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Changes in cognitive function and influencing factors in older men

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Abstract

In this study, we investigated the changes and influencing factors of cognitive function in older Korean males. Despite significant investigation into the decline of cognitive function in older adults, this particular population of patients has received insufficient research attention due to their unique socio-economic context. In this study, we utilized data from 1543 elderly men aged 65 and over, drawing from the 1st to 8th rounds of the Korean Longitudinal Study of Aging (KLoSA) conducted between 2006 and 2020. A latent growth model was employed to estimate changes in their cognitive function. Specifically, we used an unconditional model to evaluate the pattern of cognitive changes in elderly men and a conditional model to identify the factors influencing these functional changes. Analysis showed that the cognitive function of elderly men showed an increasing rate of decline over time, thus indicating a progressively sharp reduction in the level of cognitive function. Secondly, we identified a range of factors influencing cognitive function in elderly men, including age, education, employment status and depression. In addition, we found that no independent variable influenced the linear rate of change or the quadratic rate of change rate of cognitive function in elderly men. Despite certain limitations, such as the inability to control for external impacts such as the COVID-19 pandemic and a high sample attrition rate, this study paves the way for future investigations aimed at gaining a better understanding of the dynamics of cognitive function in older Korean males and designing effective interventions.

Keywords

Cognitive function; Older adults; Depression; Public health; CES-D (Center for Epidemiologic Studies Depression Scale)

1. Introduction

As medical technology advances and life expectancies rise, promoting healthy aging has become a pressing issue in modern society [1]. Various factors have been introduced over time as key determinants of healthy aging; in particular, cognitive decline poses a serious challenge in older adults. Deterioration in cognitive function can restrict social activities, elevating levels of depression [2], increasing the risk of accidents due to reductions in comprehension and judgement [3], and diminishing a number of self-care abilities, such as eating, dressing and using the toilet [4–6], ultimately reducing the quality-of-life for older adults aged over 65 years.

Neuronal loss in aging, particularly in the presence of neuropathology, can lead to cognitive decline which can then progress to mild cognitive impairment and potentially dementia [7]. According to a nationwide survey of the prevalence of dementia conducted annually in South Korea since 2008, the prevalence of dementia in patients over 65 years-of-age increased from 8.39% in 2008 [8] to 10.16% in 2018 [9], and was estimated to be 10.33% in 2020 [10], thus indicating that one in ten older Korean adults suffers from dementia. An important observation is this prevalence of dementia in older Korean adults is given as a consolidated figure on a national scale, and can differ according to gender. In fact, according to a survey by the Korean Ministry of Health and Welfare [9], the prevalence of dementia among males aged 65 years and over was lower at around 9.2% in 2022; this compared to 11.29% in older females. While the research on cognitive function differences based on gender shows varied results [11–13], recent studies have shown that the proportion of cases with "suspected dementia" or those with cognitive impairments is significantly higher in older males than among older females [14]. Furthermore, it is anticipated that the increase in the prevalence of dementia symptoms manifesting as cognitive decline will be greater in older male adults compared to older female adults [15]. Therefore, an approach considering gender characteristics is necessary. Considering the differing rates of prevalence of dementia and cognitive impairment among older Korean males and females, future research that aims to provide a foundation for the prevention of dementia and cognitive improvement in older Koreans should consider a gender-based approach.

