Going outdoors and cognitive function among community-dwelling older adults: Moderating role of physical function

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Abstract

Aims: Identifying risk factors of cognitive impairment is essential for implementing effective prevention strategies for dementia. Previous studies have indicated that the frequency of going outdoors is inversely associated with cognitive decline. Little research has examined whether the relationship between going outdoors and cognitive decline varies with physical functioning in older adults. The aim of this study was to examine the relationship between going outdoors and cognitive function in older adults with and without physical function limitations.

Methods: This study analyzed the data of 4,450 individuals (65 years or older) who participated in the Obu Study of Health Promotion for the Elderly. The measures were the Mini-Mental State Examination (MMSE), going outdoors (at least once a week or not), self-reported physical function limitations (with or without), and demographic and health-related factors as potential confounders.

Results: Analysis of covariance and post-hoc comparisons showed that while going outdoors at least once a week was associated with higher MMSE scores among older adults with limited physical function, it was not significantly associated with the MMSE scores among older adults without limited physical function. Similarly, logistic regression analyses, stratified by physical function, revealed a significant association between going outdoors and MMSE (< 24 points or not) among the older adults with limited physical function.

Conclusions: The results indicate that going outdoors less than once a week is associated with decreased cognitive function among older adults with limited physical function, but it is not associated with cognitive function among older adults without limited physical function.

Key words: Aged; Cognition Disorders; Effect Modifier; Homebound Persons;

Physical Function; Preventive Medicine

Introduction

As the world's population ages, dementia has become an important public health problem, particularly in developed countries. Identifying risk and protective factors associated with cognitive decline is essential to create effective prevention strategies for dementia. The possible role of lifestyle-related factors,[6-10] such as smoking habits, excessive alcohol intake, and dietary patterns, has been proposed to help understand cognitive decline due to age-related changes, as well as genetic, sociodemographic and medical factors.[1-5]

Going outdoors daily may help prevent cognitive decline in older people in addition to these factors. Previous studies[11-14] have indicated that the frequency of going outdoors is a predictor of both the psychological and physical health outcomes of older people. The Japan Ministry of Health, Labour and Welfare[15] regards going outdoors less than once a week to be a risk of being housebound, a condition of Need for Long-Term Care, and the Ministry instructs each local government to provide community-based programs for supporting these individuals. Some previous studies[16-19] have found that limited life space, which is a similar concept to going outdoors, is also associated with cognitive decline. The interventions designed to aid older adults expand their zones of life experience, such as the Experience Corps, may be effective to protect against cognitive decline.[20] Since going outdoors does not require any special knowledge, motivation, costs, or time, increasing outdoor activity would be easier for older people to incorporate into their daily life, compared with reducing other lifestyle-related risk factors, such as smoking cessation and avoiding excessive alcohol intake.

The effects of going outdoors on cognitive function might differ by the physical function status of older people. Previous studies have indicated that life space

differentiated patients with Alzheimer's disease from healthy older adults, and that it was strongly correlated with physical function.[21] Physical function is reciprocally associated with cognitive decline,[22-24] in that decline in physical function can reduce opportunities to engage in physical and social activities,[17,25] which are important to maintain cognitive functioning.[9,26,27] Additionally, it has been reported that regular physical activity reduces the risk of dementia among older adults with lower levels of physical functioning compared with those with higher levels of physical functioning.[28] Thus, those with limited physical function might gain more cognitive health benefits by going outdoors than those with normal physical function. However, there are no previous studies that have identified the differences between the older adults with and without limitations of physical function on the relationships among going outdoors and cognitive function among community-dwelling older adults.

The purpose of this study was to examine whether the relationships between going outdoors and cognitive function differ according to physical functioning of older people.

