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Social, behavioural, and functional characteristics of community-dwelling South Korean adults with moderate and severe cognitive impairment

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Abstract

Objectives: This study used the 2016 Korean Longitudinal Study on Aging to investigate the social, behavioural, and functional characteristics of community-dwelling South Korean adults with cognitive impairment.

Methods: Participants were classified as normal, moderate impairment, and severe impairment according to an algorithm that combined the Korean Mini-Mental State Examination score and the number of difficulties in performing instrumental activities of daily living. Selected characteristics included grip strength, depression, participation in exercise and social activities, and living in a rural, urban, or suburban community.

Results: Most (72.7%) participants were classified as having normal cognition, 20.1% were classified as moderate impairment, and 7.2% were classified as severe impairment. Regardless of sex, the differences in grip strength across the cognitive status classifications were statistically significant, except for the difference between moderate and severe cognitive impairment in males (p = 0.8477). Greater number of depressive symptoms and living in rural areas were associated with significantly higher odds for severe cognitive impairment. Participants with moderate (OR = 0.51) and severe (OR = 0.33) cognitive impairment were less likely to participate in social activities than those with normal cognition.

Conclusions: The study findings revealed that social, behavioural, and functional characteristics are closely related to the cognitive status of community-dwelling adults in South Korea.

KEYWORDS

ageing, cognition, dementia, health care surveys, healthy ageing

1 | INTRODUCTION

In 2018, an estimated 22.58% (1.67 million people) of adults aged 65 and older in South Korea were living with mild cognitive impairment, and 10.16% (750,000 people) were living with dementia (Yoo, 2019). The proportion of adults aged 65 years or older in South Korea has increased from 9.0% in 2005 to 12.8% in 2015, and this number expected to increase to 20.3% in 2025 (Korean Statistical Information Service, 2019). Diseases related to the mental and physical health of older adults are also expected to increase rapidly (Partridge et al., 2018). People with cognitive impairments often need help from family members or caregivers in performing their daily activities (Hawkley et al., 2020).

It is important to accurately describe the social, behavioural, and functional characteristics of older adults with cognitive impairment so that policymakers can formulate effective health policies that meet the needs of older adults with dementia (Mole & Demeyere, 2020). Kim and Yang (2013) reported that older age, male gender, being underweight, lack of exercise, unmarried persons, and lack of social participation are potentially important characteristics of older adults with cognitive impairment. Luck et al. (2010) also reported that older age, female sex, lower education level, limitations in activities of daily living (ADL), and depression were associated with risk for mild cognitive impairment.

Many studies that have investigated the cognitive functioning of older South Korean adults have classified cognitive status using Korean versions of the Mini Mental Status Examination (MMSE; Park & Yoo, 2002). While the MMSE, including its Korean variations, is widely used as a screening tool for cognitive impairment (Mole & Demeyere, 2020), it has been criticized for having poor accuracy in diagnosing mild cognitive impairment and dementia (Körver et al., 2019). A potential solution is to use a combination of cognitive function measured by the K-MMSE and difficulties in instrumental activities of daily living (IADL; Luttenberger et al., 2012; Mejia-Arango & Gutierrez, 2011). A study investigating the longitudinal relationship between cognitive changes and risk for IADL limitations in the general population reported that a one-word decline on an assessment of word list learning over a 10-year period was associated with 16% higher risk for IADL impairment (Passler et al., 2020). As independence in IADL decreases with cognitive decline (Sun et al., 2018), the combination of cognitive function and IADL performance could more accurately classify individuals into different stages of cognitive impairment. Incorporating limitations in daily activities is also consistent with clinical criteria for the diagnosis of dementia (McKhann et al., 2011).