To address the issue of cognitive function among older

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adults, it is first necessary to understand that the manifestations of cognitive abilities can vary significantly based on individual characteristics. In other words, even among individuals of the same age, some individuals may maintain normal cognitive function, while others may exhibit levels of decline that are severe enough to interfere with daily activities. This variability is not solely attributed to aging, but appears to stem from a variety of demographic and socio-economic factors including health status, income, education and employment status [16–18]. Generally, a more pronounced reduction in cognitive function is observed with aging; furthermore, the influence of the education level, which has a positive effect on cognitive function, has increased [19]. A higher level of education appears to be related to healthy behaviors and complex cognitive activities; these factors appear to reduce the risk of dementia [20]. The presence or absence of chronic diseases, which can serve as a direct indicator of an individual's health status, along with the degree of depression, can also exert a negative impact on cognitive function [21, 22]. Furthermore, the place of residence can influence changes in cognitive function due to infrastructural aspects, including lighting, street and path conditions [23], which support active and healthy aging by stimulating cognitive function and suppressing its decline. On the other hand, previous studies of cognitive decline in older adults can be broadly divided into two categories. First, some studies analyzed factors influencing cognitive decline and focused on older women, who have a high prevalence of dementia [2, 24]. Second, other studies investigated the factors that influence cognitive function and targeted the entire older adult population without gender distinction [4–6, 24]. The most significant limitation of these previous studies is that they failed to focus on the cognitive function of older men, even though the rate of cognitive decline in older men is higher than that in older women [14]. Of course, some research [14, 24] has made efforts to explore factors related to cognitive decline among older men. However, these studies also had certain limitations. Despite the fact that health continuously changes in later life [25], these studies generally failed to capture the patterns of changes in cognitive function because they analyzed cross-sectional data. This also presents a challenge in establishing causality in a conclusive manner.

Therefore, to overcome the limitations evident in existing studies, it was important to consider two key elements: (1) a longitudinal approach to investigate changes in the cognitive function of older adults, and (2) a specific focus on older Korean men, a population in which cognitive problems are gradually increasing. Therefore, the present study aimed to investigate the trend of cognitive changes in older Korean men and analyze the factors that influence the rate of cognitive change based on 16 years of longitudinal data by applying a latent growth model.

2. Methods

2.1 Data

This investigation utilized data from the Korean Longitudinal Study of Aging (KLoSA) study from 2006 to 2020, covering the 1st to 8th waves, to estimate changes in cognitive function among older men and identify the factors that influence these changes. The KLoSA, a representative panel study of older adults in Korea, is designed to measure and understand the social, economic, psychological, demographic aspects, and health status of senior citizens, thereby providing fundamental data for the formulation of effective socio-economic policies. In the KLoSA, stratified sampling frames, based on region and housing type, were sorted in the order of administrative codes. Then, systematic sampling was applied to extract the designated number of samples [26]. In this study, we targeted older men aged 65 years and over as of the first year and analyzed those who for which we could estimate changes in cognitive function for more than three years from 2006 (the 1st wave) to 2020 (the 8th wave) and those who had no missing values for key variables. In total, we analyzed 1543 participants.

2.2 Variables

2.2.1 Independent variables

The independent variables in this study were set as demographic characteristics, economic characteristics, and health characteristics. Demographic characteristics included age (a continuous variable), area of residence (urban = 0; rural = 1), and education level (elementary school graduation or less = 0, middle school graduation or more = 1). Economic characteristics were composed of household income (a continuous variable) and employment status (unemployed = 0, employed = 1). Health characteristics were set as the presence of chronic diseases (none = 0, present = 1) and depression (1 = had such depressive thoughts briefly or not at all, 2 = had depressive thoughts occasionally, 3 = had depressive thoughts often, and 4 = always had depressive thoughts). Household income was log-transformed to generate a normal distribution. Depression was analyzed using the CES-D10 (The Center for Epidemiological Studies-Depression Scale). The CES-D, developed by Radloff [21] measures depression in the Korean Longitudinal Study of Aging panel using 10 abridged items of the Korean version of the CES-D-10. In other words, the CES-D 10 Boston version, which is a shortened scale of the 20 items of the CES-D by Kohout *et al.* [27] (1993), was included in the translation into Korean. In this study, we utilized the average variable of the 10 items from the CES-D. The reliability (Cronbach's α) of the depression scale indicated in this study was 0.812.

