the statistical model would help to explore the association between engaging in CAS and cognitive impairment.

Methods

Participants

The present study used the database of the National Center for Geriatrics and Gerontology-Study of Geriatric Syndromes, a cohort study aimed to establish a screening system for geriatric syndromes, and to validate evidence-based interventions for preventing them. The detail of the survey has been described elsewhere.[14] Briefly, 5781 community-dwelling older people from Obu (June 2013) and Nagoya (July 2013 to December 2013) in Japan participated in a health checkup, including a face-to-face interview, and physical and cognitive function tests. The exclusion criteria were as follows: disability ($n = 16$); severe diseases, including dementia or Parkinson's disease ($n = 39$); general cognitive impairment (Mini-Mental State

Examination score <21;[15] $n = 162$); missing data for all variables ($n = 181$); and not meeting the inclusion criteria based on International Physical Activity Questionnaire ($n = 83$). In total, 5300 participants were included in the analysis. All participants provided informed consent before participation. The ethics committee of the National Center for Geriatrics and Gerontology approved the study protocol.

Assessment

Cognitive function

Cognitive function was assessed using a testing tool, the National Center for Geriatrics and Gerontology - Functional Assessment Tool.[16,17] Participants were accompanied by well-trained staff to ensure that the correct test protocols were followed. In the present study, cognitive impairment was assessed based on the following four cognitive domains: memory (word list memory-I [immediate recognition] and word list memory-II [delayed recall]), attention (an electronic tablet version of the Trail Making Test part A), executive function (an electronic tablet version of the Trail Making Test part B) and processing speed (an electronic tablet version of the Symbol Digit Substitution Test). These tests have acceptable test–retest reliability and moderate-to-high correlation with scores of widely-used conventional neurocognitive tests among community-dwelling older adults.[17] The standardized thresholds for each domain were determined by a score <1.5 standard deviations below the age- and education-specific mean for healthy older adults in the National Center for Geriatrics and Gerontology-Study of Geriatric Syndromes. Cognitive impairment was defined by low scores in two or more of the tests in the National Center for Geriatrics and Gerontology - Functional Assessment Tool.[14]

Cognitive activity in a sitting position

Based on previous studies, six cognitive activities, which are usually carried out in a sitting position, were used as CAS: reading books or newspapers; writing a diary or letters, without using a mobile or smart phone; solving crossword puzzles; playing board games (e.g. card games, Go or Japanese chess); using a computer, including internet use; and maintaining housekeeping records.[12,18] A 5-point scale was used for assessment of the frequency: every day, several times a week, once a week, once a month, once in several months and never.[9] Although this approach could not assess the duration of CAS, the 5-point scale was converted into one or more time(s)/week and less than one time/week to assess the frequency of CAS, based on a previous study.[19] In addition, the variety of CAS was assessed based on the number of CAS carried out one or more time(s)/week, which ranged from 0 to 6, with a higher number implying a greater variety of CAS.

Sitting time and physical activity

Sitting time and physical activity were evaluated using the International Physical Activity Questionnaire (IPAQ) - Short Form.[20] Sitting time was determined by asking the question: how much time do you usually spend sitting on an average weekday? The reason for specifying weekday was to reflect usual behavior for the IPAQ short form, as a result of the IPAQ validation process.[21] Physical activity was assessed using total metabolic equivalents-min per an average week of moderate-to-vigorous physical activity (MVPA) calculated based on six items that asked about the frequency and duration of vigorously intense physical activity (e.g. heavy lifting, digging, aerobics or fast bicycling), moderate intensity physical activity (e.g. carrying light loads, bicycling at a regular pace or playing doubles tennis) and walking. Based on the established methods posted on the IPAQ website, those who reported >960 min (16 h) of total duration of walking, and moderate and vigorous PA were excluded, and each activity was allocated a metabolic equivalents value.[22]

Covariates

Sociodemographic characteristics (age, sex and education level), whether employed (yes/no), instrumental activities of daily living limitation, the number of chronic diseases (hypertension, diabetes and hyperlipidemia) and depressive symptoms were assessed by face-to-face interviews. The number of chronic diseases per individual was categorized into: 0, one and two or more. Compliance with instrumental activities of daily living limitation was assessed based on the presence of one or more limitations in any of the three subitems: (i) using the bus or train by myself; (ii) buying daily necessities by myself; and (iii) managing my own deposits and savings at the bank by myself.[23] Depressive symptoms were assessed using the 15-item Geriatric Depression Scale (GDS), which contains 15 yes/no question items, and provides a score ranging from 0 to 15.[24]