Given the increase in social costs and the demand for healthy ageing (Sun et al., 2018), it is necessary to describe the social, behavioural, and functional characteristics of South Korean older adults with moderate and severe cognitive impairment. The data used for the present study were derived from the Korean Longitudinal Study on Aging (KLoSA). The cognitive functioning of KLoSA participants is assessed using the K-MMSE. Given the known limitations of the MMSE to classify cognitive status, we proceeded with reference to studies that classified cognitive status by combining IADL and cognition measures (Downer et al., 2016; Mejia-Arango & Gutierrez, 2011). We investigated if there was a strong correlation between cognitive impairment and social and behavioural characteristics of the Korean adult population, including previously reported grip strength, depression, exercise duration, residential area, and social participation (Kim et al., 2019). We hypothesized that more severe cognitive impairment would be associated with weaker grip strength, more depressive symptoms, reduced exercise duration, living in a rural area, and less social participation.

2 | MATERIALS & METHODS

2.1 | Data source and study design

This study used a cross-sectional design, deriving data from the 2016 KLoSA. The KLoSA has been used to establish and implement effective socio-economic policies for successfully transition to an ultra-aged society (Boo & Chang, 2006). A total of 7490 South Korean adults aged 53–107 years completed the survey in 2016. The survey items included information on the health, income, and assets of household members (Boo & Chang, 2006). More information about the KLoSA can be found on the website (https://survey.keis.or.kr).

Among the 7490 South Koreans who completed the 2016 survey, 1337 participants with missing values for one or more selected variables were removed from the sample (Figure 1). Proxy responses were not separately indicated for the K-MMSE and IADL items of the KLoSA data used in this study. Therefore, only items directly answered by the participants were used.

The KLoSA database is publicly available, and all personal identification information was de-identified by the Korea Employment Information Service. This study was approved by the Yonsei University institutional review board and met the study exemption criteria of the participating institutions.

2.2 | Selection of social and behavioural characteristics related to cognitive impairment

Cognitive-related social and behavioural characteristics included social participation, duration of exercise, residential areas, grip strength, and depression. Social participation was divided into religious gatherings, social gatherings, leisure, and reunions. Social participation responses were collected with 'yes' or 'no' responses to the gathering to which the respondent belonged at present. Exercise was measured as a response to the length of the period in which the respondents continued to exercise regularly. The response for the regular exercise period was (1) three months or less, (2) three months or more to four years, and (3) four to seven years or more. Residential areas were divided into urban, suburban, and rural categories. Grip strength (kg) of both hands was measured twice using a grip

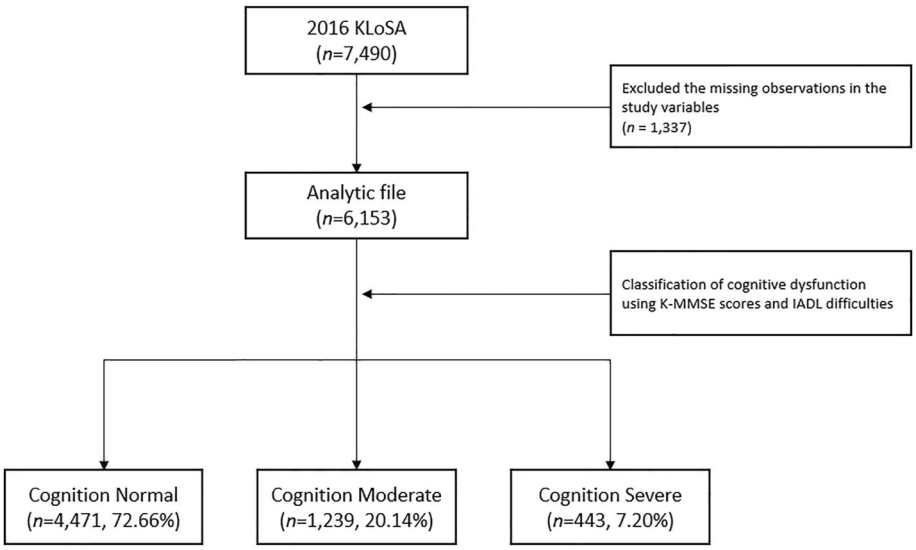

FIGURE 1 Study flow diagram

dynamometer, and the average value of the measurements for the left and right hands was used. Depression was measured using the total score of the Centre for Epidemiologic Studies Depression Scale 10 (CES-D 10; Irwin et al., 1999).

