

Effects of Depression on Changes in Cognitive Function in Older Adults

A Fixed-effects Model Analysis Using the Korean Longitudinal Study of Aging (KLoSA)

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Purpose: This study identified the rate of change in cognitive function of community-based middle-aged and older adults and investigated the longitudinal effects of depression, health status, and health behavior by cognitive function group [normal, mild cognitive impairment (MCI), dementia] using data from the Korean Longitudinal Study of Aging.

Methods: This longitudinal panel analysis collected 21,425 data points from 4285 participants. Cognitive function change patterns in the groups were examined through descriptive analysis. A fixed-effects model was estimated using demographic factors, such as depression, health behavior, and disease states as independent variables.

Results: Compared with the baseline score of the mini-mental state examination (MMSE), the 8-year mean score decreased by 10.51, 8.6, and 1.21 for the dementia, MCI, and normal groups, respectively. The estimates for the normal group showed that an increase in the depression score significantly negatively impacted the MMSE score ($B = -0.059$, $P < 0.001$). However, compared with those of the MCI group ($B = -0.044$, $P > 0.05$), the estimates of the dementia group confirmed that depression significantly negatively affected cognitive function ($B = -0.146$, $P < 0.05$).

Conclusion: Each group showed different patterns of cognitive decline. An annual follow-up cognitive impairment screening to investigate changes in MMSE score in community-based older individuals can enable early detection of dementia.

Key Words: aged, cognition, mental status, dementia tests, depression, longitudinal studies

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Cognitive function refers to various functions of the human brain, such as memory, spatiotemporal orientation, sustained attention, language, and reasoning. Older individuals have reduced short-term memory and learning, language, and information processing abilities.^{1,2}

Aging population is increasing worldwide, resulting in an increased interest in successful aging. An important prerequisite for successful aging is a state of health based on complex interactions between physical, mental, and socioeconomic factors. Here, health does not mean a disease-free state; instead, it is a state of subjective well-being involving psychological adaptation and acceptance of one's situation.³ Even at an old age, people want to continue living in a familiar environment—and not in a nursing home—maintaining social activities and functional independence. Cognitive function is a mediating factor that can determine a person's health behavior. The delayed decline of cognitive function can be set as a health goal to promote healthy behavior and achieve independence in daily living.³

Depression is currently considered a significant risk factor for the onset of dementia. Further, some studies view it as a prodromal clinical manifestation of dementia rather than a risk factor, or as an early response to cognitive impairment.^{4–6} However, a clear consensus has not yet been reached. In previous studies, the prevalence of depression was 4.2% to 10.6% in normal older adults, 11.0% to 42.2% for older adults with mild cognitive impairment (MCI), and 3.9% to 46.3% in patients with dementia.^{7–9} In addition, according to one meta-analysis, the pooled risk ratio of progression to dementia was 28% higher in participants with MCI and depressive symptoms than in participants with MCI and no depressive symptoms.¹⁰ However, community-based longitudinal studies have not revealed a significant association between depression and the onset of dementia. Depression significantly impacted the incidence of dementia only in a univariate analysis, but not postadjustment for cognitive and functional impairment.⁴ In addition, although depression and dementia showed a high correlation, depression did not affect the onset of dementia.¹¹

In the case of dementia, an individual's unique genetic (Apo E gene, etc.) and biological factors play a major role. Only the effects of depression, health status, and behavior, which are variables of interest in this study, should be considered, but individual characteristics cannot be excluded when conducting a cross-sectional study. Alternatively, panel data provide both within variation, which is a time-series variation within a panel entity, and between variation, which is a variation between panel entities. An advantage of panel analysis is its ability to solve the bias caused by endogeneity.¹² The fixed-effects panel analysis method represents the effects of factors that change over time; therefore, it is an effective method for examining changes within respondents. This study uses this model to investigate the effect of the depression level, which changes

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over time, on an individual's cognitive level, and to efficiently infer a causal relationship.

This study attempts to efficiently infer relationships by using systematically sampled panel data from older individuals from 2010 to 2018 in the Republic of Korea. This study could be used as primary data for health care interventions for successful aging of community-living older individuals by identifying the changing pattern of cognitive function and the prevalence of depression, MCI, and dementia, and inferring the relationship between depression and cognitive function.