2.2.2 Dependent variables

The dependent variable of this study was cognitive function, for which we utilized the Korean version of the Mini-Mental State Examination (K-MMSE) translated by Kang *et al.* [28]; this examination was originally developed by Folstein *et al.* [29]. The MMSE is a 30-point questionnaire that is widely used in clinical and research settings to measure cognitive function [23]; a higher K-MMSE score implies better cognitive function.

2.3 Statistical analysis

Data were analyzed by SPSS version 28.0 (IBM, New York, NY, USA) and M-plus version 8.0 (Mplus, Los Angeles, CA, USA) software. First, descriptive statistical analysis was conducted to understand the characteristics of the main variables of the subjects. Second, we conducted latent growth modeling assuming a single group to estimate changes in the cognitive function of older men. The latent growth model consisted of two stages. In the first stage, we used an unconditional model to analyze the pattern of change in longitudinal data. In the second stage, we used a conditional model to identify factors influencing the patterns of change in the longitudinal data. To judge the fitness of the model, we applied the Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA); these methods allowed us to consider sensitivity to the size of the sample, the representativeness of the fit index, and the simplicity of the model.

3. Results

3.1 Descriptive statistics

The demographic, economic and health characteristics of the research participants are outlined in Table 1. Of the sociodemographic characteristics, the mean age was 72.03 ± 5.64 years (standard deviation). In terms of residential area, 1049 participants (68.0%) lived in urban areas, while 494 participants (32.0%) lived in rural areas, thus indicating that the urban population was more than double that of the rural population. With regards to the level of education, 820 received education up to primary school were (53.1%) while 723 received at least middle school education (46.9%). With regards to economic characteristics, the mean household income was $5403.80 ± 6935.51. In terms of employment status, 1077 participants (69.8%) were unemployed, while 466 participants (30.2%) were employed, meaning that the unemployed outnumbered the employed by more than two-fold. With regards to health characteristics, 629 participants (40.8%) reported no chronic diseases, while 914 participants (59.2%) reported having one or more chronic disease, thus indicating that those with chronic diseases were more common. Depression, rated on a 4-point scale, averaged 1.70 ± 0.51 points.

In the descriptive analysis of cognitive function (Table 2), the average cognitive function score for older men decreased over time, from 24.79 ± 5.31 points in 2006 to 22.41 ± 6.18 points in 2020.

3.2 Research model analysis

In this study, we performed two-step analysis with a latent growth model. In the first step, an unconditional model was used to estimate the initial values and rates of change in cognitive function in older adult men. In the second step, an analysis of the conditional model was conducted; this was based on the initial values and rates of change determined in the first step and was performed to investigate the relationship between changes in cognitive function and independent variables.

3.2.1 The unconditional model

Before conducting an analysis of the conditional model (Table 3), we used an unconditional model to investigate the changes in cognitive function. The unconditional model was used to identify the optimal pattern of change; this involved a no-change model, a linear change model, and a quadratic function change model. The fitness of the quadratic function change model for cognitive function was given as follows: χ^2 = 97.097 ($p < 0.001$), CFI = 0.979, TLI = 0.978 and RMSEA = 0.041, thus indicating that this particular model explained changes in cognitive function better than the no-change model and linear change model, and was therefore adopted as the final model.

Upon examining the data arising from the final unconditional quadratic function change model (Table 4 & Fig. 1), the average initial cognitive function, representing cognitive function in 2006, was 24.707 ($p < 0.001$). The linear change rate in cognitive function was −0.277 ($p < 0.01$) and the quadratic function change rate was −0.058 ($p < 0.001$); these were both statistically significant. This suggests that the cognitive function of older adult men decreased at an increasing rate over time, indicating a gradually steep decline in cognitive function levels. The variances in the initial value, linear change rate, and quadratic function change rate were 19.681 ($p < 0.001$), 3.363 ($p < 0.001$), and 0.065 ($p < 0.001$) respectively, all of which were significant, thus indicating considerable differences in the initial levels and rates of change in cognitive function among older adult men.

