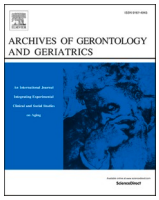
Archives of Gerontology and Geriatrics 104 (2023) 104809

Contents lists available at ScienceDirect

Archives of Gerontology and Geriatrics

journal homepage: www.elsevier.com/locate/archger



Patterns and risk factors of cognitive decline among community-dwelling older adults in South Korea

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ARTICLE INFO

Keywords:
Older adults
Cognitive function
Dementia
South Korea
Longitudinal study

ABSTRACT

Dementia prevalence is increasing worldwide. Thus, the global impact of cognitive impairment and dementia have become significant public health issues. This study assessed the patterns of and investigated risk factors associated with cognitive decline over time in community-dwelling Korean adults (age ≥65 years). We enrolled 1,369 older adult respondents without cognitive decline in the baseline survey of the Korean Longitudinal Study of Aging (2006–2016) in South Korea. The risk of first-ever mild-to-moderate or severe cognitive decline during the 10-year follow-up (2006–2016) was comparatively evaluated between the cognitive decline group (comprising participants with mild-to-moderate or severe cognitive decline; $n = 728$) and the normal cognition group (participants without a cognitive decline event; $n = 641$). The cognitive decline-free survival rates for up to ten years were measured using Kaplan–Meier analysis. The generalized estimation equations model was used to analyze changes in K-MMSE over time from 2006 to 2016. The adjusted Cox proportional hazards model revealed that increased age, female, lower education level, no religious status, and living in a small city were factors that were associated with a higher risk of cognitive decline, as were health-related factors, including lower handgrip strength, a higher number of chronic diseases, and depressive symptoms. Regular exercise, non-drinking status, and active social engagements reduced the risk of cognitive decline. The identified risk factors could facilitate the development of cognitive decline-prevention programs incorporating individualized risk-modification interventions to prevent cognitive decline in older adults.

1. Introduction

Maintaining a high level of cognitive function is a key component of successful aging (Rowe & Kahn, 1997). In the policy framework for active aging, the World Health Organization (WHO) emphasized the importance of cognitive function as a key health determinant for older adults (World Health Organization, 2002). In older adults, aging-related cognitive decline most commonly occurs in individuals who are older than 70 years (Aartsen, Smits, van Tilburg, Knipscheer & Deeg, 2002). Population aging is a global phenomenon (World Health Organization, 2012), and, in South Korea, the aging population (≥65 years) is rapidly increasing. It is estimated to constitute 41% of the total population by 2060 (Kim, 2017). With an increase in the number of older adults, the number living with some form of cognitive impairment also increases.

Mild cognitive impairment (MCI) is an intermediate state of cognitive function between normal aging and dementia and does not impair daily activities. However, dementia is characterized by a more severe and widespread cognitive impairment that substantially affects daily functioning (Gauthier et al., 2006). Worldwide, the prevalence of MCI and dementia is increasing. Also, 1 out of 5 (20.15%) Korean older adults had MCI in 2017 (Ministry of Health and Welfare, 2019). Approximately 6% of the older adults with MCI in China progress to dementia annually (Ding et al., 2016). Globally in 2015, 47.47 million individuals had dementia, projected to increase to 75.63 million and 135.46 million by 2030 and 2050, respectively (Prince, Guerchet & Prina, 2015).

Dementia is a health condition characterized by a combination of cognitive decline and physical and psychological symptoms continually aggravated until death. Individuals with dementia need long-term care, a public health burden not only for the patients but also for their families, communities, and the country (Hong, Park & Oh, 2018). Even mild cognitive decline constitutes an independent risk factor for mortality (Lavery, Dodge, Snitz & Ganguli, 2009). Cognitive decline may lead to physical impairment, dementia (Bozoki, Giordani, Heidebrink, Berent &

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https://doi.org/10.1016/j.archger.2022.104809
Received 29 April 2022; Received in revised form 2 September 2022; Accepted 5 September 2022
Available online 8 September 2022

Foster, 2001), decreased quality of life (Hill et al., 2017), and increased health-related costs (Leibson et al., 2015).

Factors that affect cognitive decline include demographics and physical variables, such as age (Jeon, 2013; Kim, Kim & Kim, 2011), being unmarried (Fratiglioni, Wang, Ericsson, Maytan & Winblad, 2000), female (Lee & Kahng, 2011), decline in physical function (Middleton, Barnes, Lui & Yaffe, 2010), the presence of many chronic comorbidities (Livingston et al., 2017), and handgrip strength (Kim, Park, Lee & Lee, 2019). Brookmeyer, Gray, and Kawas (1998) estimated that a one-year delay in dementia onset could reduce the number of cases of Alzheimer's dementia by 11% worldwide by 2050. Identifying patterns and risk factors of cognitive decline in older adults and prevention of cognitive decline through interventions is a prominent public health issue in South Korea and worldwide.