Statistical analysis

The difference of the participants' characteristics between the groups with and without cognitive impairment was examined using the *t*-test for continuous variables, and the χ^2-test for discrete and ordinal variables. To compare the prevalence of cognitive impairment between engaging less than one and one or more time(s)/week for each cognitive activity, the χ^2-test was carried out. Transformations were used to improve the normality of distribution of sitting time and physical activity data (log [sitting time] and log [MVPA +0.5]). In addition, whether engaging in a greater variety of CAS was associated with a lower prevalence of cognitive impairment was examined using the Cochran–Armitage trend test. The association between the frequency or variety of engaging in CAS and cognitive impairment was assessed using logistic regression model. In order to test whether the association was affected by other factors, especially sitting time and physical activity, the adjustment variables were incorporated at three levels: crude model, model 1 (age, sex, education, number of chronic diseases and GDS score) and model 2 (model 1 + MVPA and sitting time). The Cochran–Armitage trend test was carried out using the JMP statistical package (SAS Institute, Cary, NC, USA), and the other analyses were carried out using SPSS version 24 (IBM, New York City, NY, USA). The level of statistical significance was set at $P < 0.05$ for all analyses.

Results

The characteristics of the participants are summarized in Table 1. Among the 5300 participants, 338 (6.4%) were classified into the cognitive impairment group, which had a significantly lower GDS score and a lower MVPA value than the non-cognitive impairment group. There was no significant difference in sitting time between the two groups (non-cognitive impairment group: 395.6 ± 197.3, cognitive impairment group: 394.2 ± 186.8, $P = 0.891$).

Figure 1 shows the comparison of the prevalence of cognitive impairment between groups, based on the frequency of each CAS (<1 time/week *vs* ≥1 time(s)/week). The percentage of participants engaging one or more time(s)/week for each CAS was: 12.3% for playing board games, 33.1% for using a computer, 33.7% for solving crossword puzzles, 36.1% for maintaining housekeeping records, 44.5% for writing a diary or letters and 93.6% for reading books or newspapers. In all CAS, the group with a frequency of one or more time(s)/week category had a significantly lower prevalence of cognitive impairment than the group with frequency less than one time/week. After adjustment for covariates, the logistic regression model showed that engaging in each CAS one or more time(s)/week was significantly associated with reduced odds ratio (OR) of cognitive impairment, except for playing board games; the OR were 0.33 (95% confidence interval [CI] 0.24–0.47) for using computer, 0.39 (95% CI 0.29–0.52) for solving crossword puzzles, 0.50 (95% CI 0.36–0.71) for reading books, 0.60 (95% CI 0.46–0.80) for maintaining housekeeping records, 0.65 (95% CI 0.51–0.83) for writing a diary or letters and 0.72 (95% CI 0.48–1.07) for playing board games.

A comparison of the prevalence of cognitive impairment with the variety of CAS is described in Figure 2. The variety of CAS

Table 1 Overall characteristics of the participants, and comparison between the cognitive and non-cognitive impairment groups

	Overall (n = 5300)	Non-cognitive impairment (n = 4962)	Cognitive impairment (n = 338)	$P^{\dagger}$
Age (years)	75.0 ± 5.1	74.9 ± 5.0	75.7 ± 5.4	0.010
Sex (female)	2805 (52.9)	2634 (53.1)	171 (50.7)	0.375
Education (years)	12.1 ± 2.6	12.1 ±2.6	11.5 ±2.3	<0.001
Employed (yes)	1090 (20.6)	1035 (20.9)	55 (16.3)	0.044
IADL limitation (n)	915 (17.3)	816 (16.4)	99 (29.4)	<0.001
No. chronic diseases				
0	1438 (27.1)	1349 (27.2)	89 (26.4)	0.803
1	1965 (37.1)	1834 (37)	130 (38.6)	
≥2	1897 (35.8)	1779 (35.9)	118 (35.0)	
GDS score	2.9 ± 2.7	2.8 ± 2.7	3.8 ±3.0	<0.001
MVPA (MET × min/day‡)	480.3 ±351.0	482.6 ±350.0	446.0 ±364.1	0.009
Sitting time (min/day‡)	395.5 ±196.6	395.6 ±197.3	394.2 ±186.8	0.891

Values are mean ± standard deviation or n (%). †Continuous and category variables were compared between the cognitive and non-cognitive impairment groups using the independent t-test and χ^2-test, respectively. ‡Comparison was carried out using log-transformed value: log [sitting time] and log [MVPA +0.5]. GDS, Geriatric Depression Scale; IADL, instrumental activities of daily living; MET, metabolic equivalent; MVPA, moderate-to-vigorous physical activity.