Methods

Participants and procedures

This study analyzed the data of the Obu Study of Health Promotion for the Elderly (OSHPE). The participants in the OSHPE were recruited from all people living in the city of Obu (a residential suburban area in Japan), aged 65 years or older at the time of the study, who had not participated in another study, and who were not certified as needing support or care by the Japanese long-term care insurance system (Care Level ≥3/5). A total of 14,519 people were asked to participate in the OSHPE by postal mail,

and 5,104 (35.2%) participated in this study. The OSHPE was conducted at community centers in Obu.

Participants in the OSHPE were excluded from the current study if they met at least one of the exclusion criteria: (1) a history of Alzheimer's disease, Parkinson's disease, stroke, or depressive disorder, (2) a disability in basic activities of daily living, (3) a certification of long-term care or support need from the Japanese insurance system, and (4) missing data for the variables used in this study. In total, 654 individuals were excluded; hence, the data of 4,450 individuals were analyzed in this study.

The OSHPE conducted comprehensive health assessments on all participants. The health assessments we analyzed in this study included data from neuropsychological tests (cognitive function) and survey questionnaires (going outdoors and physical function) collected by trained staff members, and face-to-face interviews (demographic and health-related factors) collected by health professionals. Written informed consent was obtained from all participants of the OSHPE. The OSHPE received prior approval from the Ethics Committee of the National Center for Geriatrics and Gerontology.

Measures

Cognitive function

Cognitive function was measured by the Japanese-language version of the Mini-Mental State Examination (MMSE).[29] The MMSE was originally developed for clinical settings, but is now widely used in epidemiological surveys. The MMSE represents general cognitive functioning. MMSE scores range from 0 to 30, with higher scores

representing higher cognitive function.

Going outdoors

An item from the Frailty Checklist for Care Prevention[15] was used to measure going outdoors. This checklist[15] consists of 25 items, which the Japan Ministry of Health Labour and Welfare developed to briefly screen physical function limitations, depressive symptoms, malnutrition, being homebound, decline in cognitive function, and decline in dental function in community settings. Going outdoors less than once a week has been used to define being homebound in previous studies.[26-28] We used the following question to measure being homebound: “Do you usually go outside the house at least once a week?” The participants answered this question with “Yes” or “No”.

Physical function

Physical function was measured by five items that are a part of the Frailty Checklist for Care Prevention,[15] which is used for screening limitations in physical functioning. The items are: “Are you able to go upstairs without holding a rail or wall?”; “Are you able to stand up from a chair without any aid?”; “Are you able to keep walking for about 15 minutes?”; “Have you fallen during the past year (reversed item)?”; and “Are you afraid of falling (reversed item)?”. The respondents answered “Yes” or “No” to each question. The numbers of “No” responses were summed for each respondent, and the respondents were categorized into two groups (without limited physical function, with limited physical function) by the cut-off point for screening physical function limitation (the numbers of “No” $\geq$ 3).[15]

Demographic and health-related factors

The study analyzed data on medical condition (histories of hypertension, heart disease, diabetes, and hyperlipidemia), drinking alcohol habits (yes, no), smoking (yes, no), sex

(men, women), age (65–69, 70–74, 74–79, or 80 ≥ years old), years of education (≤ 9, 10–12, ≥ 13 years), living with others (yes, no), and depressive mood (scores < 6, or ≥ 6 on the Geriatric Depression Scale, short version[33]). Previous research[34,35] revealed that hypertension, heart disease, diabetes, and hyperlipidemia are risk factors for dementia, and that midlife onset of these diseases is associated with later-life dementia. Thus, the current study analyzed the histories of these diseases.

Analyses

We analyzed the MMSE data in two ways: scores on the MMSE, and the categorization of MMSE (< 24 points, or higher). This cut-off point for the MMSE is widely used in screening for decline in cognitive function among older people.[36]

The associations of demographic and health-related factors with cognitive function were examined by Mann–Whitney tests (age, years of education) or chi-squared tests (other variables) for the MMSE scores, and analysis of variance (age, educational years) or *t*-tests (other variables) for the MMSE categories.