Alzheimer's dementia, characterized by a slow progression of cognitive decline, is a neurodegenerative disease diagnosed at too advanced a stage for interventional pharmacotherapy because of irreversible neuronal death (Lo, 2017). Older adults with dementia have more physical health problems than their counterparts, as they often receive less community healthcare and are more frequently hospitalized. Community healthcare providers need to develop interventions and strategies for preventing cognitive decline in community-dwelling older adults and should establish community health services for older adults with dementia. Thus, it is essential to identify patterns of cognitive decline and risk factors in older adults with normal cognition to incorporate interventions to impede rapid cognitive decline. Therefore, interventions designed to manage risk factors associated with cognitive decline and strategies to prevent or deter this decline in older adults living in the community are of great importance. Cognitive decline is distressing to the patient, their family, and the country due to its profound health and economic burdens. Therefore, there is an emphasis on the importance of dementia prevention and early detection, and, increasingly, there is a focus on MCI. However, based on current research and knowledge, few studies have explored longitudinal changes in cognitive function and risk factors in Korean older adults over a long period.

This study aimed to explore the cognitive decline in community-dwelling older adults and the associated factors in a nationally representative sample of older adults followed for up to ten years by examining a wide range of socioeconomic, behavioral, and health factors to provide a framework for the development of programs and strategies targeted at dementia prevention and management by community healthcare providers.

2. Methods

2.1. Data and participants

This study obtained data from the Korean Longitudinal Study of Aging (KLoSA) conducted by the Korean Labor Institute (KLI). The KLoSA research panel survey, conducted every two years since 2006, is a longitudinal panel survey of a nationally representative multistage- and stratified-probability sample of community-dwelling adults aged 45 years or older. The KLoSA uses computer-assisted personal interviews and includes various demographic, economic, and health-related topics (Boo & Chang, 2006). KLoSA data from the KLI from 2006 to 2016 that were in the public domain were anonymized and downloaded from the institute's website https://survey.keis.or.kr/klosa/klosa01.jsp). Participants of this study provided voluntary informed consent to researchers from the KLI prior to their study enrollment (Callegaro & Disogra, 2008). In addition, the study included participants with impaired decision-making capacity due to cognitive decline through a legal representative.

Fig. 1 shows the participant selection process. This study analyzed the data from older adults (age ≥65 years) with normal cognitive function (Korean Mini-Mental State Examination [K-MMSE] score ≥24) in 2006 and followed them for ten years until the sixth survey in 2016. Participants were divided into the normal cognition and cognitive decline groups based on the onset of the first-ever cognitive decline event (K-MMSE score ≤23 indicated cognitive decline) from 2008 to 2016. The first KLoSA dataset (2006) included 10,254 participants, excluding 2,686 individuals lacking normal cognition (K-MMSE score <24) and 5,370 individuals younger than 65. Among the 2,198 participants selected from the baseline, 456 had missing data on the covariates in 2006, and there were 373 deaths, hospitalizations, or refusals to participate in 2016, resulting in the exclusion of 829 participants. The final study cohort of 1,369 participants comprised 728 participants with normal cognition and 641 with the onset of cognitive decline.

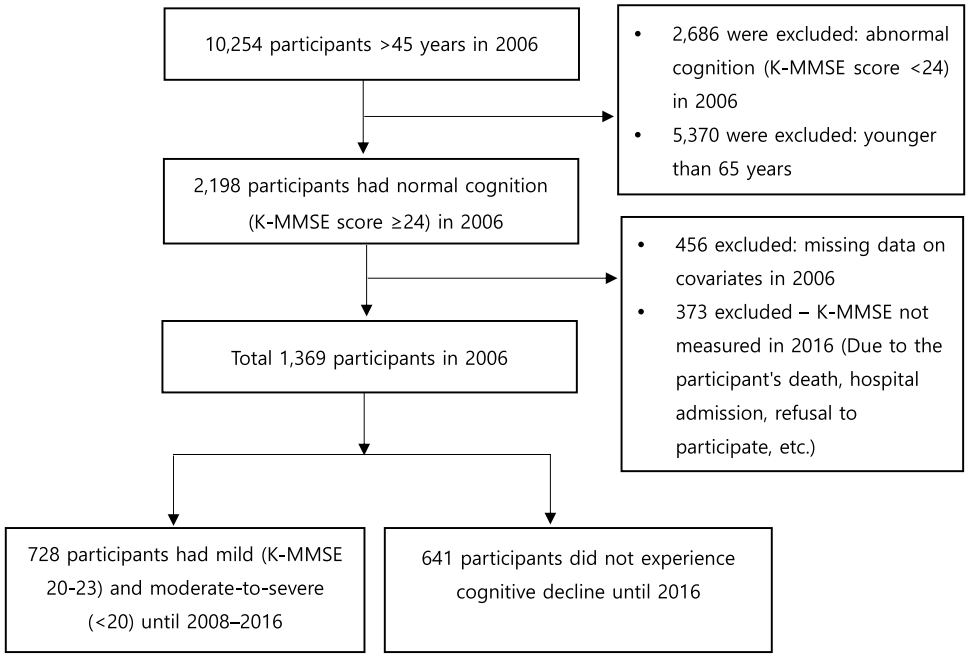

Fig. 1. Selection of the study participants.

