Table 2
Linear regression analysis of the association between brain atrophy and low-intensity physical activity.

Variables	Model 1		Model 2		Model 3	
	β	*P*	β	*P*	β	*P*
LPA	−0.209	<0.001	−0.120	0.062	−0.102	0.136
Age	–	–	0.206	0.001	0.116	0.048
Sex	–	–	0.110	0.089	0.115	0.065
BMI	–	–	−0.030	0.584	−0.034	0.528
MCI subtype	–	–	−0.008	0.887	0.015	0.766
Hypertension	–	–	0.065	0.233	0.055	0.295
Diabetes mellitus	–	–	0.049	0.356	0.037	0.473
Lipidemia	–	–	−0.021	0.692	−0.017	0.736
TUG	–	–	0.164	0.006	0.166	0.003
WML	–	–	–	–	0.287	<0.001
ΔR^2	–		0.111		0.073	
R^2	–	–			0.228	

LPA: low-intensity physical activity; BMI: body mass index; MCI: mild cognitive impairment; TUG: timed up and go test; WML: white matter lesions.

each model was calculated. All analyses were performed using commercially available software (IBM SPSS statistics software, Version 20; IBM Corp., Armonk, NY, USA). Statistical significance was set at $P < 0.05$.

3. Results

Overall, 323 subjects fulfilled with the eligibility criteria and were divided into those with severe WML ($n = 60$) or non-severe WML ($n = 263$). The characteristics of each group are summarized in Table 1. Age, TUG, and brain atrophy were significantly different between the two groups ($P < 0.05$). The proportions of time in LPA and MVPA were also significantly different between the two WML groups ($P < 0.05$).

Correlations between PA and brain atrophy in each WML group are shown in Fig. 1 for LPA and Fig. 2 for MPA. The simple correlation analysis revealed that more LPA ($r = -0.20$, $P < 0.001$) and MVPA ($r = -0.20$, $P < 0.001$) correlated with a lower rate of atrophy. Partial correlation analysis that controlled age, sex, and TUG showed that LPA was not significantly associated with brain atrophy ($pr = -0.10$, $P = 0.069$), but that MVPA was ($pr = -0.15$, $P = 0.006$). The results of the regression analysis of LPA against brain atrophy are shown in Table 2. In Model 1, brain atrophy was negatively associated with LPA ($\beta = -0.209$, $P < 0.001$). However, adjusting for demographic data in Model 2 and WML in Model 3 revealed that LPA itself was not independently correlated with atrophy (Model 2: $\beta = -0.120$, $P = 0.062$; Model 3: $\beta = -0.092$, $P = 0.136$). In contrast, MVPA was significantly associated with brain atrophy in Model 1 ($\beta = -0.202$, $P < 0.001$, Table 3), and remained so in Model 2 ($\beta = -0.148$, $P = 0.007$) and Model 3 ($\beta = -0.126$, $P = 0.015$).

Table 3
Linear regression analysis of the association between brain atrophy and moderate-to-vigorous intensity physical activity.

Variables	Model 1		Model 2		Model 3	
	β	*P*	β	*P*	β	*P*
MVPA	−0.202	<0.001	−0.148	0.007	−0.126	0.015
Age	–	–	0.206	<0.001	0.117	0.045
Sex	–	–	0.182	0.001	0.170	0.002
BMI	–	–	−0.020	0.713	−0.027	0.608
MCI subtype	–	–	−0.009	0.871	0.014	0.784
Hypertension	–	–	0.064	0.233	0.054	0.295
Diabetes mellitus	–	–	0.054	0.304	0.041	0.420
Lipidemia	–	–	−0.020	0.704	−0.017	0.744
TUG			0.135	0.025	0.142	0.014
WML	–	–	–	–	0.284	<0.001
ΔR^2	–		0.103		0.072	
R^2	–		–		0.213	

MVPA: moderate-to-vigorous intensity physical activity; BMI: body mass index; MCI: mild cognitive impairment; TUG: timed up and go test; WML: white matter lesions.

