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Original Article

Change in hand dexterity and habitual gait speed reflects cognitive decline over time in healthy older adults: a longitudinal study

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Abstract. [Purpose] There is a relationship between physical and cognitive functions; therefore, impairment of physical function would mean cognitive decline. This study aimed to investigate the association between change in physical and cognitive functions. [Subjects and Methods] Participants were 169 healthy community-dwelling older adults who attend the survey after three years from baseline (mean age, 72.4 ± 4.8 years). Grip strength, one-leg standing balance, five-times-sit-to-stand test, timed up and go, 5-m habitual walk, and a peg-moving task were used to evaluate physical performance. Five cognitive function tests were used to assess attention, memory, visuospatial function, verbal fluency, and reasoning. Cognitive function was defined as the cumulative score of these tests. [Results] At baseline, five-times-sit-to-stand test, timed up and go, and hand dexterity were independently associated with cognitive function. In longitudinal analyses, changes in habitual walking speed and hand dexterity were significantly associated with change in cognitive function. [Conclusion] Deterioration of specific physical function, such as hand dexterity and walking ability, may be associated with progression of cognitive decline. Decreasing extent of daily functions, such as hand dexterity and walking ability, can be useful indices to grasp changes in cognitive function.

Key words: Cognition, Physical function, Performance test

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INTRODUCTION

Physical and cognitive functions are important for maintaining independent living in old age[1)]. Previous epidemiological studies with cross-sectional and longitudinal designs have reported a relationship between physical and cognitive functions in older adults[2–8)]. In general, older adults with poor physical performance exhibit low cognitive function.

Advancing age leads to a decline in physical performance. A Japanese prospective study, which included grip strength, usual gait speed, and one-leg standing balance as physical performance tests, showed that the change in physical performance with increasing age depends on those tests[9)]. For example, although change in usual gait speed remains almost unchanged from the age of 65 to 75 years, one-leg standing balance decreases by approximately 10 seconds in that period. Based on the

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implications, the longitudinal association between change in physical and cognitive functions would also depend on physical performance tests. A previous systematic review pointed out that the findings on the association between change in physical and cognitive functions are relatively small because few studies have reported the association[10)]. Therefore, it is necessary to examine whether a change in physical performance is associated with a change in cognitive function.

Previous studies have predominantly used a small number of performance tests to examine the relationship between physical and cognitive functions[3, 6, 11, 12)]. As stated above, each physical performance has a different decreasing rate. A comprehensive evaluation of physical function (i.e., using various physical performance tests), as opposed to the use of a single performance test such as a walking test, is required to determine the association between changes in physical and cognitive functions in detail.

This study aimed to longitudinally investigate the association between changes in physical and cognitive functions with various physical performance tests. This would reveal the changes in physical function that correspond to/indicate changes in cognitive function. We hypothesized that physical function can be divided into two types: performance predominately requiring muscle strength, such as upper and lower extremity muscle strength, and performance that is less reliant on muscle strength, such as hand dexterity. The latter type of physical function has previously been shown to be strongly associated with cognitive function.

SUBJECTS AND METHODS

This study included participants of the cohort study known as the “Kasama study.” The detail of the Kasama study was described previously[13)]. Briefly, the Kasama study includes follow-up and new participants aged ≥65 without long-term care insurance. Physical and cognitive functions are primary measurements. We defined the first participation in the survey from 2009 to 2012 as baseline, with the follow-up period set at three years. Although 604 participants who have complete data were identified from the sampling of the baseline period of this study, we excluded data based on following criteria: loss to follow-up (n=431); missing data at follow up period (n=4). The final sample included 169 participants. Follow-up data could be obtained from only 28.0% of the participants. We assume that most participants included for the analyses are healthy and highly health-conscious because they have maintained a good health status for three years and because they responded to the call for participation in our study. This study was approved by the Ethical Committee of University of Tsukuba (Ref No., Tai 21–25 and Tai 23–36, 26–132). Details of this study were explained to participants prior to enrollment. Informed written consent was obtained from all participants.

To measure grip strength, participants were asked to demonstrate grip strength by squeezing a hand dynamometer (TKK5401, Takei Scientific Instruments Co. Ltd., Niigata, Japan) one after the other. The highest score of two trials for each hand was used for analysis. In measuring one-leg balance with eyes open, we recorded the time for which participants were able to stand on one leg up to a maximum of 60 sec to evaluate static balance. Participants were allowed to choose the lifted leg. The longest time of two trails was used for analysis. In measuring five-times-sit-to-stand movement test, participants were asked to sit on a chair with arms folded over their chests and then to stand up and sit down from a chair five times as fast as possible. The shorter time of two trials was used for analysis. The timed up and go test (TUG) is a commonly used performance test to evaluate functional mobility or dynamic balance. The distance between the chair and marker was 3 m. According to the modified method[14)], participants were instructed to rise from the chair, turn around a marker, and sit down on the chair as fast as possible. We recorded the time taken to complete the task, with the faster time of two trials used for analysis. In measuring 5-m habitual walk, we created a 11-m walking path with a 5-m central part for measurements. Participants were asked to walk at their usual pace along the walking path two times, with the shorter time being recorded. Peg-moving task was used to evaluate hand dexterity. We used a peg board (TKK1306, Takei Scientific Instruments Co. Ltd., Niigata, Japan). Participants were asked to move two pegs simultaneously from the distal board to proximal board using both hands as fast as possible. We recorded the time required for participants to finish moving 48 pegs.