2.2. Dependent variables

2.2.1. Cognitive function

In the KLoSA, cognitive function was measured with the K-MMSE and comprised six domains (i.e., time and place orientation, registration, attention and calculation, recall, language, and visual construction). The final score ranges between 0 and 30 points, with a higher score indicating better cognitive function. Accordingly, participants with a K-MMSE score ≥24, 20-23, and ≤19 points were classified as having normal cognition, mild dementia, and moderate-to-severe dementia, respectively (Kang, Na & Hahn, 1997). In this study, the time point at which the K-MMSE score was ≤23, indicating when the first decline at each survey time point occurred, was noted as the time point of the onset of cognitive decline events.

2.3. Independent variables

2.3.1. Demographic characteristics

Demographic factors included: age (continuous), gender (bivariate), education level (stratified into elementary school or lower, middle school, high school, and college or higher), marital status as "yes" (current marital status) or "no" (e.g., divorced, widowed, single), having a religion ("yes" or "no"), current employment "yes" or "no," total household income in the past year (continuous), and residential area (stratified into "large," "medium," and "small" cities).

2.3.2. Health status and health behaviors

Participants answered "yes" or "no" to their use of a hearing aid. The body mass index (kg/m^2) was considered a continuous variable. To measure handgrip strength, the KLI researchers used a handgrip dynamometer. The final handgrip strength value (range: 0–50 kg) was the average value of the right- and left-handgrip strength values. The calculation of the number of chronic diseases (range: 0–9) used the following conditions: hypertension; diabetes; cancer; arthritis and rheumatism; and chronic lung, liver, heart, cerebrovascular, and psychiatric illnesses. Regular exercise, categorized into "yes" and "no," was defined as exercising at least once per week. The categories for smoking and drinking depend on alcohol use and smoking habits; specifically, for smoking, "non-smokers," "past smokers," and "current smokers;" and for drinking, "non-drinkers," "past drinkers," and "current drinkers." Depressive symptoms were measured using the 10-item scale (short-form) of the Center for Epidemiological Studies Depression (CES-D10; Korean version; Chon, 1992), and the CES-D10 score was considered a continuous variable.

2.3.3. Activities of daily living and instrumental activities of daily living

Functional limitation was assessed using the Korean Activities of Daily Living (K-ADL) and Korean Instrumental Activities of Daily Living (K-IADL). The K-ADL scale evaluates seven actions: eating, bathing or showering, grooming, walking, dressing and undressing, transfers, and toileting (Won, Rho, Kim, Cho & Lee, 2002). For each action, respondents enter "0" if they do not require any help or "1" if they require assistance for performing the action; the final score ranges from 0 to 7 points. A higher K-IADL score indicates a higher level of dependency, and K-ADL scores were considered continuous variables. The K-IADL scale comprises ten items: shopping, grooming, going out for short walks, using transportation, laundry, ability to handle finances, housekeeping, food preparation, ability to use a telephone, and taking medications (Kang et al., 2002). The final score ranges from 0 to 10 points, and a higher K-IADL score indicates a higher level of dependency; K-IADL scores were considered continuous variables.

2.3.4. Social interactions

To measure social interaction according to the participation in regular meetings (six questions), participants categorized six activities: religious; social; leisure/culture/sports; alumni/birthplace— alumni activities are meetings with men and women who have completed their studies at the same school, college or university, while birthplace is meeting with people from the place where they were born and raised; volunteering; and political party/civic society organization/interest group meetings. Respondents entered a response of "0" if they did not participate in the activity (meeting) or "1" if they were engaging in the activity. The sum of the frequency of regular meetings was calculated to obtain a score ranging from 0 to 6.

2.4. Statistical analysis

Descriptive statistics, such as proportions (%) and mean(s) of demographic characteristics; health status; health behavior; and social interactions, were used in the initial analysis. The differences between the two groups in 2006 were analyzed using the chi-square test and analysis of variance. The generalized estimation equations (GEE) model analyzed changes in K-MMSE over time from 2006 to 2016. GEE is a general statistical method used in biomedical research to fit marginal models to longitudinal data. GEE is a population-level model based on the quasi-likelihood function approach. It can employ random effects to correlate between multiple observations on the same participants (Wedderburn, 1974). The pattern of K-MMSE examined changes in participants with cognitive decline over time. A Kaplan–Meier curve estimated the probability of cognitive decline. Adjusted hazard ratios (aHR) were calculated with 95% confidence intervals (95% CI). A multivariate Cox proportional hazards regression model was used to determine risk factors associated with cognitive decline. All statistical analyses were conducted using Stata 17/SE version (Stata Corporation, College Station, TX, USA), and a p-value $< .05$ was considered statistically significant.