Next, two-way analysis of covariance (ANCOVA) was used to examine the interactive associations of physical function and going outdoors with the MMSE scores. The covariates included all demographics, such as age, sex, education, and living with others, and health-related factors, such as medical condition, drinking and smoking, and depressive mood. If the interaction of physical function and going outdoors was significant, the Bonferroni correction was used to counteract the problem of multiple comparisons.

Then, multivariate logistic regression was used to examine the association of going outdoors and physical function with the MMSE categories as the dependent

variable. Going outdoors was included as an independent variable by the forced-entry method, and the stepwise method was used to select the demographic and health-rated factors for inclusion as independent variables. Crude and adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for each variable. Separate logistic regression analyses were subsequently conducted for the groups without and with limited physical function. All analyses were performed using IBM SPSS 21.0 software (IBM, Chicago, IL, USA). The level of significance was set at $p < 0.05$.

Results

Characteristics of the participants and associations of demographic and health-related factors with cognitive function

Table 1 presents the characteristics of the participants. The mean age of the total sample was 71.9 years old (SD 5.4; range 65–97): 72.0 years (SD 5.4; range 65–97) for men and 71.8 years (SD 5.4; range 65–94) for women. Of all the participants (N = 4,450), 220 (4.9%) did not go outdoors at least once a week and 359 (8.1%) had limited physical function. The average MMSE score was 26.3 points, and 24.5% of participants scored fewer than 24 points on the MMSE. The statistical analyses revealed that men, older age, lower educational level, current smoking, and hyperlipidemia were significantly associated with lower scores on the MMSE. Hypertension was significantly associated with MMSE scores, but not with the MMSE categories.

Associations of going outdoors and physical function with cognitive function (MMSE score)

Figure 1 shows the results of the analysis of covariance. As shown in Figure 1, the

interaction effect of going outdoors and physical function on MMSE scores was significant (p = 0.009). Multiple comparisons showed that going outdoors at least once a week was not significantly associated with higher MMSE scores among study participants without limited physical function (going outdoors at least once a week = 26.3; going outdoors less than once a week = 26.0; p = 0.090). However, going outdoors at least once a week was significantly associated with higher MMSE scores among patients with limited physical function (going outdoors at least once a week = 26.0; going outdoors less than once a week = 24.4; p < 0.001).

Associations of going outdoors and physical function with cognitive function (MMSE < 24 points or not)

Table 2 shows the result of the logistic regression for all participants. Sex, age, education, and current smoking were included as independent variables in the adjusted model, based on the stepwise regression method. While a significant relationship was found between physical function and MMSE (Adjusted OR = 1.41; 95% CI = 1.11–1.81), no significant relationship was found between going outdoors and MMSE (Adjusted OR = 1.22; 95% CI = 0.90–1.67).

Table 3 shows the results of the logistic regression analyses that were stratified by physical function. Sex, age, and history of heart disease were included as independent variables for participants with limited physical function, and sex, age, education, and current smoking were included for participants without limited physical function, using the stepwise method. The study participants with limited physical function who went outdoors less than once a week were more likely to have a lower MMSE than those who went outdoors at least once a week (Adjusted OR = 2.25; 95%

CI = 1.11–4.58). However, no significant association was found between going outdoors and MMSE among participants without limited physical function (Adjusted OR =1.04; 95% CI = 0.73–1.48).

Discussion

To our knowledge, this is the first study to examine the moderating role of physical function on the relationships between going outdoors and cognitive function among community-dwelling older adults. While various risk/preventive factors of cognitive decline have been revealed in previous studies,[1-10] the association between going outdoors and cognitive function has been studied insufficiently. Although a previous study[19] indicated that the relationship between life space and cognitive function is moderated by personal control beliefs, other moderating factors of the association between going outdoors and cognitive function have not been examined.