2.3 | Defining cognitive status classifications

Cognitive function was investigated using the K-MMSE (Kang et al., 1997), which includes (1) orientation for time, (2) orientation for place, (3) registration, (4) attention and calculation, (5) recall, (6) language, and (7) visual construction. The total score is 30 points, where a score of 24 points or higher is considered as normal cognition and 23 points or less as cognitive impairment (Folstein et al., 1975). The K-MMSE inter-rater reliability is 0.96 ($p < 0.001$) and test-retest reliability is 0.86 ($p < 0.001$; Kim et al., 1999).

The KLoSA includes questions on whether the respondent has any difficulties performing 10 IADL tasks: (1) grooming (e.g., brushing teeth, combing hair, and maintaining personal hygiene), (2) routine housework (e.g., cleaning), (3) preparing food, (4) washing laundry, (5) travelling short distances, (6) using transportation, (7) managing assets, (8) buying things, (9) making and receiving phone calls, and (10) taking medication. Consistent with prior studies (Mejia-Arango & Gutierrez, 2011), participants who received help with one or more IADLs were considered to have functional limitations.

Cognitive status was classified as normal cognition, moderate cognitive impairment, or severe cognitive impairment. Participants who had a K-MMSE score of 24 or higher were classified as having normal cognition. Participants who had a K-MMSE score of 24 or higher but needed help with IADL were also classified as having normal cognition. Moderate cognitive impairment was defined as a score of less than 24 points on the K-MMSE but not requiring assistance with any IADLs. Severe cognitive impairment was defined as scoring less than 24 points on the K-MMSE and requiring assistance with one or more IADL. These classification criteria are consistent with other studies (Downer et al., 2016) and clinical diagnostic criteria (McKhann et al., 2011).

2.4 | Covariates

We selected variables that have been reported to be related to cognition in previous studies (Björk et al., 2016; Choi, 2020; Chou et al., 2019; de Asteasu et al., 2020; Thomas & T O'Brien, 2008). Demographic and social behaviour variables included age, sex, educational attainment, marital status, employment status, weight status (body mass index, kg/m^2), self-rated health, drinking and smoking status, diabetes, hypertension, and stroke. Sex was dichotomized (female or male); educational attainment was recorded as 1 = elementary school, 2 = middle school, 3 = high school, and 4 = college degree; marital status (married, separated, divorced, widowed, unmarried) was recorded as 0 = single, 1 = married; employment status was recorded as 0 = employed, 1 = unemployed; weight status was recorded as 1 = obesity, 2 = overweight, 3 = normal, 4 = underweight (Estrella-Castillo & Gómez-de-Regil, 2019); self-rated health was recorded as 1 = very good, 2 = good, 3 = moderate, 4 = bad, and 5 = very bad; drinking and smoking were recorded as 1 = current, 2 = former, and 3 = non-drinker and non-smoker; and chronic conditions (diabetes, hypertension, and stroke) were dichotomized (yes or no).

2.5 | Statistical analysis

Descriptive analyses were performed using a *t*-test and analysis of variance for the continuous variables and a chi-squared test for the

categorical variables. Multinomial logistic regression models were used to examine the association between cognitive status and the independent variables of depression, period of exercise, and residential area. Logistic regression was used to model the association between cognitive status and social participation. Linear regression was used to model the association between cognitive status and grip strength. All models were adjusted for age, sex, educational attainment, marital status, employment status, weight status, self-rated health, drinking and smoking status, diabetes, hypertension, and stroke.

3 | RESULTS

Table 1 summarizes the demographic, behavioural, and health characteristics of the final sample across the cognitive status classifications. A total of 4471 (72.7%) individuals were categorized as having normal cognition, 1239 (20.1%) were categorized as moderate cognitive impairment, and 443 (7.2%) were categorized as severe cognitive impairment. Those with severe cognitive impairment were older, mostly female, had fewer years of education, and were less likely to be married than those with normal cognition. About 95% of participants with severe cognitive impairment were not employed (n = 422, 95.3%). Participants with severe cognitive impairment were more likely to have hypertension (n = 287, 64.8%) and to have a stroke (n = 90, 20.3%) than participants with normal cognition. Drinking abstinence was most common in participants with severe cognitive impairment (n = 280, 63.2%), whereas no smoking was more frequent in participants with moderate cognitive impairment (n = 960, 77.5%; $p < 0.0001$).