The objectives of this study were as follows: (1) to identify the annual changing patterns of cognitive function in dementia, MCI, and normal groups using panel data, and (2) to estimate the fixed-effects model of cognitive function for dementia, MCI, and normal groups using depression as an independent variable after controlling for confounders.

METHODS

Research Design

This study is a longitudinal panel analysis based on secondary data. Data from the Korean Longitudinal Study of Aging (KLoSA), a survey conducted by the Korea Employment Information Service, were used for analysis.

Participants

The KLoSA survey data used in this study were collected in 2006 by sampling general households of middle-aged and older individuals (older than or equal to 45 y) living in communities across South Korea, excluding Jeju Island. The first survey was conducted in 2006, and by 2018, a biennial primary survey was performed 7 times in even-number years. The participants were sampled under a stratified design.

Raw data were obtained by downloading the light version data from the third (2010) to the seventh (2018) waves from the Korea Employment Information Service webpage. Figure 1 shows the structure of the panel data and the selection of research participants. The raw data were sequentially synthesized from the third to seventh survey data using the panel ID of the third wave data as the reference. After excluding those already classified as having dementia or MCI from the baseline, the longitudinally tracked data were analyzed. Data from 4285 survey participants were extracted after conversion to the long form. Therefore, despite the missing data structure, the panel used was unbalanced with the same interval, and the survey data on the selected 4285 participants (21,425 cases) were analyzed.

Research Instruments

Dependent Variable: Cognitive Function

Among the panel data, the mini-mental state examination (MMSE) score data and MMSE group values (0 = normal, 1 = MCI, 2 = dementia, and 3 = nonresponse or missing data) were used as variables. Cognitive function was measured using the K-MMSE, which consists of 30 items that evaluate the cognitive abilities of orientation, registration, attention, calculation, recall, language, and copying. Depending on their K-MMSE score, the survey participants were assigned to 1 of the 3 groups (dementia: ≤ 17 , MCI: 18 to 23, normal ≥ 24).¹³

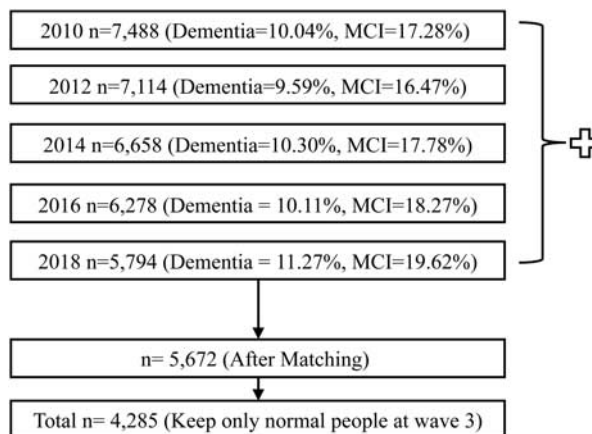


FIGURE 1. Panel data structure. MCI indicates mild cognitive impairment.

Independent Variable: Depression

For the variable of “depression” of the KLoSA survey, a tool based on the Korean version of the CES-D 10 was used. The original CES-D 10 tool consists of 10 items on the frequency of depressed feelings rated on a 4-point Likert scale (0 = <1 d, 1 = 1 to 2 d, 2 = 3 to 4 d, and 3 = 5 to 7 d), with the total score ranging from 0 to 30.¹⁴ However, the KLoSA panel dataset provides the recoded data as <1 day to 0, and 1 to 7 days were coded into 1, with the total score ranging from 0 to 10. A higher score indicates a higher level of depression.