The major finding of this study is that going outdoors at least once a week is associated with better cognitive function in older adults with limited physical function. The finding indicates that going outdoors less often might be associated with cognitive decline, especially among elderly people with limited physical function. Larsons et al. suggested that one of the ways that exercise might reduce the risk for dementia is through modulating the relationship between physical functioning and dementia.[28] Our results are consistent with earlier research showing that physical activity had a greater effect on cognitive function among persons with lower levels of physical functioning compared with persons with higher levels of physical functioning. Going outdoors could accompany some physical and social activities.[17,25] Increased outdoor activities entailing physical and social activities might have positive effects on brain health

among older adults,[9,26,27] including the preservation of brain volume and the enhancement of brain activation.[37-39] Additionally, prospective cohort studies[16,18] have reported the preventive role of life space on cognitive decline. However, they[16,18] have not focused on the mediating role of individual differences on the relationship between going outdoors, or life space, and cognitive function. Except for personal control beliefs,[19] the factors moderating these relationships have not been clarified. Physical function has a linkage with both cognitive function and level of physical activity. Lower physical functioning is associated with cognitive impairment and cognitive decline,[38,39] and older adults with lower physical activity have been found to have poorer limb function.[42] Expanding upon these previous studies, the current study suggests that the relationship between going outdoors and cognitive function differs with the level of physical functioning of older people. According to the findings of this study, individual differences must be taken into account (e.g., differences in physical function status and by personal control beliefs[19]) when considering the role of going outdoors in cognitive function.

With regard to differences in physical function, previous studies indicated that people with limited physical function lose opportunities to engage in physical and social activities[17,25] and are at higher risk of cognitive decline.[21-24] Therefore, individuals with limited physical function could exhibit further cognitive decline by failing to go outdoors. In contrast, those individuals without limited physical function have enough opportunities to engage in various physical and social activities. Thus, going outdoors itself might not be sufficiently influential to have an effect on their cognitive function, and more intensive activities might be needed to influence cognitive functioning among individuals without limited physical functions.

Analyses of the total sample of this study did not reveal an association of going outdoors with cognitive function even though previous studies[15,17] have shown this. This might be because this study measured going outdoors by only a single item. The item used in this study is part of the Frailty Checklist for Care Prevention developed by the Japan Ministry of Health, Labour and Welfare,[15] and the cut-off point of frequency of going outdoors employed in this study (less than once a week) has been widely used to screen for the risk of being homebound.[15,30-32] However, the single item may not be sensitive to detect other differences. Further research is needed to better understand how different aspects of going outdoors, such as duration and frequency, may influence cognitive function.

The prevalence of going outdoors less than once a week was 5.0% in this study. In contrast, previous studies[17,31,32] have reported that the prevalence of going outdoors less than once a week was 10.3% to 19.5%. These previous studies[17,31,32] employed (at least partially) door-to-door surveys. Participants in the present study had to come to community centers where the research was conducted, and the measure of going outdoors was collected by self-reports. Thus, sampling bias could be predominant in this study, and the inconsistency of survey methods might influence the differences in prevalence between this study and previous studies. Furthermore, because a significant association was found between going outdoors and cognitive function with a lower prevalence of going outdoors less than once a week, it is possible that the associations may be larger among people with a higher prevalence of going outdoors less than once a week. Thus, the influence of going outdoors on cognitive function may be underestimated in this study.

The strength of this study is that it analyzed a community-based sample with

an adequate sample size. However, the study has some limitations. First, these data are cross-sectional and therefore causal associations cannot be demonstrated. Second, as previously discussed, sampling bias might have existed in the survey. Despite these limitations, the present study contributes to understanding the influence of going outdoors on cognitive function.

In conclusion, the major finding of this study indicates that going outdoors is associated with cognitive decline among older adults with limited physical function. According to these findings, encouraging individuals to go outdoors might be effective to prevent cognitive decline among older persons with limited physical function. Further research on the causal role of going outdoors in preventing cognitive decline is recommended.

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Disclosure statement

There are no potential conflicts of interest to disclose.

