ORIGINAL ARTICLE

J Korean Acad Community Health Nurs (지역사회간호학회지)

ISSN 1225-9594 (Print) / ISSN 2288-4203 (Online)
Vol. 28 No. 2, 107-117, June 2017
https://doi.org/10.12799/jkachn.2017.28.2.107

# Analyzing Factors Affecting Cognitive Function in the Elderly using Computerized Neurocognitive Tests

Shim, Joohee[1] · Kang, Seungwan[2]

[1]Graduate School, College of Nursing, Seoul National University, Seoul
[2]College of Nursing, Seoul National University, Seoul, Korea

**Purpose:** The purpose of this study is to examine the cognitive function in the elderly and to identify the influencing factors. **Methods:** The design of this study was descriptive research design. A total of 139 elderly people (aged 65 years and over) visiting the electroencephalogram (EEG) center in Seoul, Korea were evaluated. Data were assessed by self-administered questionnaires and CNS Vital Signs (CNSVS). Data were analyzed using SPSS Statistics 23.0 for Windows. **Results:** There were significant differences in the Korean Mini-Mental State Examination (K-MMSE), executive functions and reasoning according to education level. K-MMSE, visual memory and executive functions were different depending on the jobs. Age was highly correlated with cognitive function. In addition, stepwise multiple regression analyses showed that the factor significantly associated with reaction time and visual memory was depression. Depression and Trait-Anxiety had significant impacts on executive functions and K-MMSE. **Conclusion:** CNSVS enabled the accurate and objective measurement of cognitive function. Therefore, this study provides useful data to improve cognitive function of the community-dwelling elderly. The results suggested that there is need for comprehensive interventional programs that manage cognitive impairment.

**Key Words:** Aged, Cognition, Depression, Anxiety

## INTRODUCTION

### 1. Necessity of the Research

The population of South Korea is aging rapidly compared to other countries. In 2015, the number of elderly people aged 65 or older is estimated to be 6,624,000, accounting for 13.1% of the total population and is expected to account for 40% in 2060 [1]. As the elderly population is rapidly increasing, there is a growing interest in geriatric diseases. Among them, cognitive impairment is one of the most common mental illnesses in the elderly [2] and it is also a major predictor of dementia, so it is currently receiving medical and social attention [3].

As the age increases, people experience physical, psychological, and social changes, among which the decline of intellectual ability and the tendency of depression are prominent [4]. This decline of intellectual ability is the most serious problem that occurs during the aging process, which makes it difficult for the elderly to live independently in their daily life, and furthermore, if the decline of cognitive ability progresses to dementia, it causes severe behavioral disorder and causes devastation of life [5]. In addition, dementia is presented as a social problem because it weakens the self-reliance of the patient and increases reliance on the family and community support system [3]. However, since it is recognized as one of the aging process, it is being neglected and not properly assessed. In recent years, the number of elderly people aged 65 or older with dementia in Korea has increased steadily from 470,000 in 2010 to 540,000 in 2012, which is estimated to increase about twice every 20 years [6]. The growth of the elderly population with dementia increases the mental, physical and economic burden of dementia patients

**Corresponding author:** Kang, Seungwan
College of Nursing, Seoul National University, 103 Daehak-ro, Jongno-gu, Seoul 03080, Korea.
Tel: +82-2-747-7422, Fax: +82-2-745-7422, E-mail: drdemian@snu.ac.kr

- This study was supported by the research fund in Ministry of Trade, Industry and Energy(No.: 10051255).

Received: Feb 21, 2017 / Revised: Apr 7, 2017 / Accepted: Apr 11, 2017

and their caregivers, and also requires a lot of medical expenditure at the national level [2], requiring interest in the problem and management projects at the community or national level [3], and management measures to promote the health of the elderly are in urgent need. The severity and increased prevalence of dementia led to studies of the cognitive function of the elderly domestically and abroad, and the age, gender, and level of educational attainment were commonly presented as influencing factors in previous studies [3-5,7]. In addition, depression [4,7,8], presence of the spouse, the degree of health perception [4], presence of illness, letter decoding ability, and religious activities [5] have also been reported as related factors. In this way, studies on cognitive decline and related factors have been conducted, but most of the previous studies used the Mini Mental State Examination (MMSE), which is a simple mental state test using a questionnaire, in order to assess the cognitive function. There are two types of cognitive function evaluation: conventional tests, such as interview surveys, paper-pencil tests, and combined tests including interview surveys and paper-pencil tests, and computerized tests [9]. The MMSE, which is currently commonly used in clinical practice, has a merit of being standardized as a conventional test and easy to perform, but it does not allow us to obtain detailed information about various cognitive functions using and it is difficult to assess the cognitive function of patients with a linguistic deficit by this test [10]. In addition, it takes a lot of time to perform the test and analyze the results, and it may be difficult to maintain consistency because it is affected by the environment, subject and examiner. In the mid-1980s, with the widespread use of computers, computer-based cognitive function testing was developed rather than using one-on-one interviews or questionnaires in order to overcome the drawbacks of traditional assessment methods [10].