Control Variables

Variables reported as factors affecting cognitive function in previous studies, such as age, education level, sex, marital status, and socioeconomic status (average monthly pocket money), activities of daily living (ADL), instrumental activities of daily living (IADL), hypertension, diabetes, heart disease, cerebrovascular disease, psychiatric disorders, alcohol abuse, and smoking were selected as confounding variables to efficiently infer the effect of depression on the change in cognitive function.^{15,16} The APOE ε4 allele, depressant medications, and hypercholesterolemia are also risk factors for dementia and MCI; however, as these variables were not investigated in the KLoSA data, they could not be incorporated into the model.^{15,16}

Demographic Factors

The completed educational level was classified into elementary school, middle school, high school, and university or higher. A higher value was assigned to a higher education level. For marital status, 0 was assigned to unmarried (separated, widowed, divorced) and 1 to living with a partner (married or common-law couple). The average monthly allowance (unit: 10,000 won) was taken as a variable representing socioeconomic status to reflect the disposable resources for daily living, such as total net assets and liabilities. The number of social contacts refers to the frequency of meeting close friends, neighbors, and relatives over the previous 12 months.

ADL and IADL

The Korean activities of daily living is a 7-item tool for basic daily living performance that evaluates dressing,

washing face and hand, bathing, eating, ability to move from place to place, toileting, and continence. IADL evaluates the ability to perform daily instrumental activities of decorating, housework, preparing meals, doing laundry, short distance outings, using transportation, shopping, handling money, using the telephone, and taking medication.¹⁷ Each item was measured as 1 for partial or total dependence and 0 for no help. The ADL has 0– to 7 points and IADL 0 to 10 points. The higher the value, the lower the independence of the older individual.

Disease State

Medical diagnoses of hypertension, diabetes, heart disease, cerebrovascular disease, and other psychiatric disorders were used.

Health Behavior

Alcohol intake items were divided into current drinkers, past drinkers, and nondrinkers. Smoking items were divided into current smokers, past smokers, and nonsmokers.

Data Analysis

Data analysis was performed using STATA 17.0. The overall analysis was performed on two groups established by assigning a codified score of 0 (normal group) or 1 (MCI group), and 2 (dementia groups) referred to the seventh KLoSA (2018) survey data. The significance level was set at $P < 0.05$.

First, a descriptive analysis in 2010 (third wave), classified by the 2018 (seventh wave) cognitive group, was performed. Frequency (N) and percentage (%) were used for nominal variables and mean (M) and SD for continuous variables. Differences between groups were analyzed using the χ^2 test and ANOVA. In addition, the quantified MMSE and depression scores over time for the normal, MCI, and dementia groups were presented as time-series graphs.

Second, the hypothesis that demographic factors, socioeconomic factors, and depression could be used as antecedent factors when cognitive function is set as the dependent variable through fixed-effects model estimation was tested using panel data. The Hausman test was performed to check the fit of the fixed-effects model against that of the random-effects model, and the fixed-effects model was estimated according to the results. The fixed-effects model presented whether the value of the dependent variable changes according to the changing levels of the independent variables included in the model. In a cross-sectional study, the absence of effects of the independent variables on the dependent variable can be primarily attributed to the impact of the intrinsic heterogeneity of the participants not observed in the study. However, unlike the regression analysis of cross-sectional studies, the effect of change in the independent variables over time on the dependent variable can be confirmed, resulting in an accurate inference of causal relationships.¹⁸

RESULTS

Participants' General Characteristics

Table 1 shows the general characteristics and descriptive statistics of the study participants.

Interpretation of the descriptive analysis results revealed the following: the mean ages of the normal, MCI, and dementia groups were 60.05 ± 7.93 , 65.48 ± 7.98 , and 69.20 ± 9.14 years, respectively; regarding education level,

915 (28.50%) in the normal group, 392 (58.25%) in the MCI group, and 143 (62.17%) in the dementia group graduated from elementary school, with the MCI and dementia groups showing a significantly higher ratio than the normal group. Those with college graduation or higher in the normal group were 423 (13.18%), and in the MCI and dementia groups were 27 (4.01%) and 12 (5.22%), respectively. The number of participants who were unmarried (widowed, divorced, or separated) was higher in the MCI and dementia groups than in the normal group (normal: 380 (11.83%); MCI: 123 (18.28%); dementia: 72 (31.30%)). The mean monthly pocket money of the normal, MCI, and dementia groups were 19.30 ± 17.87 , 14.00 ± 17.20 , and 11.91 ± 9.05 won, respectively, showing that the normal group had higher pocket money than the MCI and dementia groups. Hypertension, diabetes, heart diseases, and cerebrovascular diseases were significantly higher in the MCI and dementia groups than in the normal group. However, psychiatric disorders were not significantly different between the groups.