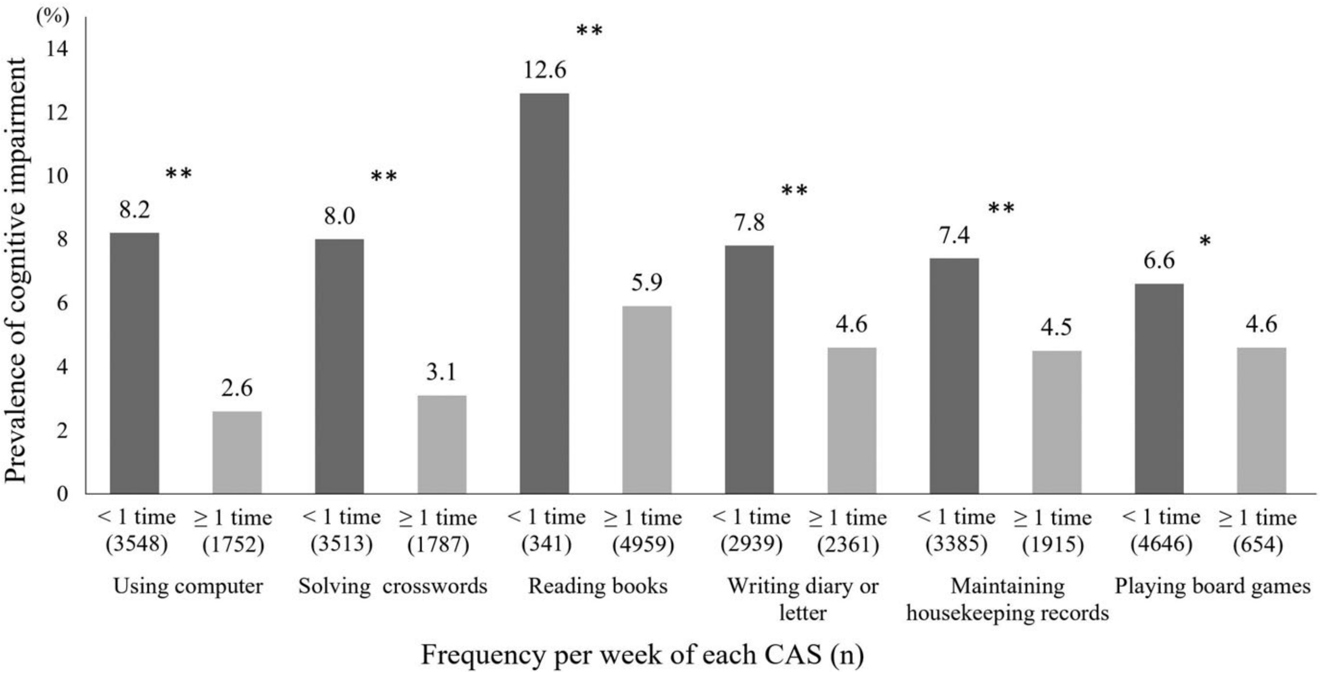

Figure 1 Comparison of the prevalence of cognitive impairment between groups with less than one and one or more time(s)/week frequency for each cognitive activity in a sitting position (CAS). The difference between each category was examined using the χ^2-test (*P < 0.05, **P < 0.001).

showed normal distribution, and the frequency of engaging in three items of CAS was the highest (n = 1564, 29.5%). The Cochran–Armitage trend test indicated that those who engaged in a greater variety of CAS showed a significantly lower prevalence of cognitive impairment (P < 0.001). When the variety of CAS was used as a continuous variable in the logistic regression model, it showed a significant association with the lower OR of cognitive impairment even after adjustment for covariates, including sitting time and MVPA value (OR 0.61, 95% CI 0.55–0.68; Table 2). Compared with participants who carried out zero to one item of CAS one or more time(s)/week, engaging in a higher number of CAS one or more time(s)/week was significantly associated with a greater reduction in OR of cognitive impairment (ranging from 0.19 to 0.53; Fig. 3).

Discussion

The present study showed the association between the frequency and variety of engaging in CAS and cognitive impairment. Engaging in individual CAS one or more time(s)/week and a greater variety of CAS were significantly associated with lower OR of cognitive impairment, even after adjustment for self-reported MVPA and sitting time.

The present findings are similar to those of previous studies that reported that the time spent reading books and using the internet are associated with better cognitive performance.[10,11] The significant favorable associations of the other individual CAS, including writing a diary or letters, solving crossword puzzles, playing board games and maintaining housekeeping records, were also consistent with the results of previous studies.[9,19] In addition, the present findings showed that engaging in a greater variety of CAS was associated with a lower OR of cognitive impairment. This result is also in accordance with that of a previous study.[12] These findings suggest that cognitive activities, even those carried out in a sitting position, have a positive impact on cognition.