Since cognitive impairment can be caused by dementia, traumatic brain injury, and various cerebral metabolic diseases, it is important to confirm the presence of cerebral dysfunction and identify the site of damage through appropriate neurocognitive assessment. Using this type of assessment, it is possible to plan a rehabilitation program and provide treatment through identification of cognitive and behavioral weaknesses and strengths of the subject [9]. In addition, although the brain function tests such as magnetic resonance imaging (MRI) and electroencephalography (EEG) have been developed in recent years with the development of science, patients who have no abnormal findings in the brain imaging test may have a cognitive problem in the neurocognitive assessment [9]. Thus, there is a need for a standardized cognitive function test whose reliability and validity have been demonstrated and which has systematic procedures and enable consistent assessment.

The Computerized Neurocognitive Function Test employing the computer can assess cognitive function employing the advantages of the computer, such as standardizing the presentation of stimuli and the reaction process, securing the test-retest reliability, accuracy of measurement, and ease of explaining the procedure and results [11]. In addition, since it has a high correlation with MMSE, it can be used not only for assessment of the cognitive function of the general population but also for assessment of the cognitive function and evaluation of the therapeutic effect of brain injured patients [10]. Moreover, it has additional several advantages in that it makes it easier to standardize management and scoring, it can be transformed into various types, and it makes it possible to precisely control stimuli, track response elements of various subjects, and build a cost-effective, extensive and accurate database [12]. Therefore, assessment of the cognitive function of the elderly through a computer program is more effective in identifying the related factors of the cognitive decline [3], which is a predictive factor of dementia, by obtaining more objective and detailed measurement results. Especially, the elderly suffer from decreased vision and hearing loss due to aging, and often have difficulty in writing letters, which makes it difficult for them to understand and answer questions during the assessment using questionnaires and interview methods. Therefore, a computer-based cognitive function test, which is easy to manipulate simply by clicking the keys on the keyboard, can be an appropriate assessment tool for elderly patients.

Thus, this study aimed to assess the cognitive function of the community-dwelling elders

and identify the influencing factors of cognitive function, using the Central Nervous System Vital Signs Test (CNSVS), and to provide the basic data for a nursing intervention program for proper prevention and early treatment of dementia.

## 2. Research Purpose

The purpose of this study was to investigate the cognitive function and related factors of the community-dwelling elders by using the computerized neurocognitive assessment tool. The specific goals of this research were as follows:

- Identify the domain-specific functions of cognitive function in elderly people.
- Investigate the differences in cognitive function ac-

cording to the general characteristics of elderly people.

- Investigate the correlations between age and cognitive function of elderly people.
- Identify factors influencing to cognitive function of the elderly.

## METHODS

### 1. Research Design

This study is a descriptive, cross-sectional study to measure the cognitive function of the community-dwelling elders and to identify the influencing factors.

### 2. Subjects

The subjects of this study were elderly people who visited the EEG center in a university located in S city, and inclusion criteria were as follows:

- An elderly person aged 65 or older
- A person with the MMSE score of 21 points or more
- A person who understands the purpose of the study and signs the informed consent form
- A person who can understand and respond to the contents of the questionnaire and does not have difficulty in communicating
- A person who has no history of psychiatric illness or psychiatric symptoms and is able to fill out a questionnaire

In this study, the same size in terms of subjects was calculated using the G*Power 3.1.9.2 program. The regression analysis showed that the minimum sample size was 114 persons: $\alpha$ error probability of .05, the effect size (medium) of .15 and power (1-$\beta$) of .8.

As a results, 140 persons were selected considering the dropout rate and total of 139 data were used for the analysis except for one with missing answers.