The mean depression scores of the normal, MCI, and dementia groups were calculated at 1.38 ± 1.44 , 1.60 ± 1.82 , and 1.48 ± 1.94 , respectively; those of the MCI and dementia groups were higher compared with the normal group. The mean MMSE scores for cognitive impairment screening for the normal, MCI, and dementia groups were 28.15 ± 1.85 , 27.08 ± 2.01 , and 27.42 ± 2.08 , respectively. With regard to the mean number of social contacts, 76 (2.37%) in the normal group, 28 (4.16%) in the MCI group, and 14 (6.09%) in the dementia group answered that no one was in close contact with them. Smoking, ADL, and IADL were not significantly different between the groups; however, alcohol consumption was significantly higher in the normal group than in the MCI and dementia groups.

Changing Patterns in Cognitive Function and Depression in Participants

Figure 2 shows the values tracking the time-series changes for the MMSE and depression scores of the normal, MCI, and dementia groups classified based on the MMSE scores of the seventh wave data.

When the changes were tracked using the third wave data as the baseline, the normal group showed an 8-year mean reduction of the MMSE scores from 0 to -0.048 . However, 8 years after the baseline, reductions in the mean gap between the groups widened, and -5.976 and -14.596 points were observed in the MCI and dementia groups, respectively. Depression increased from 1.48 to 2.27 in the dementia group and from 1.6 to 2.19 in the MCI group, but the normal group maintained a relatively similar value of 1.55 (from 1.38) (Table 2).

Fixed-effects Model for Cognitive Function Based on the Panel Data

Table 3 outlines the results of the fixed-effects (within) regression model estimated from the panel data using the factors affecting cognitive function as the input variables. The fixed-effects model was estimated by considering depression associated with cognitive function as a factor of interest. Drawing on the findings of previous studies, control variables were entered into the model as factors affecting cognitive function.^{15,16} Each model was statistically significant ($P < 0.001$). The within R^2 value was 44.3% in the MCI group and 73.6% in the dementia group, which was much higher than that of 2.1% in the normal group.

TABLE 1. Descriptive Analysis of the Subject's Characteristics in 2010 (Third Wave) as Classified Using the 2018 Cognitive Group

Variable	Categories	Normal	MCI	Suspected Dementia	P
		Mean ± SD or N (Column %)			
N (%)		3211 (78.05)	673 (16.36)	230 (5.59)	—
Age		60.05 ± 7.93	65.48 ± 7.98	69.20 ± 9.14	< 0.001***
Sex	Male	1521 (47.37)	279 (41.46)	105 (45.65)	0.019*
	Female	1690 (52.63)	394 (58.54)	125 (54.35)	
Education	Elementary school	915 (28.50)	392 (58.25)	143 (62.17)	< 0.001***
	Middle school	652 (20.31)	122 (18.13)	41 (17.83)	
	High school	1220 (38.01)	132 (19.61)	34 (14.78)	
	Above college	423 (13.18)	27 (4.01)	12 (5.22)	
Marital state	Divorce, separation etc.	380 (11.83)	123 (18.28)	72 (31.30)	< 0.001***
	Married	2,831 (88.17)	550 (81.72)	158 (68.70)	
Monthly pocket money		19.30 ± 17.87	14.00 ± 17.20	11.91 ± 9.05	< 0.001***
Hypertension and diabetes	Yes	370 (11.53)	114 (16.94)	39 (16.96)	< 0.001***
	No	2840 (88.47)	559 (83.06)	191 (83.04)	
Cerebrovascular disease	Yes	62 (1.93)	27 (4.01)	12 (5.22)	0.003**
	Stroke symptoms or transient ischemic attacks	7 (0.22)	2 (0.30)	1 (0.43)	
	No	3142 (97.85)	644 (95.69)	217 (94.35)	
Psychiatric disease	Yes	65 (2.02)	19 (2.82)	7 (3.04)	0.322
	No	3146 (97.98)	654 (97.18)	223 (96.96)	
Heart disease	Yes	156 (4.86)	56 (8.32)	19 (8.26)	0.001**
	No	3055 (95.14)	617 (91.68)	211 (91.74)	
Depression		1.38 ± 1.44	1.60 ± 1.82	1.48 ± 1.94	0.003**
Social contacts	No one	76 (2.37)	28 (4.16)	14 (6.09)	< 0.001***
	Almost no contact	6 (0.19)	1 (0.15)	0 (0)	
	1-6/y	209 (6.51)	84 (12.48)	21 (9.13)	
	1-2/mo	807 (25.13)	104 (15.45)	31 (13.48)	
	1/wk	433 (13.48)	102 (15.16)	29 (12.61)	
	2-3/wk	781 (24.32)	135 (20.06)	55 (23.91)	
	Almost everyday	899 (28.00)	219 (32.54)	80 (34.78)	
Smoking	Present	603 (18.78)	107 (15.90)	49 (21.30)	0.307
	Past	458 (14.26)	104 (15.45)	30 (13.04)	
	Never	2150 (66.96)	462 (68.65)	151 (65.65)	
Alcohol drinking	Present	1368 (42.60)	244 (36.26)	78 (33.91)	0.004**
	Past	316 (9.84)	80 (11.89)	25 (10.87)	
	Never	1527 (47.56)	349 (51.86)	127 (55.22)	
ADL		0.007 ± 0.153	0.016 ± 0.286	0.017 ± 0.21	0.374
IADL		0.125 ± 0.615	0.131 ± 0.768	0.183 ± 0.832	0.435
MMSE score		28.15 ± 1.85	27.08 ± 2.01	27.42 ± 2.08	< 0.001***