4. Discussion

The proportions of time spent in LPA and MVPA were lower in subjects with severe WML than in those without severe WML. Subjects with severe WML were older, had less mobility and more extensive brain atrophy. Our study revealed that in this cohort of subjects with MCI, objectively measured PA was associated with brain atrophy, independent of WML. Specifically, multivariate regression models showed that greater MVPA was associated with less extensive brain atrophy, even after adjusting for WML. In contrast, the amount of LPA could not explain the amount of brain atrophy better than the other covariates.

The results of studies using objectively measured PA, including our study, provide evidence for sustained protective effects of PA in preserving brain health. Some studies have shown that PA is associated with macrostructural brain measures (Benedict et al., 2013; Burzynska et al., 2014; Erickson et al., 2010; Flöel et al., 2010; Gow et al., 2012). Most of those studies assessed PA using questionnaires. For example, it was found that the self-reported duration and frequency of PA were associated with gray matter and white matter volume (Benedict et al., 2013) and greater walking distance at baseline was related to greater gray matter volume 9 years later in older adults (Erickson et al., 2010). In contrast, there is less evidence of a relationship between objectively measured PA and brain health. Burzynska et al. (2014) focused on the association between white matter and PA among low-fit older adults. Their findings showed that more MVPA was associated with a smaller volume of white matter hyperintensities and that sedentary time was associated with lower white mater integrity. In contrast, the LPA was less associated with these brain measures than with other covariates. Additionally, they reported that the correlation between PA and brain health depended on the intensity of the PA. However, these studies did not investigate the effects of PA among older adults with MCI. Thus, our results provide further insight into the benefits of PA on maintaining brain health, even among subjects with MCI.

Based on the hypothesis that PA has a positive impact on brain health, several intervention studies have examined the effects of introducing exercise or enhancing PA on improving cognition in subjects with MCI (Gates et al., 2013). However, a consensus has not been reached, partly because the intensity of the interventions varied among studies. An intervention aimed at promoting PA helped to maintain cognitive function, although the effect was dependent on the severity of cognitive impairment (Lautenschlager et al., 2008). By contrast, a walking program aimed at enhancing PA had limited effects on cognition in subjects with MCI (van Uffelen et al., 2008). In other studies, aerobic exercise at moderate to high intensities had a positive impact on hippocampus volume in older adults (Erickson et al., 2011) and cognitive function in subjects with MCI (Baker et al., 2012). Thus, our results suggest that the benefits of PA, especially MVPA, on brain health extend to older adults with MCI.

The strength of our study is that we performed multivariate analysis, which included WML. WML are thought to represent the loss of myelin, axons, oligodendrocytes, and other glial cells in the subcortical white matter because of ischemic damage caused by underlying small-vessel disease (Brun and Englund, 1986) or other explanations, such as Wallerian degeneration (Leys et al., 1991). The presence of WML is thought to be a strong mediating factor for brain atrophy. The coexistence of WML and brain atrophy is a common age-related change in the brain, even in people without overt diseases, because disturbances in white matter integrity contributes to the pathogenesis of brain atrophy (Appelman et al., 2009). Additionally, WML may be associated with PA, although the results published to date are conflicting (Gow et al., 2012; Podewils et al., 2007; Wirth et al., 2014). Thus, when investigating the factors associated with brain atrophy, it is important to consider the

severity of WML. Additionally, neuroimaging studies have revealed that brain atrophy and white matter lesions are typical age-related structural changes in the brain (Seidler et al., 2010), while physical performance, particularly mobility, is correlated with gray matter volume and WML (de Laat et al., 2012; Rosano et al., 2010). Based on this evidence that brain structure is associated with age and mobility, we included age, TUG, and other demographic data as covariates in this study. Higher age, being male, and low mobility were associated with more brain atrophy. Results of the partial correlation and multivariate analysis indicated that age and TUG could explain atrophy better than LPA, but also supported the association between MVPA and brain measures even after adjusting for other factors.