### 3. Measurement

#### 1) General characteristics

For general characteristics of the subjects, their age, gender, education level, occupation, number of diagnosed diseases, medication use, depression and anxiety were measured.

#### 2) Cognitive function

(1) Central Nervous System Vital Signs Test (CNSVS)

The CNSVS is a computerized neurocognitive test battery and it is a program designed to allow the subject to do his or her own neurocognitive tests that were traditionally performed by a clinical psychologist and is available in 60 languages at http://cnsvs.com. In this test, a Korean version of the test program was purchased and downloaded, and was performed by inputting the test ID and password given by CNSVS. The CNSVS displays a validity indicator which is a guideline identifying the possibility of an invalid test of domain score. If the test results indicate that the test is invalid, the examiner will consider additional confirmation and retesting to ensure that the subject understood the test well and made the best effort.

In this study, the subjects' reaction time, verbal memory, visual memory, executive function, and reasoning were measured by performing the verbal memory test, visual memory test, shifting attention test, and nonverbal reasoning test. If the test results are given, the standard and percentile scores are automatically determined through comparison with the standard for the same age on the basis of the CNSVS standard database constructed with 1,069 people aged 7~90. The standard score is a standardized value derived using an average of 100 and a standard deviation of 15. The percentile score is a mathematically converted value of the index of where the standard score and the subject's score are located in the range from 1 to 99 when compared to other subjects of the same age. It is assumed that the higher the standard score and percentile score are, the higher the neurocognitive function is. If the standard score is higher than 110 (percentile 74), 90~110 (25~74), 80~89 (9~24), 70~79 (2~8), or less than 70 (less than 2), it indicates the above, average, low average, low, very low level of cognitive function in that order, respectively [13]. In this study, analysis of cognitive function was conducted using percentile scores. The instrument used in the present study was tested for reliability and validity in a study by Gualtieri and Johnson [13], and the test-retest reliability at the time was .65~.88[13].

① Reaction time

Reaction time is obtained by measuring how quickly (1/1,000th of a second) the subject responds to increasingly complex instruction sets beginning with simple instructions and it is calculated through the attention transition test.

② Verbal memory

Verbal Memory is measured through immediate recall and delayed recall and is related to learning words, memory for words, word recognition [12]. First, for the immediate recall measurement, 15 words to memorize are presented on the screen one by one every 2 seconds, and then

15 words to memorize and 15 new words are randomly presented on the screen one by one. If the subject thinks the word on the screen is a word to remember, he or she is supposed to press the space bar. After approximately 20 minutes, the delayed recall is measured after the other neurocognitive tests. If the subject thinks that each of the 30 words presented on the screen is one of the 15 words to remember presented earlier, he or she should press the space bar.

③ Visual memory

Visual memory is related to recognition memory for figures or shapes and is measured in the same way as verbal memory, but geometric figures are presented instead of words.

④ Executive function

Executive function is measured through an shifting attention test and is related to the recognition of rules and categories and the ability of rapid decision-making and work processing [12]. Circles or squares on the screen are shown in red or blue. A total of three figures are shown, one on the top and two on the bottom. The problem is presented as a color match or a shape match, and the subject chooses the shape that matches the upper figure from the bottom two figures according to the given condition.

⑤ Reasoning

Reasoning is measured through nonverbal reasoning tests and it is related to how well the subject is able to recognize, reason, and respond to nonverbal visual abstract stimuli. There are 2x2 squares, of which three squares each have a different shape and the lower right one is empty. The subject looks at the three figures and makes a guess of the appropriate figure to fill in the remaining blank and selects from the given five figures.

(2) The Korean Mini-Mental State Examination (K-MMSE)

In this study, the Korean Mini-Mental State Examination (K-MMSE) developed by Kang et al.[15], which is a Korean version of the Mini-Mental State Examination (MMSE) developed by Folstein et al.[14], was used. The total score is 30 points. If each item is properly performed, 1 point is given, and if not performed, 0 point is given. The test consists of 7 domains, which include orientation for time (5 points), orientation for place (5 points), registration (3 points), recall (3 points), language (8 points), attention and calculation (5 points), and visual construction (1 point). In the study of Kim et al.[16], the inter-rater reliability was .96 and the test-retest reliability was .86. In this study, the reliability was Cronbach's α=.61

**3) Depression**

The Korean version of Beck Depression Inventory (BDI), which Lee and Song [18] made by translating the Beck Depression Inventory (BDI) developed by Beck et al.[17], was used in this study. Each of a total of 21 questions were scored from 0 to 3 points, with the total score ranging from 0 to 63 points. A higher score indicates a greater degree of depression. 0~9 points indicate a normal level, 10~15 points indicate mild depression, 16~23 points represent moderate depression, and 24 points indicate severe depression [17]. Cronbach's α at the time of development was .78 in the general population, .85 in depression patients, and was .89 in the present study.