P* < 0.05.*P* < 0.01.****P* < 0.001.

ADL indicates activities of daily living; IADL, instrumental activities of daily living; MCI, mild cognitive impairment; MMSE, mini-mental state examination; N, total number.

This means that the explanatory power of the change over time of the independent variable input in this model is higher in the dementia and MCI groups than in the normal group.

An increase in age had a significant positive effect on the decline of cognitive function in the MCI and dementia groups. However, the difference in the coefficient between the MCI ($B = -0.72$, $P < 0.001$) and dementia groups ($B = -1.434$, $P < 0.001$) indicated that an increase in age adversely affected the cognitive function of dementia with greater severity compared with the MCI group.

The estimates for the normal group showed that an increase in the depression score significantly negatively impacted the MMSE score ($B = -0.059$, $P < 0.001$). However, compared with those of the MCI group ($B = -0.044$, $P > 0.05$), the estimates of the dementia group confirmed a significant negative effect of depression on cognitive function ($B = -0.146$, $P < 0.05$).

Sex and education were time-invariant variables, and no coefficient was derived from the fixed-effects model, but

the effects of variables were controlled. With regard to marital status, the coefficients of married people indicated a greater positive direction than those of the reference values (those living alone due to separation, widowhood, and divorce) in the MCI and dementia groups, but without statistical significance in all models ($P > 0.05$).

In the case of social contact, those who had no close friends were considered the standard value, with the frequent presence of a person having a positive effect on cognitive function (normal group: $B = 0.253$, $P < 0.05$; dementia group: $B = 1.527$, $P < 0.01$). For the variable “monthly mean pocket money,” used as a proxy for economic effect, no significant effect was observed in any group (normal group: $B = -0.002$; MCI: 0.002; dementia group: 0.009, $P > 0.05$).

Hypertension and diabetes had a statistically significant negative effect on cognitive function scores in only the dementia group ($B = -1.843$, $P < 0.05$). When cerebrovascular disease occurred, the cognitive function score was negatively affected in the normal group ($B = -0.599$, $P < 0.01$).