2.5. Ethical considerations

The KLoSA study was approved by the National Statistical Office (approval number: 33602) and used computer-assisted personal interviews conducted by well-trained interviewers. Prior to the survey, the interviewer explained the purpose, methods, and procedures of the study to participants in a face-to-face meeting and obtained informed consent. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and the national research committee and with the Declaration of Helsinki (1964) and its later amendments or comparable ethical standards. This present study for secondary analysis was approved by the respective Yonsei University Health System Institutional Review Board (Y-2019-0043).

3. Results

3.1. Participant characteristics

In 2006, 1,369 older adults with normal cognition participated in the study. Of these individuals, 728 had experienced cognitive decline between 2006 and 2016, whereas 641 maintained normal cognitive function. Table 1 shows the intergroup differences in demographic characteristics, health status and health behavior, and social interaction in 2006. The mean age was 70.08 years (SD = 4.31), 48.1% of the study cohort was female, 56.3% were elementary school graduates, 75.6% were married, 59.9% were religious, and 26.6% were currently employed. The cognitive decline group had a 16.1% higher proportion of female participants than the normal cognition group. The percentage of elementary school graduates in the cognitive decline group was 23.9% higher than in the normal cognition group.

Regarding marital status, 70.7% of participants in the cognitive decline and 81.1% in the normal cognition groups were married. Furthermore, 31.6% of participants in the cognitive decline group and 20.1% in the normal cognition group live in a small city. Again, the

Table 1
Baseline Participant Characteristics in 2006 in the Two Cognitive Function Groups (n = 1,369).

Variables	Total (N = 1,369)		Cognitive decline group (n = 728)		Normal cognition group (n = 641)		p–value
	n	%	n	%	n	%	
Gender							
Male	711	51.9	323	44.4	388	60.5	<.001
Female	658	48.1	405	55.6	253	39.5	
Education level, n (%)							
Elementary school or lower	770	56.3	491	67.5	279	43.6	<.001
Middle school	192	14.0	94	12.9	98	15.3	
High school	275	20.1	102	14.0	173	27.0	
College or higher	130	9.5	40	5.5	90	14.1	
Marital status, n (%)							
Yes	1,035	75.6	515	70.7	520	81.1	<.001
No	334	24.4	213	29.3	121	18.9	
Religion							
Yes	820	59.9	431	59.2	389	60.7	.192
No	549	40.1	297	40.8	252	39.3	
Currently employed, n (%)							
Yes	364	26.6	183	25.1	181	28.2	.195
No	1,005	73.4	545	74.9	460	71.8	
Residential area, n (%)							
Large city	598	43.7	300	41.2	298	46.5	<.001
Medium city	412	30.1	198	27.2	214	33.4	
Small city	359	26.2	230	31.6	129	20.1	
Hearing aid use, n (%)							
Yes	65	4.7	36	4.9	29	4.5	.715
No	1,304	95.3	692	95.1	612	46.9	
Smoking, n (%)							
Current smoker	212	15.5	111	15.2	101	15.8	.291
Past smoker	192	14.0	91	12.5	101	15.8	
Non-smoker	965	70.5	526	72.3	439	68.5	
Drinking, n (%)							
Current drinking	480	35.1	236	32.4	244	38.1	.041
Past drinking	119	8.7	67	9.2	52	8.1	
Non-drinking	770	56.2	425	58.4	345	53.8	
Regular exercise, n (%)							
Yes	602	44.0	283	38.9	319	49.8	<.001
No	767	56.0	445	61.1	322	50.2	
	M	*SD*	*M*	*SD*	*M*	*SD*	
Age (years)	70.08	4.31	70.41	4.42	69.71	4.17	.003
Total household income in last year (USD)	13,058.10	17,057.50	11,640.00	15,630.90	14,668.80	18,425.60	.001
Body mass index	23.32	2.75	23.16	2.77	23.49	2.72	.025
Handgrip-strength index	24.54	7.53	23.04	7.14	26.26	7.60	<.001
Number of chronic diseases	1.18	1.06	1.20	1.04	1.11	1.08	.085
Depression (CES-D10 score)	1.33	1.64	1.46	1.80	1.18	1.42	.001
K-MMSE	27.26	1.94	26.88	1.94	27.70	1.84	<.001
K-ADL score	0.03	0.31	0.04	0.38	0.02	0.20	.290
K-IADL sore	0.30	1.14	0.38	1.35	0.19	0.74	.004
Number of participations in regular meetings	1.41	0.68	1.36	0.64	1.46	0.73	.006

CES-D10, Center for Epidemiological Studies Depression; K-MMSE, Korean-Mini-Mental State Examination; K-ADL, Korean Activities of Daily Living; IADL, Korean Instrumental Activities of Daily Living

mean income was 13,058.10 USD (SD = 17,057.50) and was calculated based on the average exchange rate in 2006 (used as the exchange rate throughout the analysis: ~1000 Korean won per dollar. The mean age for participants with cognitive decline was 70.41 (SD = 4.42) compared to 69.71 (SD = 4.17) years for the normal cognition group.