3.2.2 The conditional model

Next, we used a conditional model to investigate the impact of independent variables on the initial values and rates of change in cognitive function (Table 5). The fitness of the conditional model was as follows: χ^2 = 140.062 ($p < 0.001$), CFI = 0.980, TLI = 0.973 and RMSEA = 0.029, thus indicating that there were no issues with the model. Our analysis revealed that several factors influenced the initial values and rates of change in cognitive function, including age (Coefficient = −0.246, $p < 0.001$), education (Coefficient = 2.385, $p < 0.001$), employment status (Coefficient = 0.600, $p < 0.05$), and depression (Coefficient = 2.573, $p < 0.001$). In other words, cognitive function was higher in individuals who were younger, had an educational level above middle school when compared to those who only completed elementary school, were employed compared to unemployed, and had lower levels of depression. However, place of residence, household income, and the presence of chronic disease, did not appear to affect the initial values of cognitive function. Furthermore, none of the independent variables exerted any significant impact on the linear change rate or the quadratic function change rate.

4. Discussion

With the global trend towards an aging population, the challenges posed by certain diseases, such as dementia, are becoming more evident. Especially in the Korean society, where population aging is more drastic when compared to other countries, the problem of dementia is becoming increasingly severe [30]. This has drawn attention to the fact that this

TABLE 1. Sociodemographic characteristics of the study participants (N = 1543).

Variable		Categories	N	%
Sociodemographic Characteristics	Age (M (SD))			72.03 (5.64)
	Area of Residence	Urban	1049	68.0
		Rural	494	32.0
	Education	Elementary school or below	820	53.1
		Middle school or above	723	46.9
Economic Characteristics	Household Income $ (M (SD))			5403.80 (6935.51)
	Employment Status	Unemployed	1077	69.8
		Employed	466	30.2
Health Characteristics	Chronic disease status	None	629	40.8
		Present	914	59.2
	Depression (M (SD))			1.70 (0.51)

Key: M: Mean; SD: Standard Deviation.

TABLE 2. Descriptive statistics of the main variables.

Variable	Min	Max	M	SD
Cognitive function in 2006	0	30	24.79	5.31
Cognitive function in 2008	0	30	24.36	5.40
Cognitive function in 2010	0	30	24.32	5.41
Cognitive function in 2012	0	30	24.27	5.66
Cognitive function in 2014	0	30	23.91	5.83
Cognitive function in 2016	0	30	23.76	5.66
Cognitive function in 2018	0	30	22.88	6.54
Cognitive function in 2020	0	30	22.41	6.18

Key: M: Mean; SD: Standard Deviation.

TABLE 3. Fitness of the unconditional model.

Model	χ^2	df	CFI	TLI	RMSEA
No Growth Model	1028.898***	34	0.699	0.752	0.138
Linear Growth Model	217.732***	31	0.943	0.949	0.062
Quadratic Growth Model	97.097***	27	0.979	0.978	0.041

****$p < 0.001$. Key: df: degree of freedom; CFI: comparative fit index; TLI: Tucker-Lewis index; RMSEA: root mean square error of approximation.*

TABLE 4. Mean and variance of the initial score and rate of change when applying the unconditional model.

Category	Mean		Variance	
	Estimate	S.E.	Estimate	S.E.
Initial score	24.707***	0.132	19.681***	1.163
Linear rate of change	−0.277**	0.081	3.363***	0.413
Quadratic rate of change	−0.058***	0.013	0.065***	0.009