**4) Anxiety**

The State-Trait Anxiety Inventory-Korean YZ (STAI-KYZ), which Hahn et al.[20] made by modifying the State-Trait Anxiety Inventory (STAI-Y) developed by Spielberger [19] into Korean version, was used in this study. This is a self-report survey for measuring state anxiety (20 items) and trait anxiety (20 items), and it is a 4-point Likert scale with a total of 40 items. The total score ranges from 20 to 80 points, and a higher score indicates a higher anxiety level. While Cronbach's α at the time of development was .92 for state anxiety and .90 for trait anxiety [20], in this study, it was .71 for state anxiety, .64 for trait anxiety, and .77 for the total score.

## 4. Data Collection

This study was conducted with the community-dwelling elders who visited the EEG centers in a university located in S city from March 2015 to June 2016. Data collection was carried out by the researcher and two clinical pathologists with clinical experience in a hospital. The subjects were provided with explanations on the purpose of the study and research instruments, precautions and instructions on how to apply the questionnaire. A self-made poster was used for the recruitment of research participants. The researcher interviewed applicants directly and created a structured questionnaire to minimize unanswered items or errors. The neuropsychological test using CNSVS was performed using a laptop computer, and the test was performed in a quiet and independent space so that the examiner could concentrate. Considering the fact that the subjects were elderly people who were relatively inexperienced in using a laptop computer, sufficient explanations were provided about how to perform the test by pressing the keys on the keyboard. The keys on the keyboard used for the test were minimized by using only the space bar, numeric keys, right shift key and left shift key. In particular, the examiner explained the test method each time the items of cognitive function to be measured were changed, and immediately afterwards, additional explanations were provided while observing the subject perform the exercises presented for the measurement item in order to minimize problems that could arise from insufficient understanding or misunderstanding of the test method or the inadequate use of the instrument due to inexperience. In this study, it took about 40 minutes to complete the questionnaire and measure the cognitive function to collect test data.

## 5. Ethical Considerations

This study was approved by the Institutional Review Board of Seoul National University (IRB No. 2013-93). Before data collection, the explanations about the purpose and method of the study and personal information protection were provided, and the structured questionnaires were distributed after receiving written informed consents from the subjects who expressed their willingness to participate in this study voluntarily.

## 6. Data Analysis

The collected data were analyzed using SPSS 23.0.

- The subjects' general characteristics, depression, anxiety, and cognitive function were calculated as the frequency, percentage, mean, and standard deviation.
- Differences in cognitive function according to general demographic characteristics and differences between specific domains of cognitive function were analyzed using the independent t-test and one-way ANOVA. When equal variances were assumed through Levene's test for equality of variances, the one way ANOVA was conducted, and then the post-hoc test was performed using the Bonferroni test.
- Pearson's correlation coefficient was used to analyze the correlation between age and cognitive function.
- Influencing factors of cognitive function were analyzed by multiple linear regression analysis.

# RESULTS

## 1. General Characteristics of the Subjects

The average age of the subjects was 70.3±4.14 years. The resulting samples consist of 109 (78.4%) female & 30 (21.6%)males. For the education level, the highest percentage of them was high school graduates and there were 52 high school graduates (37.4%), followed by those with a college degree or higher education (28.8%), those with no formal education (12.2%), middle school graduates (11.5%) and elementary school graduates (10.1%). Currently, 78 persons (56.1%) did not have a job, 66 persons (47.5%) were housewives, 40 persons (28.8%) were blue collar workers, and 21 persons (15.1%) were white collar workers. 91 persons (65.5%) had an underlying disease and 85 persons (61.2%) were taking medicines (Table 1).

The mean depression score of the subjects measured by BDI was 1.73±1.04 points. Among them, 84 were normal (60.4%) and they accounted for the largest percentage, followed by mild depression (15.8%), severe depression (19.7 %) and severe depression (14.1%). The mean state anxiety score of the subjects was 36.43±10.85, the mean trail anxiety score was 37.51±12.13, and the total anxiety score was 73.94±21.43 (Table 1).