The overall mean BMI was 23.32 (SD = 2.75), handgrip was 24.54 (SD = 7.53), number of chronic diseases was 1.18 (SD = 1.06), CES-D10 was 1.33 (SD = 1.64), and K-MMSE score was 27.26 (SD = 1.94). For participants with cognitive decline, the mean handgrip was 23.04 (SD = 7.14), and the CES-D10 was 1.46 (SD = 1.80); for the normal cognition group, the mean handgrip was 26.26 (SD = 7.60), and the CES-D10 was 1.18 (SD = 1.42). The overall mean number of participations in regular meetings was 1.41 (SD = 0.68); the mean ADL scores was 0.03 (SD = 0.31), and IADL scores was 0.30 (SD = 1.14). Furthermore, 39.8% of participants in the cognitive decline group and 49.8% in the normal cognition group exercised regularly.

3.2. Changes in cognitive decline

Of the 1,369 participants representing community-dwelling older adults in the South Korean population, 728 (53.2%) experienced cognitive decline in follow-up surveys. Table 2 presents the results of the K-MMSE scores by group and over time for the cognitive decline group. The cognitive decline group had a significantly lower group by time interaction. Their K-MMSE scores were collected for 2008 ($\beta = -2.713$, $p < .001$), 2010 ($\beta = -2.775$, $p < .001$), 2012 ($\beta = -3.279$, $p < .001$), 2014 ($\beta = -3.984$, $p < .001$), and 2016 ($\beta = -4.587$, $p < .001$). Kaplan–Meier analysis showed that the first event of cognitive decline changed over time. Figs. 2 and 3 show the Kaplan–Meier cumulative probability curves of the probable incidence of cognitive decline.

3.3. Risk factors of cognitive functional decline

Adjusted Cox regression models confirmed the effects of these risk factors on cognitive decline: increased age, female, lower education level, no religion status, living in the small city, lower handgrip strength, higher number of chronic diseases, higher depressive symptoms, non-drinking status, and lower frequency of participation in regular meetings. Specifically: age (aHR 1.006, 95% CI [1.003–1.010], $p < .001$), female (male as the reference group, aHR 1.250, 95% CI [1.051–1.468],

Table 2
Generalized Estimating Equations Analyses of Cognitive Decline (n = 1,369).

Change in K-MMSE	Adjusted			
	Coefficient	SE	95% CI	p-value
Cognitive decline group (ref. Normal cognition group)	−0.396	0.186	−0.762–0.032	.033
Time (year)	0.053	0.038	−0.022–0.128	.168
Cognitive decline group *time (ref. Normal cognition group *time 2006)				
Cognitive decline group * time 2008	−2.713	0.234	−3.172–2.255	< .001
Cognitive decline group * time 2010	−2.775	0.240	−3.246–2.304	< .001
Cognitive decline group * time 2012	−3.279	0.243	−3.757–2.802	< .001
Cognitive decline group * time 2014	−3.984	0.251	−4.475–3.492	< .001
Cognitive decline group * time 2016	−4.587	0.257	−5.091–4.084	< .001

SE: standard error; CI, confidence interval; MMSE: Mini Mental State Examination; SE: Standard error; BMI: body mass index; CES-D10: Center for Epidemiologic Studies Depression Scale; K-ADL: Korean active daily living, K-IADL: Korean instrument active daily living; adjusted covariates**:** age, gender, education level, religion, marital status, present job, residential area, BMI, handgrip-strength, number of chronic diseases, CES-D10, K-ADL, K-IADL, regular exercise, smoking, drinking, number of participations in regular meetings in 2006.

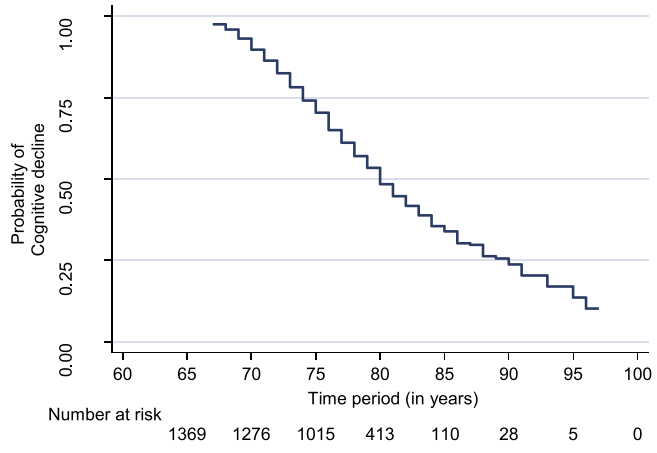

Fig. 2. Kaplan–Meier curve of the overall cumulative first-ever cognitive decline event over time (years).