We used five cognitive function tests, known as the “5 Cog,” to evaluate cognitive function[15, 16)]. This included five tests. The position Stroop, category cued recall, clock drawing, category fluency, and similarity tests that are part of the Wechsler Adult Intelligence Scale-Revised were included for evaluating attention, memory, visuospatial function, verbal fluency, and reasoning respectively. Participants were asked to perform the 5 Cog. We calculated total 5-Cog scores to define cognitive function in this study.

Using a self-questionnaire, we obtained the demographic information: age; gender; education; medical history of stroke, diabetes, and heart disease; current medications. Depression symptoms were evaluated using the Geriatric Depression Scale[17)]. Height and weight were used to calculate body mass index according to the following formula: [kg/m^2].

The mean and standard deviation of continuous variables and the ratio of categorical variables at baseline were described as descriptive data. Change in physical and cognitive functions were defined as the amount of change from baseline to the end of the follow-up period (minus indicates function decline). We analyzed the following associations: 1) the cross-sectional association between physical and cognitive functions; 2) the longitudinal association between change in physical and cognitive functions. Multiple regression analysis was used to determine associations. In the crude model, cognitive function was used as the dependent variable and physical function as the independent variable. The adjusted model included age, gender, body mass index, education (<12 or ≥12), depressive mood (<6 or ≥6), smoking status (none, past, current), current medications,

Table 1. Characteristics of the participants

		All (n=169)
		Mean ± SD
Characteristics		
Age	(year)	72.4 ± 4.8
Women	n, (%)	80 (47.3)
Height	(cm)	156.7 ± 8.3
Weight	(kg)	57.2 ± 9.0
Body mass index	(kg / m^2)	23.2 ± 2.6
Education	(year)	
<12	n, (%)	113 (66.9)
12≤	n, (%)	56 (33.1)
Depression mood		
<6	n, (%)	136 (80.5)
6≤	n, (%)	33 (19.5)
Smoking status		
None	n, (%)	125 (74.0)
Past	n, (%)	40 (23.7)
Current	n, (%)	4 (2.4)
Current medications	n, (%)	39 (29.8)
Medical history of stroke	n, (%)	6 (3.6)
Medical history of diabetes	n, (%)	20 (11.8)
Medical history of heart disease	n, (%)	29 (17.2)
Physical function		
Grip strength	(kg)	30.1 ± 7.7
One-leg standing balance	(sec)	37.4 ± 21.3
Five-times-sit-to-stand test	(sec)	7.5 ± 2.1
Timed up and go	(sec)	5.7 ± 1.0
5-m habitual walk	(sec)	3.6 ± 0.5
Peg-moving task	(sec)	37.2 ± 5.5
Cognitive function		
Total score	(point)	67.5 ± 15.7

Table 2. Change in physical and cognitive functions

		All (n=169)
		Mean ± SD
Physical function		
ΔGrip strength	(kg)	−1.11 ± 2.79
ΔOne-leg standing balance	(sec)	−4.06 ± 19.76
ΔFive-times-sit-to-stand test	(sec)	−0.27 ± 2.07
ΔTimed up and go	(sec)	−0.21 ± 0.88
Δ5-m habitual walk	(sec)	−0.13 ± 0.65
ΔPeg-moving task	(sec)	0.40 ± 3.97
Cognitive function		
ΔTotal score	(point)	5.72 ± 9.21

Δ: amount of change from baseline to the end of the follow-up period (minus indicates function decline).

medical history of stroke, diabetes, and heart disease as covariates. P-values <0.05 were considered to be statistically significant. All analyses were conducted using IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Participant characteristics at baseline are shown in Table 1. Changes in physical and cognitive functions are presented in Table 2. Table 3 shows the cross-sectional association between physical and cognitive functions. All measurements were significantly associated with cognitive function in the crude model, except the grip strength. However, the five-times-sit-to-stand test (β=−0.222, p=0.001), TUG (β=−0.169, p=0.030), and peg-moving task (β=−0.213, p=0.005) remained significantly associated with cognitive function after the inclusion of covariates. In longitudinal analyses, changes in the five-times-sit-to-stand test, 5-m habitual walk, and peg-moving task performance were found to be significantly associated with change in cognitive function in the crude model (Table 4). In the adjusted model, these associations were also observed in the 5-m habitual walk (*Δ* 5-m habitual walk, β=0.174, p=0.031) and peg-moving task (*Δ* peg-moving task, β=0.172, p=0.029).

DISCUSSION

This study investigated the association between physical and cognitive functions from two perspectives. First, the evaluation of cross-sectional associations revealed that the five-times-sit-to-stand test, TUG, and peg-moving task were independently associated with cognitive function. Next, we confirmed a significant longitudinal association between change in 5-m habitual walk and the peg-moving task and change in cognitive function.