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Figure Legends

Figure 1. Interaction of physical function and going outdoors on cognitive function. MMSE scores were adjusted for sex, age, education, living with others, current drinking, current smoking, hypertension, heart disease, diabetes, hyperlipidemia, and depressive mood. Interaction of physical function and going outdoors (Analysis of Covariance) was $F = 43.4$, $p = 0.009$.

MMSE, Mini-Mental State Examination. *$p < 0.05$, **$p < 0.01$, *** $p < 0.001$

Table 1. Characteristics of the participants and the associations of demographic and health-related factors with cognitive function

		Scores on the MMSE			Categories of the MMSE		
	Total	Mean	SD	p value[a]	< 24 (%)	≥ 24 (%)	p value[b]
Total	4450	26.3	2.68		24.5	75.5	
Sex				<0.001			<0.001
Men	2196	25.9	2.61		28.8	71.2	
Women	2254	26.9	2.71		20.4	79.6	
Age (in years)				<0.001			<0.001
65–69	1809	26.9	2.33		17.2	82.8	
70–74	1389	26.3	2.56		23.5	76.5	
75–79	787	25.6	2.90		33.2	66.8	
≥ 80	465	24.9	3.10		41.3	58.7	
Education (in years)				<0.001			<0.001
≥ 13	996	26.8	2.33		16.8	83.2	
10–12	1871	26.7	2.48		19.6	80.4	
≤ 9	1583	25.4	2.90		35.2	64.8	
Living with others				0.731			0.705
No	415	26.3	2.68		25.3	74.7	
Yes	4035	26.3	2.68		24.5	75.5	
Current drinking habits				0.694			0.496
No	2385	26.3	2.79		24.9	75.1	
Yes	2065	26.3	2.55		24.1	75.9	
Current smoking				0.002			0.003

No	4002	26.3	2.67		23.9	76.1	
Yes	448	25.9	2.76		30.4	69.6	
History of hypertension				0.018			0.083
No	2440	26.4	2.67		23.5	76.5	
Yes	2010	26.2	2.69		25.8	74.2	
History of heart disease				0.470			0.774
No	3741	26.3	2.70		24.5	75.5	
Yes	709	26.2	2.57		25.0	75.0	
History of diabetes				0.488			0.684
No	3863	26.3	2.67		24.4	75.6	
Yes	587	26.2	2.77		25.2	74.8	
History of hyperlipidemia				<0.001			0.001
No	2648	26.1	2.75		26.2	73.8	
Yes	1802	26.5	2.55		22.0	78.0	
Depressive mood (GDS ≥ 6)				<0.001			<0.001
No	3843	26.4	2.63		23.5	76.5	
Yes	607	25.8	2.94		31.1	68.9	
Going outdoors (1 ≥ day a week)				<0.001			0.016
No	4230	26.3	2.64		24.2	75.8	
Yes	220	25.5	3.27		31.4	68.6	
Limited physical function				<0.001			<0.001
Without	4091	26.3	2.61		23.6	76.4	
With	359	25.5	3.26		35.4	64.6	

MMSE, Mini-Mental State Examination; GDS, Geriatric Depression Scale short version

[a]t-test or analysis of variance, [b]chi-square test or Mann–Whitney test

Table 2. Associations of going outdoors and physical function with cognitive function

	n	Crude OR (95% CI)	p value	Adjusted OR	p value
Sex					
Men	2196	1.00		1.00	
Women	2254	0.63 (0.55–0.73)	<0.001	0.57 (0.49–0.66)	<0.001
Age (in years)					
65–69	1809	1.00		1.00	
70–74	1389	1.48 (1.24–1.76)	<0.001	1.42 (1.19–1.70)	<0.001
75–79	787	2.38 (2.00–2.89)	<0.001	2.10 (1.72–2.57)	<0.001
≥ 80	465	3.37 (2.71–4.21)	<0.001	2.75 (2.17–3.46)	<0.001
Education (in years)					
≥ 13	996	1.00		1.00	
10–12	1871	1.21 (0.99–1.48)	0.062	1.35 (1.09–1.66)	0.005
≤ 9	1583	2.70 (2.22–3.29)	<0.001	2.71 (2.21–3.33)	<0.001
Current smoking					
No	4002	1.00		1.00	
Yes	448	1.39 (1.12–1.72)	0.003	1.39 (1.10–1.75)	0.005
Going outdoors					
≥ 1 day/week	4230	1.00		1.00	
< 1 day/week	220	1.43 (1.07–1.92)	0.016	1.22 (0.90–1.67)	0.207
Physical function					
Normal	4091	1.00		1.00	
Limited	359	1.77 (1.41–2.23)	<0.001	1.41 (1.11–1.81)	0.005