Some limitations must be mentioned. Because of the cross-sectional design, we could not assess the causal relationship between PA and brain structure in these subjects with MCI. Further prospective studies are required to address this issue. In addition, other brain measures including Aβ burden and white matter integrity might mediate the association between PA and MCI. Additionally, we used a voxel-based analysis to assess gray matter atrophy of the entire brain. The possibility that PA has differential effects depending on brain region should be investigated in future studies.

5. Conclusion

Our study showed that PA, particularly MVPA, was negatively associated with the extent of brain atrophy in older adults with MCI. This association was independent of the severity of WML. These results support the possibility that enhancing PA could contribute to brain health. Further studies, including interventions, are needed to confirm the benefits of PA on cognition and brain health.

Conflict of interest

The authors declare that they have no competing interests.

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Article

Cognitive Functioning and Walking Speed in Older Adults as Predictors of Limitations in Self-Reported Instrumental Activity of Daily Living: Prospective Findings from the Obu Study of Health Promotion for the Elderly

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Abstract: Our aim was to determine whether baseline measures of cognitive functioning, walking speed, and depressive status are independent predictors of limitations in instrumental activities of daily living (IADL) in older adults. The cross-sectional study involved 1329 community-dwelling adults, aged 75 years or older. At baseline, the Mini-Mental State Examination (MMSE), Symbol Digit Substitution Test (SDST), Geriatric Depressive Scale (GDS), and a word list memory task were completed, and self-reported IADLs and walking speed were recorded. The longitudinal study involved 948 participants without baseline IADL limitation, which was assessed at baseline and 15-month follow up, using the three

Kihon Checklist subitems. In cross-sectional analyses, participants with IADL limitation demonstrated greater GDS scores, slower walking speeds, and lower MMSE, word list memory task, and SDST (only for women) scores relative to those without IADL limitation. In the longitudinal analyses, baseline walking speed (men: OR 0.98; women: OR 0.97, $p < 0.05$) and word list memory task scores (men: OR 0.84; women: OR 0.83, $p < 0.05$) in both sexes and SDST scores in women (OR 0.96, $p = 0.04$) were independent predictors of subsequent IADL limitation. Walking speed, memory, and processing speed may be independent predictors of IADL limitation in older adults.

Keywords: instrumental activities of daily living; memory; processing speed; walking speed

1. Introduction

The loss of the ability to conduct daily activities leads to a rise in morbidity, caregiver burden, and mortality [1,2]. Generally, everyday functioning ability in older adults consists of separate assessments of basic activities of daily living (BADLs) and instrumental activities of daily living (IADLs). BADLs are self-maintenance skills, such as bathing, dressing, and toileting, whereas IADLs are also routine activities, but they are more goal oriented and related to more complex and higher functional abilities, such as preparing a meal, handling finances, shopping, and other activities [3,4].

Older people with IADL limitations are frailer, because they have a greater number of associated health problems, such as disorders (e.g., histories of heart disease, stroke, depression, or diabetes), poorer cognitive function, and frequent falls [5]. Conversely, physical and cognitive status could also be predictors for the onset of IADL limitation in older people [6,7].

With respect to associations between cognitive function and IADL difficulty, a few longitudinal studies have focused on specific neuropsychological domains and examined causal relationships between multidimensional cognitive function and future decline in IADLs. For instance, Johnson and colleagues performed a longitudinal study and showed that baseline executive functioning was associated with future worsening of IADL dependence [8]. Other studies have also examined associations between baseline cognitive domains, including memory or executive function, and a decline in IADLs in older people [9,10]. Taken together, baseline cognitive functioning, particularly executive function and memory, appear to be important predictors of the onset of IADL limitation.

In contrast, physical function is strongly associated with the ability to perform IADLs [11]. In particular, aspects of walking ability, such as walking speed, could be strong predictors for the onset of IADL limitation in aged populations [12,13]. In addition, depressive symptoms may be a predictor for an increase in IADL limitation [14]. However, no studies have examined the means by which specific cognitive functions, including concurrent walking ability and depressive status in older adults, predict future IADL limitation.