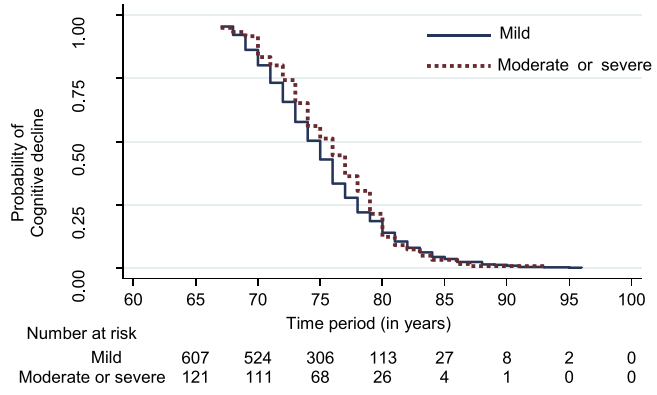

Fig. 3. Kaplan–Meier curve of the cognitive decline group cumulative first-ever cognitive decline event over time (years).

Table 3
Risk Factors of Mild and Moderate-to-severe Cognitive Impairment for all Participants using the Multivariate Cox Proportional Hazards Regression Model (n = 1,369).

Variables	Cognitive decline*		
	HR	95% CI	p-value
Age, years	**1.006**	**1.003–1.010**	**<.001**
Female (ref: Male)	**1.250**	**1.051–1.468**	**.011**
Education level (ref: elementary school or lower level)			
Middle school	**0.816**	**0.706–0.943**	**.006**
High school	**0.645**	**0.554– 0.751**	**<.001**
College or higher	**0.412**	**0.316–0.536**	**<.001**
Marital status (ref: Yes)			
No	0.897	0.800–1.006	.065
Religion (ref: Yes)			
No	**1.119**	**1.013–1.236**	**.026**
Currently employed (ref: Yes)	1.096	0.960–1.251	.174
Total household income in last year	1.000	0.999–1.000	.849
Residential area (ref: Large city)			
Medium city	1.101	0.977–1.240	.113
Small city	**1.339**	**1.190–1.507**	**<.001**
Hearing aid use (ref: Yes)	1.238	0.960–1.597	.099
Body mass index	1.005	0.988–1.022	.531
Handgrip-strength index	**0.963**	**0.955–0.972**	**<.001**
Number of chronic diseases	**1.086**	**1.041–1.132**	**<.001**
Depression (CES-D10 score)	**1.078**	**1.054–1.102**	**<.001**
K-ADL score	0.990	0.889–1.103	.868
K-IADL score	1.001	0.962–1.041	.959
Regular exercise (ref: Yes)	**1.205**	1.082–1.341	**.001**
Smoking (ref: Non-smoker)			
Current smoker	1.095	0.936–1.281	.256
Past smoker	0.857	0.721–1.019	.081
Drinking (ref: Current drinking)			
Non-drinking	**1.212**	**1.140–1.484**	**.049**
Past drinking	**1.301**	**1.001–1.467**	**<.001**
Number of participations in regular meetings	**0.755**	**0.703–0.812**	**<.001**

* Cognitive decline includes mild and moderate-to-severe cognitive impairment

HR, hazard ratio; CI, confidence interval; CES-D10, Center for Epidemiological Studies Depression; K-ADL, Korean Activities of Daily Living; K-IADL, Korean Instrumental Activities of Daily Living

p = .011), education level (elementary school or lower as reference group, middle school: aHR 0.816, 95% CI [0.706–0.943], p = .006; high school: aHR 0.645, 95% CI [0.554–0.751], p < .001; college or higher: aHR 0.412, 95% CI [0.316–0.536], p < .001), religion status (yes as the reference group, aHR 1.119, 95% CI [1.013–1.236], p = .026), residential area (large city as the reference group, small city: aHR 1.339, 95% CI [1.190–1.507], p < .001), handgrip strength (aHR 0.963, 95% CI [0.955–0.972], p < .001), number of chronic diseases (aHR 1.086, 95% CI [1.041–1.132], p < .001), depressive symptoms (CES-D10; aHR 1.078, 95% CI [1.054–1.102], p < .001), regular exercise (yes as the reference group, aHR 1.205, 95% CI [1.082–1.341], p = .001), drinking (current drinking as the reference group, non-drinking: aHR 1.212, 95% CI [1.140–1.484], p = .049; past drinking: aHR 1.301, 95% CI [1.001–1.467], p < .001), and frequency of participation in regular meetings (aHR 0.755, 95% CI [0.703–0.812], p < .001) Table 3.