Dependent variable: Mini-Mental State Examination < 24

OR, odds ratio; 95% CI, 95% confidence interval

Going outdoors and physical function were included by the forced-entry method. Other factors were selected by the stepwise method.

Hosmer–Lemeshow test for the adjusted model: $\chi^2=4.65(8)$, p=0.795

Table 3. Association of going outdoors with cognitive function in participants with or without limited physical function

	Without limited physical function (n = 4091)					With limited physical function (n = 359)				
	n	Crude OR (95% CI)	p value	Adjusted OR	p value	n	Crude OR (95% CI)	p value	Adjusted OR	p value
Sex										
Men	2086	1.00		1.00		110	1.00		1.00	
Women	2005	0.62 (0.54–0.72)	<0.001	0.60 (0.51–0.70)	<0.001	249	0.41 (0.26–0.65)	<0.001	0.35 (0.22–0.58)	<0.001
Age (in years)										
65–69	1729	1.00		1.00		80	1.00		1.00	
70–74	1303	1.48 (1.24–1.77)	<0.001	1.44 (1.20–1.73)	<0.001	86	1.32 (0.66–2.63)	0.438	1.39 (0.68–2.86)	0.370
75–79	692	2.25 (1.84–2.76)	<0.001	2.05 (1.66–2.53)	<0.001	95	2.66 (1.38–5.11)	0.003	2.78 (1.41–5.47)	0.002
≥ 80	367	3.47 (2.72–4.42)	<0.001	2.89 (2.25–3.72)	<0.001	98	2.21 (1.15–4.26)	0.017	2.67 (1.36–5.27)	0.002
Education (in years)										
≥ 13	955	1.00		1.00			–		–	
10–12	1737	1.21 (0.98–1.49)	0.080	1.35 (1.09–1.67)	0.006		–		–	
≤ 9	1399	2.70 (2.21–3.32)	<0.001	1.36 (1.07–1.73)	<0.001		–		–	
Current smoking										

No	3662	1.00		1.00			–		–	
Yes	429	1.38 (1.11–1.73)		1.36 (1.07–1.73)	0.011		–		–	
History of heart disease										
No	3459	–		–		282	1.00		1.00	
Yes	632	–		–		77	0.57 (0.33–1.01)	0.053	0.48 (0.27–0.88)	0.018
Going outdoors										
≥ 1 day/week	3912	1.00		1.00		318	1.00		1.00	
< 1 day/week	179	1.16 (0.83–1.63)	0.390	1.04 (0.73–1.48)	0.840	41	2.35 (1.22–4.53)	0.011	2.25 (1.11–4.58)	0.025