**Table 1.** General Characteristics of Subjects (*N*=139)

| Variables | Categories | n (%) or M±SD |
|---|---|---|
| Age (year) | | 70.3±4.14 |
| Gender | Male | 30 (21.6) |
| | Female | 109 (78.4) |
| Level of education | No school | 17 (12.2) |
| | Elementary school | 14 (10.1) |
| | Middle school | 16 (11.5) |
| | High school | 52 (37.4) |
| | ≥College | 40 (28.8) |
| Job | Blue collar | 40 (28.8) |
| | White collar | 21 (15.1) |
| | House-wife | 66 (47.5) |
| | Inoccupation | 12 (8.6) |
| Disease | Yes | 91 (65.5) |
| | No | 48 (34.5) |
| Medication | Yes | 85 (61.2) |
| | No | 54 (38.8) |
| Depression | | 10.38±9.28 |
| | None or Minimal depression | 84 (60.4) |
| | Mild to Moderate depression | 22 (15.8) |
| | Moderate to Severe depression | 19 (13.7) |
| | Severe depression | 14 (10.1) |
| Total anxiety | | 73.94±21.43 |
| State anxiety | | 36.43±10.85 |
| Trait anxiety | | 37.51±12.13 |

## 2. Cognitive Function Evaluation Results

3. The measurement results of cognitive function of the subjects were represented in terms of the five levels of above (> 74 percentile), average (25~74), low average (9~24), low (2~8), and very low (<2), according to the percentile calculated based on the same age standard comparison database. And as a result, it was found that those evaluated as the low level accounted for the largest percentage of the subjects for each measurement item: 53 persons (38.1%) for verbal memory, 68 persona (48.9%) for visual memory, 60 persons (43.2%) for executive function, and 62 persons (44.6%) for reasoning. Next, for verbal memory, the evaluation results were in the order of average (30 persons, 21.6%), very low (29 persons, 20.9%), low average (20 persons, 14.4%) and above (7 persons, 5%), for visual memory, the evaluation results were in the order of low average (32 persons, 23.0%), very low (26 persons, 18.7%), average (10 persons, 7.2%) and above (3 persons, 2.2%), for executive function, the evaluation results were in the order of very low (28 persons, 20.1%), low average (25 persons, 18.0%), average (13 persons, 9.4%) and above (13 persons, 9.4%), and for reasoning ability, the evaluation results were in the order of low average (47 persons, 33.8%), average (16 persons, 11.5%), above (10 persons, 7.2%) and very low (4 persons, 2.9%).

## 3. Cognitive Functions according to General Characteristics

As a result of investigating the cognitive function of the subjects, the cognitive function percentile scores using CNSVS were 39.12±30.92 points for verbal memory, 42.59 ±28.30 points for visual memory, 41.04±29.46 points for executive function, 26.20±21.34 points for reasoning ability, and 25.66±2.38 points for K-MMSE. The analysis of the cognitive function according to general demographic characteristics showed that visual memory was significantly associated with occupation, executive function had a significant correlation with the education level and occupation, and reasoning had a significant correlation with the education level. In other words, for the visual memory the group of white-collar workers had better visual memory than the group of blue-collar workers (F=4.62, $p$=.004), for executive function, the scores of the group of white-collar workers were higher than those of the group of blue-collar workers (F=7.62, $p$<.001), and for the reasoning the group of the higher education level showed higher scores than the group of the lower education level (F=3.79, $p$= .009). In addition, there were significant differences in K-MMSE scores according to the education level and occupation. The group of the higher education level obtained higher scores (F=10.95, $p$<.001) than the non-education group (F=10.95, $p$<.001) and the scores of the white-collar group were higher than those of the blue-collar group (F=5.05, $p$=.002)(Table 3).

## 4. Correlations between Age and Cognitive Functions

Before converting the raw scores to the relative scores based on the same age standard comparison database, the correlations between the raw scores and age of the subjects are as follows (Table 4). Age was positively correlated with reaction time (r=.25, $p$=.003), indicating that as age increased, reaction time increased. On the other hand, it showed a negative correlation with verbal memory (r= -.19, $p$=.025), visual memory (r=-.17, $p$=.043), executive function (r=-.40, $p$<.001), reasoning (r=-.18, $p$=.037) and K-MMSE (r=-.23, $p$=.007), indicating that as age increased, memory, executive function, reasoning and cognitive ability decreased.