3.1 | Grip strength

Table 2 illustrates the results of the association between grip strength and cognitive status classification. Male and female participants were modelled separately. For males, participants classified as normal cognition had significantly higher mean grip strength (32.61 kg) than participants classified as moderately impaired (26.21 kg, $p < 0.0001$) and severely impaired (26.74 kg, $p < 0.0001$). The difference in grip strength between male participants with moderate and severe cognitive impairment was not statistically significant ($p = 0.85$).

The average grip strength for female participants classified as normal cognition, moderate impairment, and severe impairment was 21.217, 18.04, and 14.50 kg, respectively. Participants with normal cognition had significantly higher mean grip strength that participants with moderate impairment ($p < 0.0001$) and severe impairment ($p < 0.0001$). Additionally, female participants with moderate impairment had significantly higher mean grip strength than participants with severe impairment ($p < 0.0001$).

3.2 | Depression, area of residence, duration of exercise, and social participation

Table 3 shows the results of the multinomial logistic regression analyses according to depressive symptoms, residential area and exercise period with cognitive status classifications. Depressive symptoms were associated with 1.15 higher odds (95% confidence interval (CI) = 1.12–1.18) for moderate cognitive impairment and 1.26 higher odds (95% CI = 1.20–1.32) for severe cognitive impairment. Compared to living in an urban community, living in a suburban (OR = 1.36, 95% CI = 1.14–1.62) or rural (OR = 1.70, 95% CI = 1.42–2.03) community were both associated with significantly higher odds for moderate cognitive impairment. Living in a rural (OR = 1.61, 95% CI = 1.21–2.15) but not suburban (OR = 1.19, 95% CI = 0.89–1.59) community was associated with significantly higher odds for severe cognitive impairment. Fourth, engaging in exercise for four years or more was associated with significantly lower odds for moderate (OR = 0.50, 95% CI = 0.40–0.63) and severe (OR = 0.23, 95% CI = 0.14–0.37) cognitive impairment.

Table 4 shows the association between social participation status and cognitive status classifications from a series of multivariate logistic regression models. Those with moderate and severe cognitive impairment had lower odds of participating in any social activities than those with normal cognition (OR = 0.51, 95% CI = 0.44–0.60; OR = 0.33, 95% CI = 0.26–0.42, respectively). Specifically, those with severe cognitive impairment were 0.31 (95% CI = 0.21–0.46) times less likely to participate in religious gatherings than those with normal cognition. Those with severe cognitive impairment had 0.40 (95% CI = 0.31–0.51) lower odds of participating in social gatherings than those with normal cognition. Those with severe cognitive impairment had 0.39 (95% CI = 0.19–0.83) lower odds of participating in leisure than those with normal cognition. Finally, those with severe cognitive impairment had 0.24 (95% CI = 0.11–0.52) lower odds of participating in reunions than those with normal cognition.

4 | SENSITIVITY ANALYSIS

The K-MMSE main cut-off score of 23/24 was used when classifying the cognitive criteria in this study. Kim et al. (2003) reported a cut-off score of 17/18 according to sex, age, and education level. We classified and analysed the criteria using a cut-off score of 17/18, but there were no meaningful differences in the findings for participation in leisure and reunion activities, and all other variables were equally significant (see Tables A1-A4).