Therefore, we sought to determine whether baseline measures of cognitive functioning are independent predictors of subsequent IADL limitation, with walking speed and depressive symptoms considered covariates, in community-dwelling older adults aged 75 years and over with no IADL limitation

at baseline. We hypothesized that the association between cognitive function and future IADL decline would be independent of age, sex, education, medication, depressive status, and walking speed.

2. Methods

2.1. Participants

All of the participants in this study were enrolled in the Obu Study of Health Promotion for the Elderly (OSHPE) [15]. A letter of invitation was sent to all older individuals living in Obu, a residential suburb of Nagoya, Japan, to participate in the OSHPE. Excluded were participants requiring support or care certified by the Japanese public long-term care insurance system (care level ≥3/5) and those in similar ageing cohort studies. At baseline, 1392 community-dwelling older adults aged 75 years or older participated in the study. We conducted a baseline assessment for the OSHPE, including a face-to-face interview and measures of physical and cognitive function (August 2011 to February 2012). A follow-up postal survey was conducted approximately 15 months after baseline assessment (November 2012 to May 2013), with an offer of assistance in completing the study. In the cross-sectional study, we excluded participants with a history of Parkinson's disease, stroke, Alzheimer's disease, or depression. Participants with missing values for education level (n = 4), depression symptoms (n = 4), walking speed (n = 13), cognitive function (n = 31), and self-reported IADLs (n = 11) at baseline were also excluded. In this prospective study, we included participants who had completed baseline measures of walking speed and cognition and follow-up assessments of self-reported IADLs. Of the participants included in the cross-sectional study (N = 1329), participants who could not complete self-reported IADL assessment in a follow-up postal survey (n = 247) or suffered a stroke, Alzheimer's disease, depression, or a hip fracture (including those for whom onset of the disease was unknown) subsequent to baseline assessment (n = 134) were excluded. Ultimately, 948 participants without IADL limitation at baseline were included in the current prospective cohort study. Informed consent was obtained from all participants prior to their inclusion in the study, and the ethics committee of the National Center for Gerontology and Geriatrics approved the study protocol.

2.2. Measurements

Demographic data including age, sex, and number of medications used on a regular basis were recorded during face-to-face interviews at baseline. The participants completed a standardized questionnaire, which included the self-rated 15-item Geriatric Depression Scale (GDS) [16].

IADL limitation was assessed using the three subitems of the Kihon-Checklist [17], a self-reported comprehensive health checklist that was developed by the Japanese Ministry of Health, Labour and Welfare [18], at baseline and 15-month follow up. The three sub-items are as follows: (1) using the bus or train by myself, (2) buying daily necessities by myself, (3) managing my own deposits and savings at the bank by myself. In the cross-sectional study, a participant response of "no" to one or more items at baseline assessment represented IADL limitation. In the longitudinal study, none of the participants reported IADL limitation in any of the three sub-items at baseline. Participants with no IADL limitation, according to their responses to a 15-month follow-up survey, were considered independent,

and those who reported one or more IADL limitations in the 15-month follow-up survey were assigned to the IADL-limitation group.

We measured baseline walking speed in seconds, using a stopwatch. Participants were asked to walk 6.4 m (divided into two 2.0 m zones at each end and a 2.4 m middle zone) at their usual pace. We measured the time required (in seconds) to pass the 2.4 m middle zone over five trials in order to calculate mean gait speed (meter per minute: m/m).

Participants also underwent measures of global cognitive function, verbal memory, executive function, and processing speed using the National Center for Geriatrics and Gerontology Functional Assessment Tool (NCGG-FAT) [19]. Global cognitive function was assessed using the MMSE translated into Japanese [20], which is based on the original version [21]. Verbal memory was assessed using delayed recall in a word list memory task. Before delayed recall was tested, participants were instructed to memorize 10 words that were presented on a tablet PC. Each of the 10 target words was shown for 2 s. A total of 30 words, including 10 target and 20 distracter words, were then presented, and participants were asked to choose the 10 target words immediately. This was repeated for three trials, and participants were instructed to recall (write down) the 10 target words following a delay of approximately 20 min. We calculated the total number of recalled target words. One point was awarded for each word recalled correctly within 60 s, with a maximum score of 10. We used the tablet version of the symbol digit substitution test (SDST) to assess processing speed. In this task, nine pairs of numbers and symbols were presented at the top of the display. A target symbol was presented at the center of the display. Participants then chose a number that corresponded to a target symbol at the bottom of the display as rapidly as possible. The score comprised the sum total of the correct numbers chosen within 90 s. One point was given for each number chosen correctly within the time limit. Higher scores represented better performance. A previous study reported that SDST and the delayed recall word list memory task demonstrated excellent test-retest reliability and validated the test in comparison with scores on widely used conventional neurocognitive tests (*i.e.*, the subtest of the Alzheimer's Disease Assessment Scale-Cognitive and the Digit Symbol-Coding subtest of the Wechsler Adult Intelligence Scale (Third Edition)).