4. Discussion

This study investigated the risk factors over time in community-dwelling Korean older adults. In this study, 1,369 community-dwelling older adults with normal cognitive function experienced changes in K-MMSE scores over ten years; 728 older adults progressed to cognitive decline (53.2%), whereas 641 older adults maintained normal cognitive function. Cognitive functioning in older adults is of substantial interest, given its prominent role in “successful” aging. In this study, K-MMSE scores significantly differed over time among normal cognition and

cognitive decline groups. In the cognitive decline group, the cognitive function steadily decreased after 2 years and rapidly decreased over 6 years. While the FDA recently approved drugs for symptomatic reduction of dementia, unfortunately, there currently are no treatments or disease-modifying pharmacological treatments for MCI or Alzheimer's dementia. Identifying older adults with abnormal decline early in the disease's progression presents an opportunity to implement secondary prevention interventions focused on delaying the transition to dementia (Cohen, Ryan & Lanzi, 2021). The results of this study suggest that active cognitive decline prevention is necessary within at least 6 years from the onset of the decline. Worldwide, a recent report highlighted the importance of risk reduction, which shows that modifiable risk factors account for approximately 40% of dementia cases (Livingston et al., 2020). Identifying and managing risk factors in the transitionary stage between normal aging and dementia in an older adult population is essential for preventing dementia.

The risk factors of cognitive decline identified in our study (older age, female, lower education level, no religion status, residing in a small city residential area, lower handgrip strength, higher number of chronic diseases, lack of regular exercise, current non-drinking status, depressive symptoms, and more less frequent participation in regular meetings) are similar to those in many previous studies. This study's results are consistent with previous studies, indicating that cognitive function deteriorates with increasing age (Lipnicki et al., 2017; Stewart, Prince & Mann, 2003). In South London, after a three-year follow-up of 207 people aged 55 to 75, there was an association between cognitive decline and age (65–69, OR = 2.02, CI [0.71–5.73]; 70–75, OR = 4.20, CI [1.30–13.6]; Stewart et al., 2003).

The findings of the present study are in line with those of previous studies, which showed that being female (Lee & Kahng, 2011; Sohn et al., 2018), lower education level (Koster et al., 2005; Wilson et al., 2009), and having no religion were associated with greater cognitive decline with normal aging in older adults. Gender-related differences in dementia risk are well known, and cognitive decline is more significant in women than men. In addition, women have a higher risk of developing Alzheimer's than men (Dye, Miller, Singer & Levine, 2012). Research suggests that women may experience a greater effect of apolipoprotein ε4 allele (*APOE* ε4) associated with an increased rate of cognitive decline following the onset of MCI or dementia and has a greater impact on amyloid pathology and dementia risk (Sohn et al., 2018). Previous studies have reported a faster cognitive decline in women than men in various cognitive domains, including visual and verbal processing and semantic and episodic memory (Laws, Irvine & Gale, 2016). This difference between men and women was confirmed from early development to later life (Tóthová et al., 2014).

Similar to other studies (Koster et al., 2005; Wilson et al., 2009), we observed that cognitive decline was associated with education level. For example, in a systematic review encompassing studies published between 1985 and 2010, 51 of 88 studies (58%) reported significant adverse effects of lower education levels on the risk of dementia (Sharp & Gatz, 2011). Thus, it is not surprising that we found a significant association between cognitive decline, being female, and having a lower educational level. Furthermore, we found that religion can influence cognitive decline. Agli, Bailly, and Ferrand (2015) found in their systematic review that participants who practiced greater spirituality or religion tended to reduce or stabilize cognitive impairment by maintaining beliefs, practices, and social interactions. Religion appears to have a preventive role in cognitive decline by providing mental stability and peace associated with participation in religious activities.

Living in an urban rather than rural area improves the living and working environments positively affecting cognitive function. In their study, Xu, Dupre, Gu, and Wu (2017) examined the effect of residential areas on cognitive decline in Chinese older adults; rural residents had better cognitive function at baseline but experienced a faster decline than urban residents. These results support our findings that older adults living in small cities are at a greater risk of declining cognitive function. Changes in muscle strength can be due to age-related changes in biological vitality and body function. Low handgrip strength predicted cognitive decline in older Mexican Americans (Alfaro-Acha et al., 2006). Muscle strength measurements are helpful in the clinical evaluation of older adults to identify those at a greater risk for accelerated functional, psychological, and social health decline (Taekema, Gussekloo, Maier, Westendorp & de Craen, 2010). Therefore, it is necessary to measure changes in muscle strength as well as cognitive function during the clinical evaluation of this population. Furthermore, individuals with several chronic diseases are at higher risk for declining cognitive function (Kim et al., 2019). Thus, managing and treating chronic diseases are essential to prevent or delay the occurrence of cognitive function impairment. Depression is the most common mental health condition in older adults and strongly affects cognitive function. Consistent with the findings of other studies (Barnes, Alexopoulos, Lopez, Williamson & Yaffe, 2006; Chodosh, Miller-Martinez, Aneshensel, Wight & Karlamangla, 2010; Kim, Liu, Cheung & Ahn, 2018), we observed that depressive symptoms were associated with cognitive function decline, indicating that prevention, early detection, and treatment for depressive symptoms in older adults can prevent or impede decline in cognitive function.