5 | DISCUSSION

This study described the social, behavioural, and functional characteristics of community-dwelling Korean older adults with moderate and severe cognitive impairment. We observed that grip strength,

TABLE 1 Demographics according to the cognitive status classifications. *n* (%)

Characteristic†	Normal cognition (*n* = 4,471, 72.66%)	Moderate cognition (*n* = 1,239, 20.14%)	Severe cognition (*n* = 443, 7.20%)	*p*-Value
Age, mean (SD)	66.90 (8.35)	74.74 (8.25)	80.04 (8.64)	<0.0001**
Sex				<0.0001**
Male	2099 (46.95)	345 (27.85)	159 (35.89)	
Female	2372 (53.05)	894 (72.15)	284 (64.11)	
Educational attainment				<0.0001**
Elementary school	1417 (31.69)	885 (71.43)	334 (75.40)	
Middle school	870 (19.46)	174 (14.04)	43 (9.71)	
High school	1588 (35.52)	146 (11.78)	49 (11.06)	
College degree	596 (13.33)	34 (2.74)	17 (3.84)	
Marital status				<0.0001**
Single	805 (18.00)	505 (40.76)	210 (47.40)	
Married	3666 (82.00)	734 (59.24)	233 (52.60)	
Employment status				<0.0001**
Employed	1944 (43.48)	257 (20.74)	21 (4.74)	
Unemployed	2527 (56.52)	982 (79.26)	422 (95.26)	
Weight status				<0.0001**
Obesity	1144 (25.59)	290 (23.41)	78 (17.61)	
Overweight	1327 (29.68)	320 (25.83)	104 (23.48)	
Normal	1879 (42.03)	558 (45.04)	212 (47.86)	
Underweight	121 (2.71)	71 (5.73)	49 (11.06)	
Self-rated health, mean (SD)	2.84 (0.76)	3.39 (0.80)	4.11 (0.78)	<0.0001**
Drinking				<0.0001**
Current drinker	1664 (37.22)	256 (20.66)	58 (13.09)	
Past drinker	704 (15.75)	232 (18.72)	105 (23.70)	
Non-drinker	2103 (47.04)	751 (60.61)	280 (63.21)	
Smoking				<0.0001**
Current smoker	529 (11.83)	87 (7.02)	26 (5.87)	
Past smokers	967 (21.63)	192 (15.50)	109 (24.60)	
Non-smoker	2975 (66.54)	960 (77.48)	308 (69.53)	
Chronic conditions				
Diabetes	803 (17.96)	307 (24.78)	130 (29.25)	<0.0001**
Hypertension	1816 (40.62)	676 (54.56)	287 (64.79)	<0.0001**
Stroke	215 (4.81)	92 (7.43)	90 (20.32)	<0.0001**

Note: Characteristic†: Age and self-rated health are expressed as mean and SD, and the remaining values are expressed as percentages.
**$p < 0.05$; **$p < 0.0001$.

depressive symptoms, physical exercise, social participation, and region (i.e., community size) were associated with cognitive status among older Korean adults. These findings are important to creating and providing services that can meet the needs of a growing older adult population with an increasing prevalence of cognitive impairment.

Grip strength is widely used to measure sarcopenia and it is a good indicator of the physical health of older adults (Choi & Kim, 2019). Sternäng et al. (2016) reported an association between grip strength with various cognitive functions, such as verbal ability, spatial ability, processing speed, and memory.

TABLE 2 The association between cognitive status classifications and grip strength

	Male grip strength			Female grip strength		
Cognitive function (independent variables)	**Mean difference**	**95% CI**	***p*-Value**	**Mean difference**	**95% CI**	***p*-Value**
Normal vs. Moderate	6.40	5.34–7.46	<0.0001**	3.23	2.68–3.78	<0.0001**
Normal vs. Severe	5.87	3.79–7.95	<0.0001**	6.77	5.57–7.98	<0.0001**
Moderate vs. Severe	−0.53	−2.81–1.74	0.8477	3.54	2.27–4.81	<0.0001**

*$p < 0.05$; **$p < 0.0001$.