2.3. Statistical Analysis

Data entry and analysis was performed using SPSS version 19.0 (SPSS Inc., Chicago, IL, USA). A p value of <0.05 was considered indicative of statistical significance. Means, standard deviations, and proportions were calculated to describe the samples and provide summary information regarding the measures used. Student's t tests were used to compare differences in measures between the independent and IADL-limitation groups at baseline in the cross-sectional study. Chi-square tests were used to compare differences in rates of IADL limitation onset between men and women during the 15-month follow-up period. We also compared baseline measures between the independent and IADL-limitation groups using Student's t tests in the longitudinal study.

Logistic regression analysis was performed to examine whether potential determinants were independently associated with subsequent IADL limitation. In this analysis, subsequent IADL limitation was included as a dependent variable, and age, education level, number of medications used, GDS score, walking speed, MMSE, word list memory task scores, and SDST scores were included in

the model as independent variables. Odds ratios (ORs) and 95% confidence intervals (CI) were calculated for the subsequent IADL limitations.

3. Results

Results showed that 139 (21.8% of 638) older men and 114 (16.5% of 691) older women reported IADL limitation at the baseline assessment. Table 1 shows characteristics, GDS, walking speed, and cognitive function comparisons between participants with and without IADL limitation at the baseline assessment. Men with IADL limitation exhibited significantly lower education levels, greater GDS scores, and slower walking speeds relative to those observed in men without IADL limitation ($p < 0.01$). Women with IADL limitation were significantly older than men with IADL limitation; they also exhibited significantly lower education levels, greater GDS scores, and slower walking speeds than those observed in the men ($p < 0.01$). With regard to cognitive performance tests, men without IADL limitation exhibited significantly higher scores on the MMSE ($p = 0.024$) and SDST ($p < 0.01$) than those observed in men with IADL limitation. MMSE, word list memory task, and SDST scores in women without IADL limitation were significantly higher than those observed in women with IADL limitation ($p < 0.01$).

Table 1. Comparison of characteristics between participants with and without self-reported IADL limitation in the baseline survey (n = 1329).

Variable	All Participants (n = 1329)	Men (n = 638)			Women (n = 691)		
		Independent (n = 499)	IADL Limitation (n = 139)	*p*-Value	Independent (n = 577)	IADL Limitation (n = 114)	*p*-Value
Age in years	79.2 ± 3.9	79.2 ± 3.7	79.2 ± 4.6	0.991	78.9 ± 3.7	80.9 ± 4.2	<0.001
Education in years	10.5 ± 2.6	11.3 ± 3.0	10.2 ± 2.7	<0.001	10.0 ± 2.1	9.4 ± 2.0	0.006
Number of medications used	2.5 ± 2.3	2.3 ± 2.3	2.7 ± 2.7	0.054	2.5 ± 2.2	3.4 ± 2.4	<0.001
GDS score	3.4 ± 2.8	3.1 ± 2.7	3.8 ± 2.9	0.009	3.4 ± 2.6	4.8 ± 3.0	<0.001
Walking speed in m/m	68.3 ± 13.9	70.8 ± 12.4	66.2 ± 16.5	<0.001	69.0 ± 12.8	55.9 ± 15.1	<0.001
MMSE score	25.3 ± 2.9	25.2 ± 2.7	24.6 ± 3.5	0.024	25.7 ± 2.9	24.5 ± 3.5	<0.001
Word list memory task score	2.7 ± 1.9	2.6 ± 1.8	2.3 ± 1.8	0.106	3.0 ± 1.9	2.4 ± 2.1	0.003
SDST (tablet version) score	32.0 ± 8.2	33.8 ± 7.7	31.0 ± 8.6	<0.001	31.6 ± 7.9	27.3 ± 8.4	<0.001