There are some possible explanations regarding the influence of cognitive activities on cognitive function. Engaging in cognitive activities might be associated with pathophysiological changes related to dementia. For example, greater engagement in cognitive activities was shown to be significantly associated with a decreased β-amyloid deposition in the cortex.[25] In addition, a significant association was observed between complex mental activity, including education, employment and day-to-day habits across the lifespan, and less hippocampal atrophy.[26] Furthermore, engaging in a variety of cognitive activities might stimulate neurobiological systems extensively, and enable the maintenance of multidomains of cognitive function.[12] Although similar mechanisms might be influenced by carrying out CAS, further studies are required to verify the association between engaging in CAS and β-amyloid deposition or brain volume.

The present findings show that the magnitude of the correlation with cognitive impairment differed among the six CAS. The difference of the magnitude might be explained by the difference in cognitive demand and the frequency. Cognitive psychologists rank-ordered the relative level of cognitive stimulation of some activities, and rated solving crossword puzzles, playing games/cards and reading books as having relatively high cognitive demand.[12] The present findings showed the highest OR was observed for playing board games for the least proportion (12.3%) of the study population compared with that of the other CAS (33.1%–93.6%). In addition, there might be sampling bias. To investigate the effects of CAS on cognitive demand, further studies are required for the assessment of brain activity during each CAS; for example, using functional near infrared spectroscopy, and objective measurement of the time spent in CAS.

The present study suggests that engaging in CAS contributes to the maintenance of cognitive function, independently through MVPA and sitting time. Furthermore, CAS might be a protective factor for cognitive function, even for individuals who are sedentary or experience difficulty with engaging in abundant physical activity. A randomized controlled trial in healthy older adults reported that the effect of cognitive training was not affected by whether it was combined with physical training, and suggested that cognitive activity is more effective than physical activity in maintaining cognitive function.[27] In contrast, an observational study examined the combined effect of physical and cognitive activity on the incidence of mild cognitive impairment, and suggested that physical activity played a crucial role in suppressing cognitive decline, and cognitive activity further enhanced this effect.[28] Owing to the little evidence available, further studies are required to verify that engaging in CAS is sufficient to maintain cognition independently of physical activity.

There also remains the argument as to whether the amount of sitting time is associated with worse cognitive function. The present results show no significant difference in the sitting time between cognitive and non-cognitive impairment groups. Zhu *et al.* also reported that objectively measured sedentary time was not associated with cognitive impairment, from large prospective cohort data;[8] whereas another prospective cohort study showed that excessive sedentary behavior led to worse cognitive function.[7] This inconsistency might be explained by the difference in the

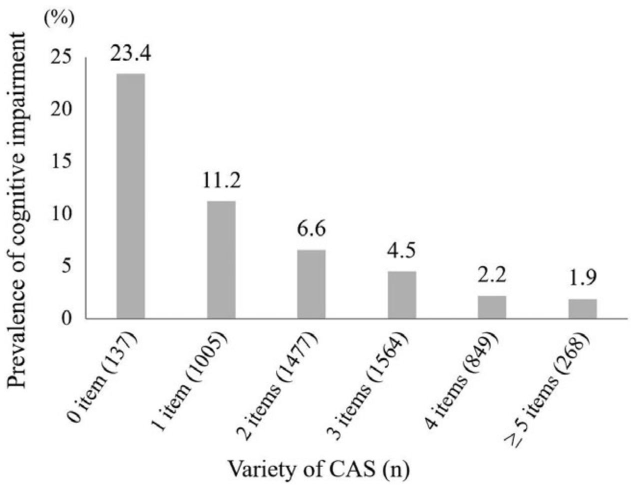

Figure 2 Comparison of the prevalence of cognitive impairment depending on the variety of cognitive activity in a sitting position (CAS). The variety of CAS was assessed by the number of the cognitive activities carried out one or more time(s)/week: using a computer, solving crossword puzzles, reading books, maintaining housekeeping records and playing board games. The difference between each category was verified using the Cochran–Armitage trend test ($P < 0.001$).