As a result of the analysis of the correlations between cognitive functions, reaction time showed a negative relationship with verbal memory, visual memory, executive function, reasoning, and K-MMSE. the participants with

**Table 2.** Severity Classification Grade of Cognitive Function (*N*=139)

| Variables | Percentile range | | | | |
|---|---|---|---|---|---|
| | >74 | 25~74 | 9~24 | 2~8 | <2 |
| | Above | Average | Low average | Low | Very low |
| | n (%) | n (%) | n (%) | n (%) | n (%) |
| Verbal memory | 7 (5.0) | 30 (21.6) | 20 (14.4) | 53 (38.1) | 29 (20.9) |
| Visual memory | 3 (2.2) | 10 (7.2) | 32 (23.0) | 68 (48.9) | 26 (18.7) |
| Executive function | 13 (9.4) | 13 (9.4) | 25 (18.0) | 60 (43.2) | 28 (20.1) |
| Reasoning | 10 (7.2) | 16 (11.5) | 47 (33.8) | 62 (44.6) | 4 (2.9) |

longer reaction time showed lower scores of memory, executive function, reasoning and low cognitive ability. The higher the score of verbal memory was, the higher the scores of visual memory (r=.23, $p$=.005) and the K-MMSE (r=.19, $p$=.028) were, while the better visual memory was, the better executive function was (r=.24, $p$=.004). In addition, executive function was positively correlated with reasoning (r=.24, $p$=.004) and K-MMSE (r=.54, $p$<.001).

## 5. Influencing Factors of Cognitive Function

Stepwise multiple regression analysis was performed to identify factors affecting the cognitive function of the subjects, including depression, state anxiety, trait anxiety, and gender as independent variables.

Multiple regression analysis showed that reaction time was established by selecting depression as the independent variable ($p$<.001). The higher the depression level was, the longer the reaction time was ($p$=.005) and the coefficient of determination ($R^2$) indicating the explanatory power of the model was .48.

In multiple regression analysis of dependent variables as visual memory, depression had a significant effect on depression ($p$<.001). The depression level increased, visual memory was lowered ($p$=.046). Depression ($p$<.001) and trait anxiety ($p$<.001) were selected as factors that had a significant effect on executive function and K-MMSE. It was found that as the depression level increased, the scores of executive function and K-MMSE became lower and as the state anxiety level became higher, the scores of executive function and K-MMSE became higher (Table 5).

**Table 3.** Cognitive Function by General Characteristics of Subjects (*N*=139)

| Variables | Categories | Verbal memory | | Visual memory | | Executive function | | Reasoning | | K-MMSE | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M±SD | t or F ($p$) | M±SD | t or F ($p$) | M±SD | t or F ($p$) | M±SD | t or F ($p$) | M±SD | t or F ($p$) |
| Age (year) | | 39.12±30.92 | | 42.59±28.30 | | 41.04±29.46 | | 26.20±21.34 | | 25.66±2.38 | |
| Gender | Male | 32.83±26.93 | -1.39 | 48.86±23.71 | 1.55 | 47.30±23.92 | 1.52 | 27.90±19.39 | 0.49 | 26.27±1.89 | 1.60 |
| | Female | 40.85±31.83 | (.171) | 40.86±29.30 | (.127) | 39.31±30.68 | (.135) | 25.73±21.90 | (.624) | 25.49±2.47 | (.112) |
| Level of education | No school[a] | 31.06±30.11 | 0.43 | 38.12±29.10 | 1.84 | 17.71±22.08 | 7.62 | 17.59±13.26 | 3.79 | 22.59±2.90 | 10.95 |
| | elementary school[b] | 36.93±31.46 | (.787) | 31.14±22.66 | (.125) | 20.64±21.88 | (<.001) | 17.79±14.18 | (.009) | 24.86±1.51 | (<.001) |
| | Middle school[c] | 39.06±30.99 | | 34.88±30.60 | | 36.56±31.92 | a, b< | 25.00±25.11 | a, b<e | 24.94±2.77 | a, b< |
| | High school[d] | 39.69±31.44 | | 43.31±29.16 | | 46.94±28.96 | d, e | 25.42±21.89 | | 26.27±1.90 | d, e |
| | ≥College[e] | 42.60±31.25 | | 50.65±26.30 | | 52.20±25.56 | | 34.30±21.83 | | 26.73±1.38 | |
| Job | Blue collar[a] | 36.13±30.14 | 0.61 | 31.65±25.79 | 4.62 | 37.50±29.70 | 7.73 | 21.60±18.68 | 1.52 | 24.85±2.76 | 5.05 |
| | White collar[b] | 34.81±29.63 | (.608) | 58.10±25.17 | (.004) | 60.14±17.96 | (<.001) | 32.62±20.80 | (.222) | 27.24±1.54 | (.002) |
| | House-wife[c] | 42.85±32.44 | | 44.86±29.89 | a<b | 39.06±30.88 | b> | 27.33±23.69 | | 25.65±2.20 | a<b |
| | Inoccupation[d] | 36.17±28.30 | | 39.42±18.00 | | 30.25±25.45 | a, c, d | 24.08±14.19 | | 25.58±1.88 | |
| Disease | Yes | 39.56±31.92 | -0.23 | 41.47±28.13 | 0.64 | 41.11±29.26 | -0.04 | 26.97±20.88 | -0.58 | 25.79±2.05 | -0.84 |
| | No | 38.29±29.26 | (.819) | 44.71±28.79 | (.524) | 40.89±30.13 | (.968) | 24.75±22.32 | (.562) | 25.40±2.90 | (.404) |
| Medication | Yes | 40.04±31.87 | -0.44 | 41.58±28.03 | 0.53 | 41.02±29.29 | 0.01 | 26.24±20.94 | -0.02 | 25.61±2.19 | 0.27 |
| | No | 37.69±29.61 | (.664) | 44.19±28.92 | (.598) | 41.06±30.00 | (.995) | 26.15±22.14 | (.981) | 25.72±2.65 | (.790) |