Notes: Values are means ± SD; GDS = Geriatric Depression Scale; MMSE = Mini-Mental State Examination; TMT-B = Trail Making Test-Part B; SDST = Symbol Digit Substitution Test; m/m = meters per minute.

Table 2 shows the results of the self-reported IADL limitation survey at 15-month follow up in participants who reported no baseline IADL limitation. Rates of "no" responses were observed in 137 (14.5%), 67 (7.1%), and 119 (2.6%) participants with respect to using a bus or train, buying daily necessities, and managing deposits and savings, respectively. Rates of subsequent activity limitation differed significantly between men and women with respect to buying daily necessities (men 9.3%, women 4.8%; $p = 0.007$) and managing deposits and savings (men 17.5%, women 7.3%; $p < 0.001$). At the 15-month follow-up survey, 153 (27.4% of 485) men and 94 (20.3% of 463) women reported one or more IADL limitations and experienced subsequent IADL limitation ($p < 0.001$).

Table 2. Self-reported IADL limitation in the 15-month follow-up survey in participants without IADL limitation at baseline (n = 948).

IADL items	No Baseline IADL Limitation (n = 948)	Men (n = 485)	Women (n = 463)	*p*-Value
Subsequent activity limitation (number of participants)				
Using bus or train by myself	137 (14.5)	66 (13.6)	71 (15.3)	0.450
Going out and buying daily necessities by myself	67 (7.1)	45 (9.3)	22 (4.8)	0.007
Managing own deposits and savings at the bank	119 (12.6)	85 (17.5)	34 (7.3)	<0.001
Number of limitations				
None (independent)	721 (76.1)	352 (72.6)	369 (79.7)	<0.001
One	152 (16.0)	83 (17.1)	69 (14.9)	
Two	54 (5.7)	37 (7.6)	17 (3.7)	
Three or more	21 (2.2)	13 (2.7)	8 (1.7)	

Notes: Values represent number of participants (%).

Table 3 represents differences in characteristics between the independent and IADL-limitation groups. Men with subsequent IADL limitation reported lower education levels ($p = 0.010$) and demonstrated higher baseline GDS scores ($p < 0.001$), slower baseline walking speeds ($p < 0.001$), and worse baseline cognitive performance (MMSE: $p = 0.030$; word list memory: $p < 0.001$; SDST: $p < 0.001$) relative to men without subsequent IADL limitation.

Table 3. Comparison of baseline characteristics between participants with and without self-reported IADL limitation in the 15-month follow-up survey (n = 948).

Variable	Men (n = 485)			Women (n = 463)		
	Independent (n = 352)	IADL Limitation (n = 133)	*p*-Value	Independent (n = 369)	IADL Limitation (n = 94)	*p*-Value
Age in years	79.0 ± 3.6	79.5 ± 4.7	0.156	78.5 ± 3.4	81.0 ± 4.6	<0.001
Education in years	11.5 ± 2.9	10.7 ± 2.9	0.010	10.2 ± 2.1	9.6 ± 2.2	0.012
Number of medications used	2.3 ± 2.3	2.7 ± 2.6	0.101	2.5 ± 2.1	3.0 ± 2.1	0.032
GDS score	2.8 ± 2.6	3.7 ± 2.9	<0.001	3.2 ± 2.5	3.9 ± 2.5	0.030
Walking speed in m/m	72.7 ± 11.6	67.6 ± 15.3	<0.001	70.6 ± 13.1	60.4 ± 13.9	<0.001
MMSE score	25.6 ± 2.7	25.0 ± 2.9	0.030	26.2 ± 2.6	24.8 ± 3.3	<0.001
Word list memory task score	2.9 ± 1.8	2.1 ± 1.7	<0.001	3.4 ± 1.9	2.2 ± 1.9	<0.001
SDST (tablet version) score	35.1 ± 7.4	31.7 ± 7.9	<0.001	33.5 ± 7.4	27.8 ± 8.2	<0.001

Notes: Values represent means ± SD or numbers of participants (%); GDS = Geriatric Depression Scale; MMSE = Mini-Mental State Examination; SDST = Symbol Digit Substitution Test; m/m = meters per minute.