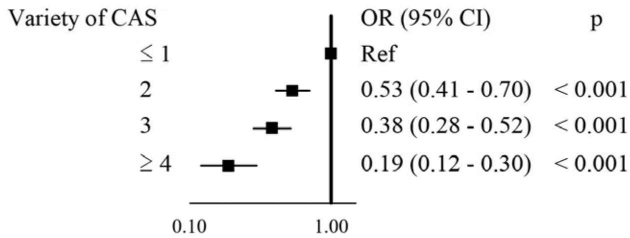

Figure 3 Associations between the variety of cognitive activity in a sitting position (CAS) and cognitive impairment using a logistic regression model. The odds ratio (OR) of variety was calculated with reference to one or fewer items of CAS. Adjusted for age, sex, education, employment, instrumental activities of daily living limitation, number of chronic diseases, Geriatric Depression Scale (GDS) score, moderate-to-vigorous physical activity (MVPA) and sitting time. The log-transformed values, log [sitting time] and log [MVPA +0.5], were used for sitting time and MVPA, respectively. Ref, reference.

Table 2 Association between the variety of cognitive activity in a sitting position and cognitive impairment using binomial logistic regression model

	Crude OR (95% CI)	*P*	Model 1		Model 2	
			OR (95% CI)	*P*	OR (95% CI)	*P*
Variety of CAS†	0.57 (0.51–0.63)	<0.001	0.61 (0.55–0.68)	<0.001	0.61 (0.55–0.68)	<0.001
Age			1.02 (1.00–1.04)	0.117	1.02 (0.99–1.04)	0.162
Sex (ref: female)			0.99 (0.78–1.26)	0.962	0.99 (0.78–1.26)	0.959
Education			0.98 (0.93–1.02)	0.291	0.97 (0.93–1.02)	0.272
Employment (ref: unemployed)			0.74 (0.54–1.02)	0.065	0.75 (0.54–1.02)	0.069
IADL limitation (ref: no limitation)			1.61 (1.24–2.10)	<0.001	1.60 (1.22–2.08)	<0.001
No. chronic diseases			0.93 (0.80–1.07)	0.296	0.93 (0.80–1.07)	0.294
GDS score			1.07 (1.03–1.11)	<0.001	1.07 (1.03–1.11)	<0.001
MVPA‡					0.85 (0.70–1.04)	0.116
Sitting time‡					0.83 (0.49–1.41)	0.495

†Variety of cognitive activity in a sitting position (CAS) was assessed by the number of the cognitive activities carried out one or more time(s)/week and ranged from 0 to ≥5: using computer, solving crossword puzzles, reading books, maintaining housekeeping records and playing board games. ‡Log-transformed values, log [sitting time] and log [physical activity +0.5], were used for sitting time and moderate-to-vigorous physical activity (MVPA), respectively. GDS, Geriatric Depression Scale; IADL, instrumental activities of daily living; OR, odds ratio.

degree of cognitive impairment of the individuals. The current study excluded participants with severe cognitive decline (Mini-Mental State Examination score <21) and dementia, and Zhu *et al.* also excluded those who have cognitive impairment at baseline.[8] However, Ku *et al.* did not apply exclusion criteria regarding cognitive function.[7] Further studies are required to clarify whether excessive sedentary behavior affects cognitive function or if individuals with dementia become more sedentary.

The strength of the present study was that the analysis was carried out using a large sample population. In contrast, there were three limitations. First, the items of CAS might not always be carried out in a sitting position, because the questionnaire used in the present study did not specifically establish sitting or lying posture during each cognitive activity. For example, books or newspaper could be read in a standing posture. Therefore, there is a need to develop an instrument for measuring the time spent in specific postures while engaging in CAS. Second, physical activity, sitting time and the frequency of CAS were assessed using self-reported questionnaire, which causes recall bias, and might increase the range of error. For example, self-reported measurement of sitting time generally underestimates the total sitting time among older adults.[29] A systematic review regarding sedentary behavior among older adults reported a large difference in average sedentary time between objective measurement and self-reported values (9.4 h for objective measurement *vs* 5.3 h for self-reported), suggesting that most self-reported values of sedentary time rather underestimate the actual sedentary time.[4] Therefore, the 6.6 h sitting time reported for the present study population might have been underestimated, distorting the association between sitting time and cognitive function. Future studies should assess physical activity and sedentary time using objective measurement. Third, the present study had a cross-sectional design; therefore, the causal relationship between CAS and cognitive impairment could not be investigated. Prospective studies are required to verify the relationship between them.

The present findings show that engaging in frequent and various CAS is negatively associated with cognitive impairment among older people, which suggests an association between sedentary behavior with cognitive activity and cognitive impairment. Further studies are required to develop an instrument to assess the time of engaging in CAS, and examine the dose–response association between CAS and cognitive impairment.

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[Correction added on 21 December 2018, after first online publication: JSPS KAKENHI (Early-Career Scientists) with grant number JP18K17995 has been added on the Acknowledgement and Funding Information sections.]

Disclosure statement

The authors declare no conflict of interest.

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