TABLE 3 Multinomial logistic regression analysis of the cognitive status classifications across depression, residential area, and exercise duration

	Moderate vs. Normal			Severe vs. Normal		
Depression, exercise period (independent variables)	**OR†**	**95% CI‡**	***p*-Value**	**OR†**	**95% CI‡**	***p*-Value**
Depression	1.15	1.12–1.18	<0.0001**	1.26	1.20–1.32	<0.0001**
Region						
Urban	Ref			Ref		
Suburban	1.36	1.14–1.62	0.0005**	1.19	0.89–1.59	0.2457
Rural	1.70	1.42–2.03	<0.0001**	1.61	1.21–2.15	0.0013*
Exercise period						
Up to 3 months	Ref			Ref		
3 months to 4 years	0.89	0.73–1.08	0.2247	0.52	0.34–0.79	0.0024*
4 years or more	0.50	0.40–0.63	<0.0001**	0.23	0.14–0.37	<0.0001**

Note: The ORs were estimated by accounting for the covariates, including age, sex, educational attainment, marital status, body weight, employment status, self-rated health, diabetes, hypertension, stroke, smoking, and drinking.

Abbreviations: CI‡, confidence interval; OR†, odds ratio.

*$p < 0.05$; **$p < 0.0001$.

Other studies have demonstrated that decreased grip strength was significantly associated with cognitive decline (Auyeung et al., 2011). Moreover, according to a study by Lee (2014), cognitive function decreased as the grip strength of older adults decreased. Choi and Kim (2019) investigated the relationship between grip strength and cognition by using grip strength and K-MMSE data of older adults aged 65 years or older using panel survey data. They found that grip strength can predict sarcopenia, senility, and cognitive function.

We found that the association between depression, duration of exercise, and residential area with cognitive status was consistent with the results of previous studies. According to Donovan et al. (2017), individuals with depression exhibited approximately 20% faster cognitive decline than individuals without depression. Thomas & T O'Brien, (2008) noted that neurocognitive impairment persists in most depressed older adults after clinical recovery. These studies support the association that depression may act as a behavioural characteristic related to cognitive function. Kwon (2018) investigated the relationship between exercise and cognitive function in older adults using the 2016 KLoSA data, and reported that older adults who participated in exercise had higher cognitive function than older adults who did not. Another study reported improved cognitive function in older adults after an exercise intervention (de Asteasu et al., 2020). These studies support the notion that exercise protects against cognitive impairment.

We also investigated the association between residential area (urban, suburban, and rural) and cognitive status classifications. According to a study by Saenz et al. (2018), cognitive functions such as language learning, language memory, language fluency, and attention were lower in rural areas compared to urban areas. This same study (Saenz et al., 2018) suggested that educational attainment contribute to differences in cognition between older adults living in rural and urban regions.

Finally, social participation was lower in participants with moderate and severe cognitive impairment than participants with normal cognition. In a study by Chung (2020), leisure activities were classified into productive, consumer, and unclassified activities to investigate the relationship between the types of leisure activity participation and cognitive function of older adults in South Korea. Chung (2020) reported that engaging in productive activities was associated with cognitive functioning among older male and female adults. Additionally, a systematic review by Yates and Orrell (2016) reported that participating in activities may reduce the risk of cognitive impairment in older adults. This may be due to loneliness, health-related, and psychological problems among older adults living alone or not participating in social activities (Choi, 2020).

TABLE 4 Multivariate logistic regression analysis between participation activities and the cognitive status classifications

Cognitive status (independent variable)	Social participation			1) Religion gathering			2) social gathering			3) leisure			4) reunion		
	OR†	95% CI‡	*p*-Value	OR†	95% CI‡	*p*-Value	OR†	95% CI‡	*p*-Value	OR†	95% CI‡	*p*-Value	OR†	95% CI‡	*p*-Value
Normal cognition	Ref			Ref			Ref			Ref			Ref		
Moderate cognition	0.51	0.44–0.60	<0.0001**	0.68	0.56–0.83	<0.0001**	0.58	0.50–0.67	<0.0001**	0.48	0.32–0.72	0.0003*	0.53	0.40–0.71	<0.0001**
Severe cognition	0.33	0.26–0.42	<0.0001**	0.31	0.21–0.46	0.0002*	0.40	0.31–0.51	<0.0001**	0.39	0.19–0.83	0.0145*	0.24	0.11–0.52	0.0003*

Note: The ORs were estimated by accounting for the covariates, including age, sex, educational attainment, marital status, body weight, employment status, self-rated health, diabetes, hypertension, stroke, smoking, and drinking.

Abbreviations: CI‡, confidence interval; OR†, odds ratio.