K-MMSE=the Korean mini-mental state examination.

**Table 4.** Correlation among Cognitive Function and Age (*N*=139)

| Variables | Age | Reaction time | Verbal memory | Visual memory | Executive function | Reasoning |
|---|---|---|---|---|---|---|
| | r ($p$) | r ($p$) | r ($p$) | r ($p$) | r ($p$) | r ($p$) |
| Reaction time | .25 (.003) | | | | | |
| Verbal memory | -.19 (.025) | -.20 (.020) | | | | |
| Visual memory | -.17 (.043) | .02 (.863) | .23 (.005) | | | |
| Executive function | -.40 (<.001) | -.13 (.144) | .06 (.506) | .24 (.004) | | |
| Reasoning | -.18 (.037) | -.04 (.648) | -.01 (.961) | .11 (.211) | .24 (.004) | |
| K-MMSE | -.23 (.007) | -.09 (.288) | .19 (.028) | .31 (<.001) | .54 (<.001) | .14 (.100) |

K-MMSE=the Korean mini-mental state examination.

**Table 5.** Factors Influencing Cognitive Function (*N*=139)

| Variables | Categories | B | SE | β | t | *p* |
|---|---|---|---|---|---|---|
| Reaction time | (Constant) | 341.56 | 7.42 | .23 | 13.44 | <.001 |
| | Depression | 1.51 | 0.53 | | 2.82 | .005 |
| | | | Adj. $R^2$=.48, F=7.96, *p*=.005 | | | |
| Visual memory | (Constant) | 47.97 | 3.57 | -.17 | 13.44 | <.001 |
| | Depression | -0.52 | 0.26 | | -2.02 | .046 |
| | | | Adj. $R^2$=.02, F=4.07, *p*=.046 | | | |
| Executive function | (Constant) | 16.05 | 5.54 | -.59 | 2.90 | .004 |
| | Depression | -1.39 | 0.22 | .35 | -6.44 | <.001 |
| | Anxiety-trait | 0.64 | 0.17 | | 3.88 | <.001 |
| | | | Adj. $R^2$=.22, F=20.77, *p*<.001 | | | |
| K-MMSE | (Constant) | 24.76 | 0.60 | -.58 | 41.58 | <.001 |
| | Depression | -0.15 | 0.02 | .33 | -6.42 | <.001 |
| | Anxiety-trait | 0.07 | 0.02 | | 3.66 | <.001 |
| | | | Adj. $R^2$=.22, F=20.60, *p*<.001 | | | |

K-MMSE=the Korean mini-mental state examination.

## DISCUSSION

The purpose of this study was to identify the cognitive functions and related factors of elderly people living in the community and to provide basic data for intervention studies for prevention and treatment of cognitive dysfunction.