There were no significant differences in age or numbers of medications used. Women with subsequent IADL limitation were older ($p < 0.001$), reported lower education levels ($p = 0.012$) and exhibited higher baseline GDS scores ($p = 0.032$), slower baseline walking speeds ($p < 0.001$), and worse baseline cognitive performance ($p < 0.001$) than women without subsequent IADL limitation during the 15-month follow-up period.

Age, sex (male), walking speed and GDS, MMSE, word list memory, and SDST scores were entered into a logistic regression model (Table 4). In men, we found that walking speed (odds ratio [OR]: 0.980, 95% CI [0.961–0.999]; $p = 0.035$) and word list memory scores (OR: 0.842, 95% CI [0.736–0.962]; $p = 0.012$) at baseline were independent predictors of subsequent IADL limitation. In women, walking speed (OR: 0.972, 95% CI [0.951–0.993]; $p = 0.009$), word list memory scores (OR: 0.833, 95% CI [0.712–0.974]; $p = 0.022$), and SDST scores (OR: 0.960, 95% CI [0.922–0.999]; $p = 0.042$) at baseline were independent predictors of subsequent IADL limitation.

Table 4. Baseline characteristics and cognitive function associated with subsequent self-reported IADL limitation in logistic regression.

Variable	Men (n = 485)		Women (n = 463)	
	Odds Ratio	95% CI	Odds Ratio	95% CI
Age in years	0.959	0.905–1.017	1.057	0.988–1.130
Education in years	0.964	0.889–1.044	0.991	0.877–1.119
Number of medications used	1.049	0.964–1.142	1.062	0.945–1.194
GDS score	1.060	0.979–1.148	1.018	0.923–1.124
Walking speed in m/m	0.980 *	0.961–0.999	0.972 **	0.951–0.993
MMSE score	1.010	0.929–1.099	0.980	0.890–1.079
Word list memory task score	0.842 *	0.736–0.962	0.833 *	0.712–0.974
SDST (tablet version) score	0.969	0.935–1.003	0.960 *	0.922–0.999

Notes: GDS = Geriatric Depression Scale; MMSE = Mini-Mental State Examination; SDST = Symbol Digit Substitution Test; m/m = meters per minute. * $p < 0.05$; ** $p < 0.001$.

4. Discussion

In this cross-sectional study, which included a large sample of adults aged 75 years and older, older adults with IADL limitations showed poorer cognitive performance including global cognition, processing speed, and memory (only in women) than those with intact IADLs. In the longitudinal analysis involving the participants without baseline IADL limitation, we confirmed that the group that had subsequently developed IADL limitation during the 15-month follow-up period exhibited poorer performance in tests assessing walking speed and cognitive function at baseline. In particular, associations between subsequent IADL limitation and baseline measures of walking speed and memory were independent of age, education, number of medications used, depression status, and global cognition in both men and women. In addition, poor processing speed was independently associated with a future decline in IADLs in older women.

Our finding that baseline cognitive function was associated with longitudinal decline in IADLs extends previous findings regarding the effects of cognitive function on the ability to function in daily life. IADL limitation may be an important predictor of mild cognitive impairment and dementia in cognitively healthy older adults [22,23]. Conversely, poor cognitive function affected the onset of IADL decline. In particular, executive and memory dysfunction may have a greater impact on future IADL limitation [8,9,24]. The results of the present study also indicate that older adults with poor performance in tests that assess memory and executive function, particularly processing speed at baseline, had a higher risk of developing subsequent IADL limitation.