*$p < 0.05$; **$p < 0.0001$.

In this study, cognitive status was classified into three stages by combining the items of the K-MMSE and needing help with IADLs. Other studies have reported that IADL reduction is associated with cognitive decline (Lee et al., 2019). Additionally, older adults with low levels of cognitive function are more likely to be disabled in daily activities than older adults with high cognitive function (McGuire et al., 2006). However, older adults can have difficulty completing IADLs because of reasons other than cognitive impairment, such as arthritis, heart failure, and falls (Keenan et al., 2006; Lo et al., 2015; Stenhagen et al., 2014). Thus, it is important to carefully consider health conditions that influence an older adult's ability to live independently that may also be associated with cognitive impairment.

5.1 | Limitation and future directions

This study had several limitations. First, there is the possibility of misclassification of cognitive status because the algorithm does not consider the rate of cognitive decline. Second, the KLoSA database does not include a formal dementia diagnosis to validate the cognitive status classification. Third, it would be difficult to generalize the study findings because the cognitive status was classified for the South Korean adult population. Fourth, out of the total 7490 data used in this study, 1233 were omitted in the grip strength variable. Imputation was attempted to explain the missing data for grip strength. However, the missing values of the grip strength variable were systematically higher in female than in male and as age increased. Finally, as this study used a cross-sectional design, the directionality of the association between participant characteristics and cognitive status could not be determined.

6 | CONCLUSION

Our objective was to establish cognitive status classification criteria using KLoSA data to identify cognition-related social and behavioural characteristics. This information can accurately identify the characteristics of cognition related to the adult South Korean population and provide basic data for health policy.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available on the Korean Longitudinal Study on Aging (KLoSA) website [https://survey.keis.or.kr/klosa/klosa01.jsp].

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Appendices

Table A1 Demographics assessed using a K-MMSE cut-off score of 17/18 for cognitive status classifications, *n* (%)

Characteristic	Normal cognition (*n* = 3,398, 86.35%)	Moderate cognition (*n* = 299, 7.60%)	Severe cognition (*n* = 238, 6.05%)	*p*-Value
Age, mean (SD)	73.99 (6.24)	79.60 (4.81)	82.62 (7.15)	0.0003*
Sex				<0.0001**
Male	1551 (45.64)	66 (22.07)	65 (27.31)	
Female	1847 (54.36)	233 (77.93)	173 (72.69)	
Educational attainment				<0.0001**
Elementary school	1801 (53.00)	252 (84.28)	197 (82.77)	
Middle school	599 (17.63)	25 (8.36)	16 (6.72)	
High school	705 (20.75)	19 (6.35)	21 (8.82)	
College degree	293 (8.62)	3 (1.00)	4 (1.68)	
Marital status				<0.0001**
Single	951 (27.99)	164 (54.85)	135 (56.72)	
Married	2447 (72.01)	135 (45.15)	103 (43.28)	
Employment status				<0.0001**
Employed	873 (25.69)	42 (14.05)	3 (1.26)	
Unemployed	2525 (74.31)	257 (85.95)	235 (98.74)	
Weight status				<0.0001**
Obesity	862 (25.37)	53 (17.73)	36 (15.13)	
Overweight	937 (27.58)	77 (25.75)	53 (22.27)	
Normal	1451 (42.70)	148 (49.50)	117 (49.16)	
Underweight	148 (4.36)	21 (7.02)	32 (13.45)	

(Continues)

TABLE A1 (Continued)

Characteristic	Normal cognition (n = 3,398, 86.35%)	Moderate cognition (n = 299, 7.60%)	Severe cognition (n = 238, 6.05%)	p-Value
Self-rated health, mean (SD)	3.16 (0.79)	3.59 (0.79)	4.16 (0.77)	0.8003
Drinking				<0.0001**
Current drinker	999 (29.40)	34 (11.37)	16 (6.72)	
Past drinker	625 (18.39)	71 (23.75)	48 (20.17)	
Non-drinker	1774 (52.21)	194 (64.88)	174 (73.11)	
Smoking				<0.0001**
Current smoker	296 (8.71)	18 (6.02)	8 (3.36)	
Past smokers	786 (23.13)	36 (12.04)	43 (18.07)	
Non-smoker	2316 (68.16)	245 (81.94)	187 (78.57)	
Chronic conditions				
Diabetes	796 (23.43)	85 (28.43)	76 (31.93)	0.0.0029*
Hypertension	1784 (52.50)	185 (61.87)	165 (69.33)	<0.0001**
Stroke	250 (7.36)	31 (10.37)	47 (19.75)	<0.0001**