***$p < 0.01$, ***$p < 0.001$. Key: S.E: Standard Error.*

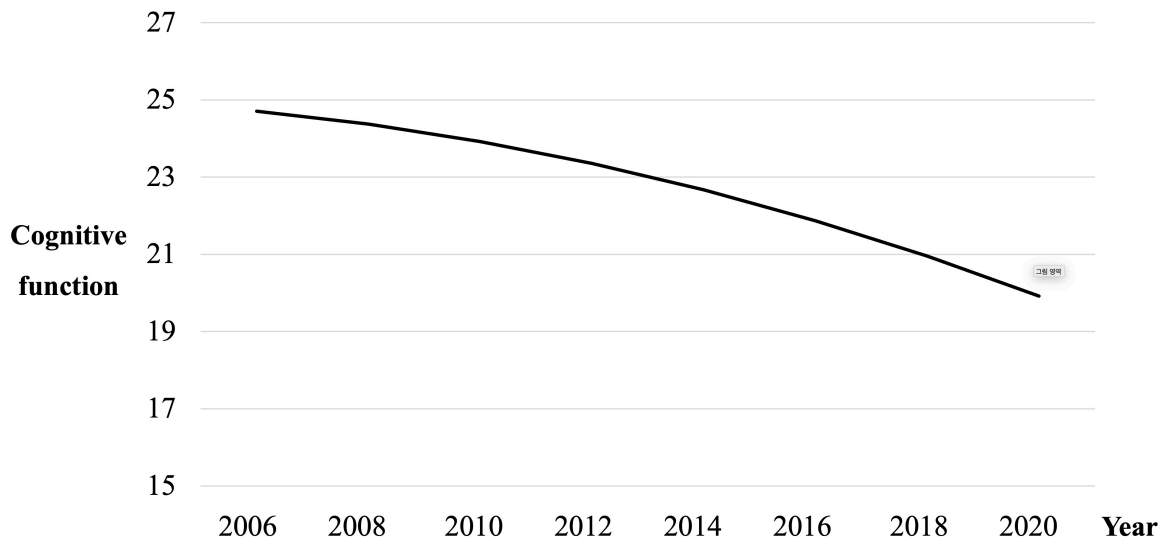

FIGURE 1. Estimations for cognitive function in older males according to the quadratic change model.

TABLE 5. Path coefficient for the study model.

Path between Variables	Coef.	S.E.
Demographic Characteristics		
Age → ICF	−0.246***	0.021
Residential Area (ref. city) → ICF	−0.156	0.258
Education (ref. Elementary School or below) → ICF	2.385***	0.241
Economic Characteristics		
Household income (log) → ICF	0.063	0.041
Employment Status (ref. unemployed) → ICF	0.600*	0.268
Health Characteristics		
Chronic Disease Presence (ref. none) → ICF	−0.066	0.231
Depression → ICF	−2.573***	0.231
Demographic Characteristics		
Age → LRCCF	0.003	0.017
Residential Area (ref. city) → LRCCF	−0.013	0.178
Education (ref. Elementary School or below) → LRCCF	−0.147	0.168
Economic Characteristics		
Household income (log) → LRCCF	0.032	0.031
Employment Status (ref. unemployed) → LRCCF	0.330	0.181
Health Characteristics		
Chronic Disease Presence (ref. none) → LRCCF	−0.167	0.160
Depression → LRCCF	0.069	0.173
Demographic Characteristics		
Age → QRCCF	−0.006	0.003
Residential Area (ref. city) → QRCCF	0.010	0.027
Education (ref. Elementary School or below) → QRCCF	0.036	0.025
Economic Characteristics		
Household income (log) → QRCCF	−0.005	0.005
Employment Status (ref. unemployed) → QRCCF	−0.038	0.027
Health Characteristics		
Chronic Disease Presence (ref. none) → QRCCF	0.025	0.024
Depression → QRCCF	−0.012	0.027

$*p < 0.05$, $***p < 0.001$. Key: ICF: Initial Cognitive Function; LRCCF: Linear Rate of Change in Cognitive Function; QRCCF: Quadratic Rate of Change in Cognitive Function.

disease does not only exert negative impacts on older adults, it also affects their families and society.