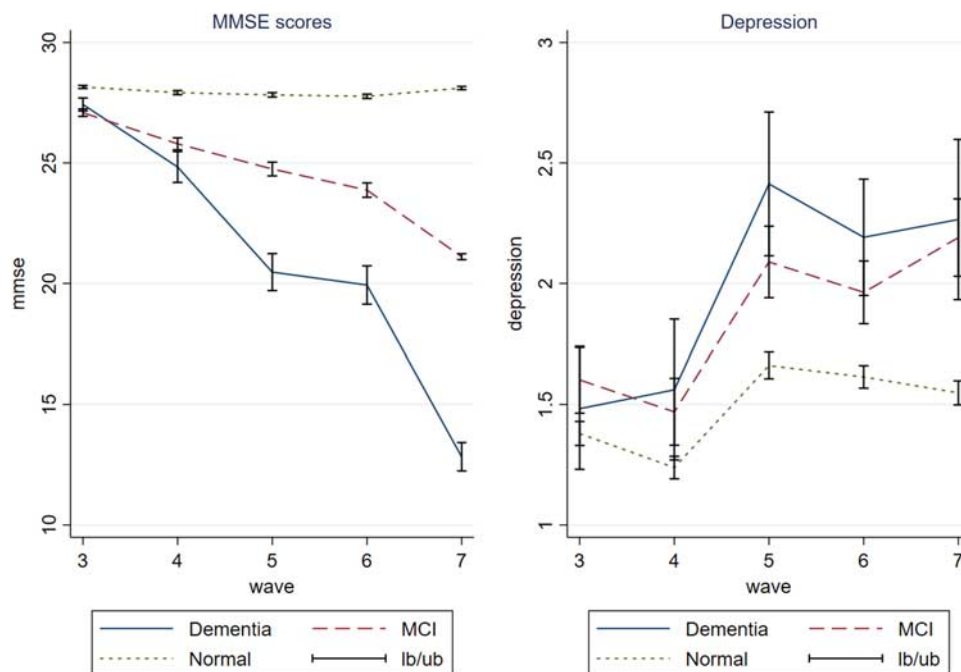


FIGURE 2. Line plot of change in mini-mental state examination and depression from baseline by cognitive state group. MCI indicates mild cognitive impairment; MMSE, mini-mental state examination. full color online

The occurrence of psychiatric diseases in the normal group significantly negatively affected the cognitive function score ($B = -0.557, P < 0.05$). Heart disease, smoking, and alcohol consumption did not significantly affect the cognitive function score decrease in any group ($P > 0.05$). In the normal group, the cognitive function score decreased as dependence on ADL increased, and it was statistically significant in the normal group ($B = -0.511, P < 0.001$). However, no statistically significant effect on cognitive function score changes in the MCI and dementia groups was observed ($P > 0.05$). In the case of IADL, as the dependence increased, it had a statistically significant effect on the decrease in the MMSE score in all the groups.

DISCUSSION

This study was conducted to identify the annual cognitive function change patterns of the normal, MCI, and dementia groups, and estimate a fixed effect model of cognitive function using depression, health status, and behavior as independent variables for each group.

According to an epidemiological survey in Korea, the prevalence of dementia and MCI among the older adults (≥ 65) ranges from 5% to 10% and 10% to 20%, respectively.^{19–21} Population aging is advancing at an unprecedented pace due to expanding life expectancy and the steadily decreasing fertility rate. Consequently, the prevalence of dementia is expected to soar. Against this background, this study intends to provide clinical suggestions to prepare for a super-aging society in the future by identifying the time-dependent changing patterns of cognitive function in older individuals using a large-scale panel data and the factors affecting cognitive function.

The gist of the content revealed in this study is as follows. First, the results verify a clear difference in the degree of cognitive decline between dementia and MCI groups and the normal group. This highlights the importance of follow-up observations of community-based older adults whose MMSE scores are lower than their scores at the previous screening by over 1 point. A meta-analysis of longitudinal

TABLE 2. Changes in MMSE and Depression Scores From Their Baseline by the Cognitive State Group

Wave	MMSE						Depression					
	Normal (n = 3211)		MCI (n = 673)		Suspected Dementia (n = 230)		Normal (n = 3211)		MCI (n = 673)		Suspected Dementia (n = 230)	
	Mean	CI	Mean	CI	Mean	CI	Mean	CI	Mean	CI	Mean	CI
3	28.15	(28.09, 28.22)	27.08	(26.93, 27.24)	27.43	(27.16, 27.7)	1.38	(1.33, 1.43)	1.6	(1.46, 1.74)	1.48	(1.23, 1.73)
4	27.92	(27.83, 28)	25.79	(25.55, 26.04)	24.83	(24.19, 25.47)	1.24	(1.19, 1.28)	1.47	(1.33, 1.61)	1.56	(1.27, 1.85)
5	27.82	(27.73, 27.92)	24.75	(24.46, 25.03)	20.47	(19.7, 21.24)	1.66	(1.61, 1.72)	2.09	(1.94, 2.24)	2.41	(2.11, 2.71)
6	27.76	(27.67, 27.86)	23.87	(23.57, 24.17)	19.93	(19.14, 20.73)	1.61	(1.57, 1.66)	1.96	(1.83, 2.09)	2.19	(1.95, 2.43)
7	28.11	(28.04, 28.17)	21.11	(20.99, 21.23)	12.83	(12.24, 13.42)	1.55	(1.5, 1.6)	2.19	(2.03, 2.35)	2.27	(1.93, 2.6)