Note: Characteristic†: Age and self-rated health are expressed as mean and SD, and the remaining values are expressed as percentages.
*$p < 0.05$; **$p < 0.0001$.

Table A2 Association between cognitive status classifications using a K-MMSE cut-off score of 17/18 and grip strength

	Male grip strength			Female grip strength		
Cognitive function (independent variables)	Mean difference	95% CI	p-Value	Mean difference	95% CI	p-Value
Normal vs. Moderate	6.86	4.37–9.35	<0.0001**	3.21	2.18–4.25	<0.0001**
Normal vs. Severe	8.65	5.24–12.07	<0.0001**	5.54	4.03–7.05	<0.0001**
Moderate vs. Severe	1.80	−2.38–5.97	0.5715	2.31	0.56–4.10	0.0059*

*$p < 0.05$; **$p < 0.0001$.

Table A3 Multinomial logistic regression analysis of the cognitive status classifications across depression, residential area, and duration of exercise using a K-MMSE cut-off score of 17/18

	Moderate vs. Normal			Severe vs. Normal		
Depression, exercise period (independent variable)	OR†	95% CI‡	p-Value	OR†	95% CI‡	p-Value
Depression	1.15	1.10–1.21	<0.0001**	1.19	1.13–1.26	<0.0001**
Region						
Urban	Ref			Ref		
Suburban	1.43	1.04–1.98	0.0289*	1.09	0.74–1.60	0.6511
Rural	1.66	1.22–2.27	0.0015*	1.56	1.09–2.25	0.0164*
Exercise period						
Up to 3 months	Ref			Ref		
3 months to 4 years	0.71	0.47–1.08	0.1097	0.30	0.14–0.64	0.0017*
4 years or more	0.37	0.22–0.62	0.0002*	0.10	0.04–0.29	<0.0001**

Note: The ORs were estimated by accounting for the covariates, including age, sex, educational attainment, marital status, body weight, employment status, self-rated health, diabetes, hypertension, stroke, smoking, and drinking.
Abbreviations: OR†, odds ratio; CI‡, confidence interval.
*$p < 0.05$, **$p < 0$; 0001.

Table A4 Multivariate logistic regression analysis between participation and cognitive status classifications using a K-MMSE cut-off score of 17/18

	Social participation			1) Religion gathering			2) social gathering			3) leisure			4) reunion		
Cognitive status (independent variable)	**OR†**	**95% CI‡**	***p*-Value**	**OR†**	**95% CI‡**	***p*-Value**	**OR†**	**95% CI‡**	***p*-Value**	**OR†**	**95% CI‡**	***p*-Value**	**OR†**	**95% CI‡**	***p*-Value**
Normal cognition	Ref			Ref		Ref				Ref			Ref		
Moderate cognition	0.58	0.44–0.75	<0.0001**	0.50	0.34–0.75	0.0007*	0.72	0.56–0.94	0.0150*	0.41	0.17–1.03	0.0585	0.23	0.07–0.75	0.0141*
Severe cognition	0.34	0.24–0.47	<0.0001**	0.21	0.11–0.40	<0.0001**	0.47	0.33–0.66	<0.0001**	0.26	0.06–1.08	0.0633	0.37	0.11–1.19	0.0939

Note: The ORs were estimated by accounting for the covariates, including age, sex, educational attainment, marital status, body weight, employment status, self-rated health, diabetes, hypertension, stroke, smoking, and drinking.

Abbreviations: CI‡, confidence interval; OR†, odds ratio.

*$p < 0.05$; **$p < 0.0001$.