First, we used a latent growth model to estimate the changes in cognitive function of older Korean men and showed that their cognitive functions steadily declined from the first survey year (2006) to the eighth survey year (2020). The rate of this decline increased gradually over the years. This indicates that older men are more vulnerable to cognitive decline than those who have just entered old age. Therefore, there is a need to introduce a dementia prevention program for older men during the early stages of old age, and incorporate approaches to prevent cognitive decline, including dementia, in middle-aged men. Various programs for dementia prevention are currently being offered in senior welfare centers in Korea. However, these programs are not focused on older men, middle-aged men or early older adults; rather, these programs aim to prevent mild cognitive impairment in the general population of older adults [31]. Therefore, improvements to the system are needed to provide an earlier response to cognitive decline in Korean older adults in addition to the development of programs specifically tailored for older men.

Next, we incorporated demographic characteristics, including age, area of residence, and education; economic characteristics, such as household income and employment status; and health characteristics, such as the presence of chronic diseases and depression, as independent variables to analyze factors affecting the initial value of cognitive function in older men. Analysis showed that the initial value of cognitive function was higher when the age was younger, the education level was at least middle school graduation compared to elementary school graduation or lower, the employment status was employed compared to unemployed, and depression was lower. The effect of age on cognitive function has been consistently confirmed in various prior studies involving older adults [32, 33]. In particular, Kim *et al.* [34] showed that age, education, poverty, depression, subjective health, Instrumental Activities of Daily Living (IADL), and participation in meetings, all influenced the types of changes in cognitive function; these findings concurred with those of the present study in that we also found that age, education, employment and depression affected the initial value of cognitive function. Education and employment status are known to be significantly related to socioeconomic status, and those who are socioeconomically disadvantaged tend to have lower cognitive function and a higher risk of dementia and Alzheimer's disease [35]. Therefore, it is necessary to specifically identify older men with low levels of education, particularly those who are not currently employed and belong to the low-income group, at the municipal level, and to provide cognitive prevention programs as a vital component of welfare policies. Encouraging social participation could also be an effective policy, as stated previously by Berkman *et al.* [36]. Although age, education, employment status and depression affected the initial value of cognitive function, the effect of depression was the most significant. In other words, depression directly affects the cognitive function of older men; therefore, it is necessary to improve this by initiating relevant programs.

On the other hand, the results we obtained by analyzing the dispersion of the initial values were significantly different from those of previous studies. A statistically significant dispersion in initial values can be interpreted as individuals not exhibiting homogeneous characteristics at the start of the analysis period [37]. In other words, analysis of variance revealed significant differences in both the initial values and the rate of change, thus suggesting that there are differences in the initial cognitive function values among older adults in Korea. Since the initial cognitive function measures differ among individual Korean older males, this highlights the need to consider differences between individuals rather than the common characteristics of the group. Moreover, the fact that employment status and depression significantly impacted the initial cognitive function scores suggests the need for active interventions to encourage employment among older adults and to prevent depression [16–18].

Third, no factors were found to influence the changes in cognitive function of older Korean males. However, there was a significant variance in the rate of change, thus suggesting that the rate of change for cognitive function varies among older adults in Korea. The finding that the degree of cognitive function change differs between individuals underscores the need for careful management at the individual level. In particular, the finding that none of the factors examined in this study had any impact indicates the need for follow-up studies to identify factors that influence changes in cognitive function. Specifically, when planning for long-term changes in cognitive function among older adults, considerations beyond demographic factors such as age, education, residence area, and income are necessary. Alternatively, there is a need to clarify the factors that influence changes in cognitive function from a short-term perspective.