CI indicates confidence interval; MCI, mild cognitive impairment; MMSE, mini-mental state examination; N, total number.

TABLE 3. Effects of Depression on Cognition Using Fixed-effects Linear Regression Analysis from the Panel Data of the 2010 to 2018 Korean Longitudinal Study of Aging (KLoSA)

Dependent Variable: MMSE Score	Normal (N = 3211)			MCI (N = 673)			Suspected Dementia (N = 230)		
	B	CI	P	B	CI	P	B	CI	P
Depression	-0.059	(-0.087, -0.032)	<0.0001***	-0.044	(-0.107, 0.02)	0.175	-0.146	(-0.28, -0.012)	0.032*
Age	-0.001	(-0.013, 0.011)	0.9	-0.72	(-0.759, -0.68)	<0.001***	-1.434	(-1.536, -1.333)	<0.001***
Sex	—	—	—	—	—	—	—	—	—
Marital state (reference: not married)	-0.227	(-0.48, 0.027)	0.08	0.027	(-0.613, 0.667)	0.934	0.556	(-1.123, 2.234)	0.516
Education	—	—	—	—	—	—	—	—	—
Social contacts (reference: no one)									
Almost no contact	-0.476	(-1.16, 0.208)	0.173	0.382	(-1.11, 1.873)	0.616	-0.503	(-3.674, 2.669)	0.756
1-6/y	0.203	(-0.056, 0.461)	0.124	-0.515	(-1.048, 0.018)	0.058	1.629	(0.394, 2.864)	0.01*
1-2/mo	0.383	(0.155, 0.612)	0.001**	0.16	(-0.353, 0.673)	0.54	0.949	(-0.15, 2.048)	0.091
1/wk	0.261	(0.023, 0.499)	0.031*	-0.485	(-1.013, 0.044)	0.072	1.044	(-0.1, 2.188)	0.074
2-3/wk	0.344	(0.115, 0.574)	0.003**	0.014	(-0.507, 0.535)	0.959	0.956	(-0.134, 2.046)	0.086
Almost everyday	0.253	(0.016, 0.49)	0.036*	-0.056	(-0.564, 0.452)	0.829	1.527	(0.478, 2.577)	0.004**
Monthly pocket money	-0.002	(-0.004, 0.001)	0.315	0.002	(-0.009, 0.013)	0.742	0.009	(-0.028, 0.047)	0.623
Hypertension and diabetes (reference: no)	0.232	(-0.014, 0.477)	0.064	-0.154	(-0.811, 0.504)	0.647	-1.843	(-3.426, -0.259)	0.023*
Cerebrovascular disease (reference: no)	-0.599	(-1.041, -0.157)	0.008**	-0.058	(-1.048, 0.933)	0.909	0.066	(-2.054, 2.186)	0.951
Psychiatric disease (reference: no)	-0.557	(-1.053, -0.06)	0.028*	-0.242	(-1.441, 0.956)	0.692	0.137	(-1.992, 2.266)	0.9
Heart disease (reference: no)	-0.235	(-0.569, 0.098)	0.167	-0.69	(-1.529, 0.15)	0.107	0.066	(-2.054, 2.186)	0.951
Smoking (reference: never)									
Present	0.068	(-0.533, 0.669)	0.824	-0.364	(-1.965, 1.237)	0.655	—	—	—
Past	-0.006	(-0.589, 0.578)	0.985	-0.594	(-2.102, 0.914)	0.44	0.132	(-1.116, 1.379)	0.836
Alcohol drinking (reference: never)									
Present	0.023	(-0.46, 0.507)	0.924	0.063	(-1.569, 1.695)	0.94	-3.788	(-8.861, 1.286)	0.143
Past	-0.106	(-0.62, 0.407)	0.685	-0.094	(-1.794, 1.606)	0.913	-4.272	(-9.383, 0.839)	0.101
ADL	-0.511	(-0.682, -0.341)	<0.001***	0.027	(-0.287, 0.341)	0.866	-0.065	(-0.354, 0.224)	0.66
IADL	-0.095	(-0.163, -0.026)	0.007**	-0.337	(-0.467, -0.208)	<0.001***	-0.855	(-1.002, -0.707)	<0.001***
Constant	27.418	(26.136, 28.701)	<0.001***	75.334	(72.186, 78.483)	<0.001***	127.384	(119.52, 135.248)	<0.001***
F	10.60	—	<0.001***	83.54	—	<0.001***	107.39	—	<0.001***
R ²									
Overall		0.071			0.104			0.166	
Between		0.121			0.069			0.092	
Within		0.021			0.443			0.736	