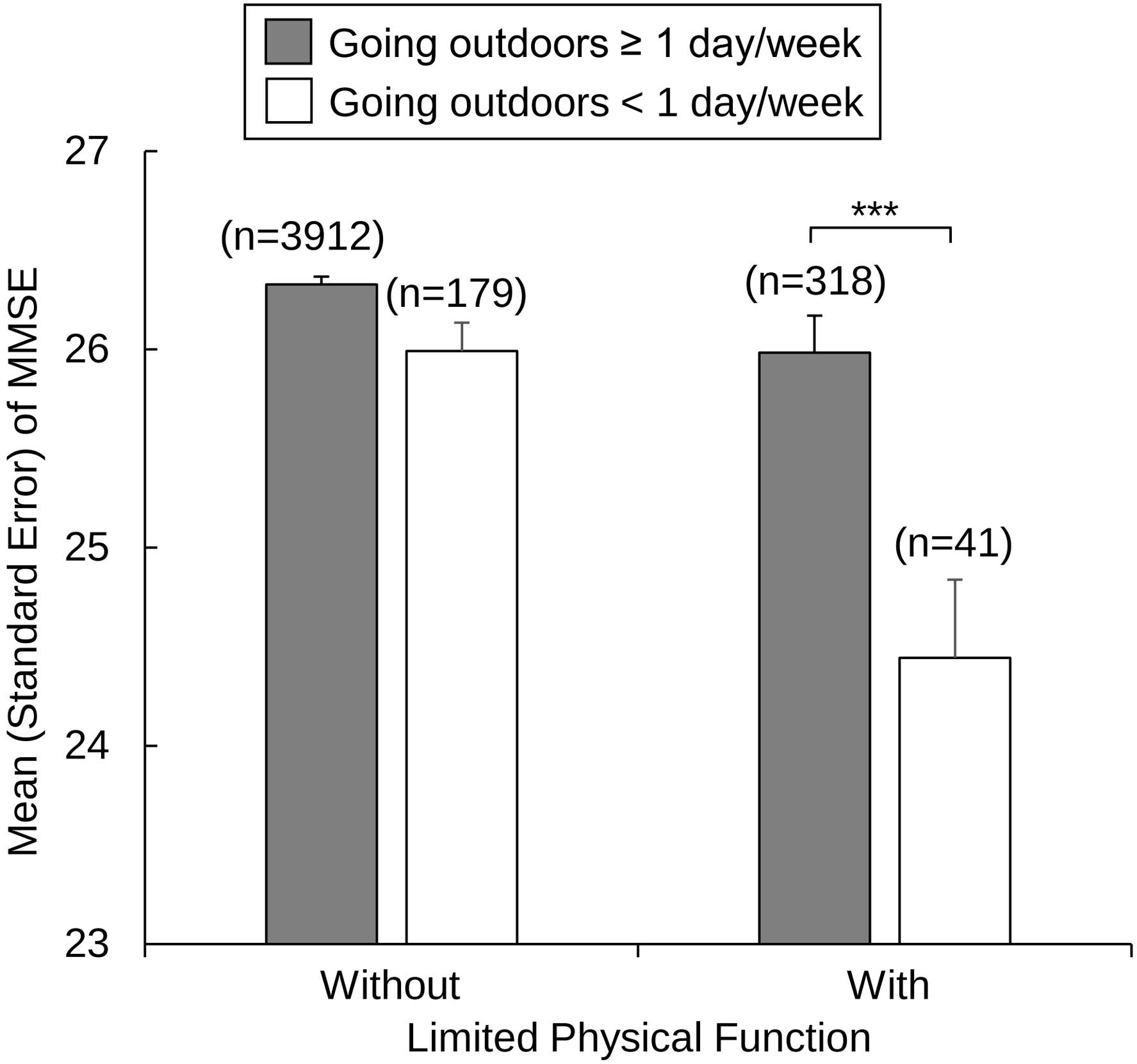
Dependent variable: Mini-Mental State Examination < 24

OR, odds ratio; 95% CI, 95% confidence interval

Going outdoors and physical function were included by the forced-entry method. Other factors were selected by the stepwise method.

Hosmer–Lemeshow test for the adjusted model of those without limited physical function: χ^2=8.19(8), p=0.415

Hosmer–Lemeshow test for the adjusted model of those with limited physical function: χ^2=2.23(6), p=0.898


Going outdoors ≥ 1 day/week
Going outdoors < 1 day/week
27
26
25
24
23
Mean (Standard Error) of MMSE
(n=3912)
(n=179)
***
(n=318)
(n=41)
Without
With
Limited Physical Function