Our study found that regular exercise, current non-drinking status, and participation in regular meetings reduced the risk of cognitive decline. Regular physical exercise enhances and maintains the general health, quality of life, physical fitness, and ADL of older adults. Regular physical activity has recently been studied as a predictor of various physical health conditions, consequently garnering greater interest in the relationship between physical health and cognitive function. Studies have shown that regular exercise in older adults may delay the progression of dementia (Larson et al., 2006). Older physically active women have a low risk of cognitive decline (Middleton et al., 2010). For example, walking lowers the risk of dementia; thus, older adults who exercise regularly have a lower risk of cognitive decline (Abbott et al., 2004). Alcohol use in this study was associated with cognitive decline, consistent with previous studies; minimal and moderate alcohol use was associated positively with decreases in MMSE and memory function compared with no alcohol use (Baumgart et al., 2015). A meta-analysis of alcohol consumption as a risk factor for a prospective study of dementia and cognitive decline showed that when the more generally classified "drinkers" were compared with "non-drinkers," they had a reduced risk of Alzheimer's disease (RR = 0.66, 95% CI = 0.47–0.94) and any dementia (RR = 0.53, 95% CI = 0.53–0.82)(Anstey, Mack & Cherbuin, 2009). However, there is still much controversy regarding alcohol consumption. There is not enough evidence to suggest that non-drinkers should start drinking, especially given the potential adverse effects of excessive alcohol consumption, such as an increased risk of falls in older adults (Mukamal et al., 2004; Stahre, Roeber, Kanny, Brewer & Zhang, 2014).

In this study, the risk of cognitive decline was reduced with increased participation in regular meetings. Previous studies have identified poor social engagement and frequency as predictive factors of the risk of cognitive decline in older adults (Fratiglioni et al., 2000; Zunzunegui, Alvarado, Del Ser & Otero, 2003). Increased social activity and social network interactions may consist of cognitively stimulating activities that improve cognitive performance and increase the likelihood of positive health behaviors and participation in cognitively stimulating activities (Kelly et al., 2017; Umberson, 1987). Hence, healthcare providers should promote and support this population's active lifestyle and social engagement.

Our findings provide an essential framework for developing and implementing interventions to maintain and improve the cognitive function of community-dwelling Korean older adults. In Korea, there are limited studies of risk factors for cognitive function impairment. Our study identified changes in cognitive function and analyzed the associated risk factors from a comprehensive and longitudinal perspective. As the incidence of dementia increases with age, early risk factor

management should be a priority for the early detection and prevention of dementia in older adults (Ministry of Health and Welfare, 2013). In the future, interventional studies should be conducted to determine the values of regular screening of cognitive function and implementation of programs that allow community-dwelling older adults to maintain healthy levels of physical function (handgrip strength) as well as programs for mental (depressive symptoms) and physical (chronic diseases) health management and prevention.

This study had some limitations. First, while the pattern of K-MMSE was evaluated with a large cohort of 1,369 older adults between 2006 and 2016, we only included community-dwelling older adults and not those living in nursing homes. Second, we may not have fully controlled for all potential risks or confounding factors; the database lacks relevant information to include as potential confounding factors, such as intelligence quotient, family history of dementia, medications, levels of oxidative stress, and migration history; we included only variables in the KLoSA. Third, participants were asked to describe whether they participated in exercise levels based on this broad response option. However, this may not have effectively represented the level needed for disease prevention in the older adult population. Despite these limitations, we believe our study is valuable because of the relatively long follow-up and the use of a representative sample of older adults. In addition, by identifying risk factors that affect the K-MMSE score, our findings can be utilized to improve the preventive care of older adults.

5. Conclusion

This study found that demographic characteristics, health status (chronic disease, handgrip strength, and depressive symptoms), regular exercise, and social engagement influence the risk of decline in cognitive function. In addition, it provides a basis for understanding the risks related to cognitive decline and changes in Korean older adults. Given that MCI can progress to moderate or severe dementia, timely and appropriate strategies according to the stage of cognitive function impairment are required to reduce personal, family, and social burdens. The findings of this study can provide information for the development and application of dementia prevention and management interventions for older adults. Furthermore, the results have important implications for policies pertaining to interventions focusing on Korean older adults and for cognitive function.

Authors' contributions

JS conceptualized and designed the study and performed the data analysis. JS and EC participated in the interpretation of the results. All authors developed the manuscript, read, and approved the final manuscript.

Availability of data and materials

The data used in this study are available at http://survey.keis.or.kr.

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Declaration of Competing Interest

The authors declare that they have no competing interests.

Acknowledgments

We sincerely thank Dr. Chang Gi Park, a senior statistician at the College of Nursing, University of Illinois of Chicago, for statistical consultation.

Funding sources

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No. 2020R1A6A1A03041989).

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