Sex, education, present smoker variable's coefficient omitted because of collinearity but controlled in the model.

All model showed $P < 0.05$ in Hausman test.

* $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$.

ADL indicates activities of daily living; CI, confidence interval; IADL, instrumental activities of daily living; MCI, mild cognitive impairment; MMSE, mini-mental state examination.

studies on the cognitive function status of community-based older adults revealed that their annual MMSE score decreased from 0.1 to 1.3 points. In contrast, in the analysis excluding those diagnosed with dementia, the annual decrease in MMSE score ranged from 0.16 to 0.56 points.²² In this study, the mean MMSE scores of the normal, MCI, and dementia groups were lowered by 0.048, 5.976, and 14.596 points from their respective baseline MMSE scores measured 8 years earlier (Fig. 1, Table 2).

Second, MCI can be divided into “predementia” in the early stage of dementia and “stable MCI” in which MCI is maintained. Through this study, it was found that among them, MCI with depression is highly likely to indicate a state of “predementia,” which is, in turn, highly likely to progress to dementia in the future. Mourao and colleagues analyzed the research hypothesis on whether people with depression among MCI patients are more likely to progress to dementia through systematic literature review and meta-analysis. As a result of analyzing 18 studies, the pooled RR was 1.28 ($P=0.003$), indicating that the MCI group with depression had a high risk of dementia progression.²³ In light of the results of this study, the change in the individual’s degree of depression had a significant effect on the cognitive function in the normal group. This is evidence that depression can affect cognitive functions except daily living ability within the normal range.

Among those diagnosed with MCI after 8 years of follow-up in this study, it is judged that there will be a mixture of those who will develop dementia later and those who maintain stable MCI. In the fixed effect model in Table 3, the effect on depression was significant at the levels of $B=-0.044$, $P>0.05$ in the MCI group, and $B=-0.146$ and $P=0.032$ in the dementia group. In the case of cognitive function within the normal range, an individual’s depression may be affected by the increase or decrease. This can be evidence that depression can act as a risk factor for cognitive decline within the normal category, but for groups in which neurodegenerative changes have already occurred, the increase or decrease in depression is closer to the initial symptoms rather than acting as a risk factor. The peculiarity of this study is whether intraindividual fluctuations in depression affect cognitive function over time, so a pattern different from that of previous studies could be confirmed. It can be concluded that close observation is necessary because people with MCI and depression are more likely to progress to dementia.

In the case of irreversible dementia such as Alzheimer disease, early identification can delay cognitive function degeneration through drug and nonpharmacological treatment. Therefore, it is important to differentiate between the normal aging process and MCI or dementia.^{24,25} With regard to the results of this study, it may be of greater importance to follow up on the cognitive decline in older adults and check the amount of change compared with simply understanding the current state. Depression accounts for up to 4.5% of reversible dementias.²⁶ This highlights the need to provide depression and dementia interventions by differentiating dementia associated with depression from other types of dementia. This can be achieved by administering periodical depression screenings for those diagnosed with MCI after dementia screenings, which is expected to efficiently reduce the prevalence of dementia among community-based older adults.

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