Table 3. The association between physical and cognitive functions at baseline

	Crude		Adjusted	
	β	p value	β	p value
Grip strength	0.068	0.383	0.181	0.073
One-leg standing balance	0.294	0.001	0.123	0.075
Five-times-sit-to-stand test	−0.402	<0.001	−0.222	0.001
Timed up and go	−0.379	<0.001	−0.169	0.030
5-m habitual walk	−0.231	0.003	−0.115	0.099
Peg moving task	−0.381	<0.001	−0.213	0.005

Adjusted for age, gender, body mass index, education (<12 or ≥12), depressive mood (<6 or ≥6), smoking status (none, past, current), current medications, medical history of stroke, diabetes, and heart disease.

Table 4. The association between change in physical and cognitive functions

	Crude		Adjusted	
	β	p value	β	p value
ΔGrip strength	0.022	0.774	0.010	0.904
ΔOne-leg standing balance	0.103	0.182	0.094	0.251
ΔFive-times-sit-to-stand test	0.165	0.033	0.148	0.060
ΔTimed up and go	−0.149	0.053	0.056	0.492
Δ5-m habitual walk	0.194	0.011	0.174	0.031
ΔPeg-moving task	0.180	0.019	0.172	0.029

Adjusted for age, gender, body mass index, education (<12 or ≥12), depressive mood (<6 or ≥6), smoking status (none, past, current), current medications, medical history of stroke, diabetes, and heart disease.

A cross-sectional association between physical and cognitive functions has been reported by previous epidemiological studies[2–5]. In the five-times-sit-to-stand test, our results supported previous studies[2, 4]. As for TUG and hand dexterity, there is relatively little evidence. It has been confirmed that TUG is associated with executive function in older adults with mild cognitive impairment (MCI)[18]. Most participants in this study were without MCI or dementia because they did not use long-term care insurance. We obtained results that were similar to those obtained from older adults with MCI. Evaluations of hand dexterity were not included in previous epidemiological studies previous epidemiology studies[2–5]. A review focused on hand motor function and demonstrated that hand dexterity is associated with cognitive function[19]. Schröter et al.[20] reported that participants with mild cognitive impairment or probable Alzheimer's disease have decreased hand motor function compared with participants without cognitive decline. In corroboration with these studies, hand dexterity was found to be significantly associated with cognitive function in this study. Except for hand dexterity, some physical functions were not found to be associated with cognitive function even adjustment for covariates, indicating that variables included as covariates influenced these associations. Therefore, as a novel finding, it is likely that TUG and hand dexterity as well as the five-times-sit-to-stand test are more closely associated with cognitive function than physical function, such as grip strength or lower extremity function, in cross-sectional analyses.

The relation between changes in physical and cognitive functions has been demonstrated by previous longitudinal studies[8, 21]. The performance tests used in this study, for example, the TUG or peg-moving task, differed from those used in previous studies. Accordingly, our results demonstrate that change in physical function, such as hand dexterity and walking ability, are associated with change in cognitive function in the adjusted model. In particular, cross-sectional and longitudinal associations were observed between hand dexterity and cognitive function in this study. These findings indicate that a decline in hand dexterity may accompany cognitive decline and suggest that hand motor function is connected to brain function[22]. Of measures of physical function, hand motor function appears to be most relevant to cognitive function. Watson et al.[12] reported declining cognitive function to be associated with change in walking ability. In corroboration with their study, a significant relation between changes in walking ability and cognitive function was observed in this study. Furthermore, gait speed at baseline is known to be a predictor of incident dementia[7]. Our findings indicate that rapid decreases in gait speed may be a sign of cognitive decline even if older adults do not have a slow gait speed at baseline.

This study has some limitations. First, it is possible that the follow-up period was insufficient for healthy older adults as changes in cognitive function from baseline to the end of the follow-up period were relatively small. Accordingly, we were unable to study the development of mild cognitive impairment or dementia. Future long-term observation studies with large sample sizes are required to overcome this limitation. Next, our study cannot deny a sampling bias because our sample consisted of some individuals who attended the follow-up survey. Older adults with a lower level of cognitive function or bad health status tend to be non-responders[23]; that is, participants who were included in the analysis had good health conditions. Therefore, our results can only be generalized to healthy older adults. Finally, we were unable to investigate potentially confounding factors, such as nutrition. Few studies have indicated a longitudinal association between physical function and cognitive functions. The results of this study are of importance to this field as we obtained new findings by comprehensively measuring physical function in a longitudinal study.

In conclusion, performance tests that were associated with cognitive function had differences between the cross-sectional and longitudinal analyses. Declines in specific physical functions are associated with cognitive function, particularly hand dexterity and walking ability, and may reflect progressing cognitive decline. The peg-moving task, which showed significant association with cognitive function in the cross-sectional and longitudinal analyses, would enable measuring not only hand dexterity but also cognitive function in healthy older adults.

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