Our analysis suggests the need for more in-depth research on cognitive function, given the wide variability in cognitive function changes among Korean older adults. In particular, and following the suggestion made by Kim *et al.* [34], this study focused on a more specific group of older Korean males, and similar to previous studies, we found that the decline in cognitive function among older Korean males varied greatly. Hence, it is necessary to conduct analyses for each subgroup divided by various factors, such as age and income. In particular, the academic significance of this study lies in the empirical verification of the diversity of changes in cognitive function among older Korean males; this was only covered briefly in some previous studies. In addition, previous research showed that the decline in cognitive function among older Korean males becomes more dramatic as the years pass, thus echoing the findings of previous studies [37, 38] in that older males experience a serious decline in cognitive function. This emphasizes the necessity of prevention measures for the decline in cognitive function in older males. Although we verified the variability of cognitive function changes in older adults in Korea, further research is still needed to categorize these changes. Our findings indicate the need for a series of follow-up research studies. Many previous studies identified a range of factors that contribute to cognitive decline, but unlike these earlier studies, our present research found that demographic, economic and depressive factors do not influence cognitive decline in older males. It is anticipated that further studies investigating the different types of change in cognitive function in older Korean

males could lead to policy and practical suggestions for each type of change.

Many previous studies have identified factors that contribute to cognitive decline; however, unlike these earlier studies, the present research found that demographic, economic and depressive factors do not influence cognitive decline in older males [14, 39]. This seems to be because differences appear in the sociocultural context, which includes social interaction activities such as education level, economic activities, living environment, religious activities, and camaraderie of both men and women, depending on the region where the survey subjects belong. The sociocultural context of a region can stimulate cognitive function, and stimulation over a long period can serve as a protective factor for an individual's cognitive function [40]. Thus, it is necessary to identify specific influential factors for these individuals and generate strategies to address these factors. Specifically, factors such as hobbies, other physical activities, and school activities can be considered. On the other hand, we measured cognitive function by the Korean version of the Mini-Mental State Examination (K-MMSE). In follow-up studies, it is recommended to consider various global cognitive function scales, such as the Allen Cognitive Level Screen (ACLS). Of course, while the K-MMSE is widely used in Korea for cognitive assessment and has been validated in its Korean version, there is a significant need to verify whether similar results can be derived using other global cognitive function scales. Despite this, our study, which investigated changes in cognitive function and influential factors over a period of 16 years, has its own unique value. In particular, this study is significant in that it suggests the importance of cognitive function and the direction of intervention measures for older males based on specific research data. However, this study has certain limitations in that it did not control for the external impact of the COVID-19 pandemic on the levels of cognitive function in older males between 2006 and 2020. Moreover, the secondary data used in this study was associated with a high sample attrition rate over the 16-year period. Furthermore, the independent variables analyzed in this study did not appear to affect cognitive function in the medium to long term, thus suggesting that a variety of variables should be considered to develop long-term cognitive function prevention policies. We look forward to further research that will address these issues in the future.

5. Conclusions

The significant findings of this study highlight marked heterogeneity in the initial cognitive function scores of older Korean adults, particularly males. Factors such as employment status and depression had a considerable influence on these initial scores, thus highlighting the substantial impact of individual circumstances on cognitive health within this demographic. Interestingly, our investigation did not identify any factors that exerted significant effects on the changes of cognitive function over time. These data underscore the importance of considering individual differences when designing and implementing health interventions. Moreover, our findings draw attention to the urgent need for continuous research to fully understand the fundamental factors influencing the variability of changes in cognitive function in older Korean males over time. The transformative potential of such understanding could be pivotal in reshaping the strategies for cognitive health interventions among this population, thus providing lasting impact on the quality of their life in later years.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

KHJ, HJC, BKK, GHK and SEK—designed and conducted the research study; interpreted the data. KHJ and BKK—collected and analyzed the data. GHK and SEK—drafted the manuscript. KHJ and HJC—revised the manuscript's content. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of Semyung University in Korea (SMU-EX-2023-07-001). Informed consent was obtained from all participants. Additionally, the survey of KoWePS is approved by the Institutional Review Board of Korea Institute for Health and Social Affairs prior to commencement every year.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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