The percentile results obtained by converting the cognitive function results of the subjects into percentiles based on the same age standard comparison database showed that the largest proportion of the subjects was evaluated as the low level (2~8 percentile) in verbal memory, visual memory, executive function, and reasoning. CNSVS has the validity index that indicates whether the test result performed by the subject is valid for each item. All the test results of this study are confirmed to be valid and the possibility of measurement error is considered small. However, despite enough explanation and practice with examples, the test results may have been affected by the fact that the subjects were older people who were not accustomed to using a computer and that once the test started after the exercise, the program system could not be stopped or reversed even though a mistake was made. In particular, in the case of the memory test, because there is no practice problem, during the measurement of delayed recall, the subject may often be unaware that it is connected to the initial test, and this may have resulted in overall low cognitive test results. Therefore, computer-based assessments of cognitive function of the elderly need to be actively carried out in the future and a comparison of the results and a study for cause analysis are required.

In the analysis of age-related differences in cognitive function, age was found to have a significant correlation with the response rate, verbal memory, visual memory, executive function, reasoning and K-MMSE, indicating that the increase in age is an important influencing factor of cognitive function. This result is consistent with the previous studies which reported that as age increased, cognitive function declined [2,4,5,7,21]. In addition, it supports the previous study which reported that the MMSE scores of the subjects in their 60s, 70s, and 80s were 22.88±2.44, 20.00±2.45, and 18.66±4.16, respectively (F=24.81, $p$<.001), and claimed that it was clearly demonstrated that the selective response became slower with increasing age [4]. The strongest risk factor of cognitive decline is age [22], and the decline in cognitive function with increasing age can be attributed to the process of aging [2]. In addition, older people may not have received much education due to poor socioeconomic conditions of the times, and thus the education level may have had a great effect on the age-related decline of cognitive function for them [4]. In many studies, the duration of education has been suggested as a major influencing factor for cognitive impairment [3], and this study also found that the subjects of a lower education level showed lower scores in executive function ($p$<.001) and reasoning ($p$=.009), which is consistent with the previous research which demonstrated that age and duration of education were clear influencing factors affecting cognitive function [3]. In particular, in respect of the relationship between the duration of education and cognitive function, the cerebral reserve secured through education before the old age may be effective in preventing cognitive decline in the elderly [5]. In addition, it has been claimed that when the education level is low, cognitive decline may be accelerated due to the lack of cognitive stimulation, but for those who have received continuous education, less cognitive impairment may occur due to larger cognitive reserve or more extra neurotransmitter fibers [3].

In this study, there was no significant gender difference in cognitive function and the response rate. Although this result is consistent with the previous research where cognitive function was measured using CNSVS as in this study [23] and with the preceding study which reported that assessment of the cognitive function of the elderly living at home in the community by MMSE showed no statistically significant gender differences with 24.41±3.62 points for men and 23.64±4.08 for women ($p$=.171)[5], it is in contrast to results of previous studies that reported that females showed lower cognitive functions than males [3-5]. There are gender differences in the mental health of the elderly, and dementia and depression are common risk factors especially for the elderly women [8]. This may be attributed to a longer aging period, a lower education level, and female hormone effects due to longer life expectancy of females, although this has not been clearly elucidated [3]. In addition, for gender differences in old age, previous studies explained that the elderly women are consistently vulnerable in socioeconomic terms from the viewpoint of the lifelong process, and this accumulates and becomes a risk factor of old age health [8]. However, the lack of gender differences in cognitive function in the present study is believed to be attributable to the insufficient data of male subjects due to a small number of male subjects. Therefore, it is necessary to take into consideration the gender ratio in the future study on geriatric depression and cognitive function and conduct research to identify more precise gender differences in cognitive functions and investigate the causes.

In terms of the correlation between occupation and cognitive function, the group of white-collar workers showed higher scores of the K-MMSE, visual memory, and executive function than the group of blue-collar workers. This result is similar to that of Shin et al.[24], which investigated the cognitive impairment of the elderly and found that severe cognitive impairment was the lowest in the group of elderly people who had engaged in white-collar jobs with 10.5%, and the highest in the group of those who had engaged in agriculture with 21.0%. These occupation-related differences may be related to the fact that it is highly likely that the group of white-collar workers had a longer duration of education than the group of blue-collar workers, and it is thought to support the previous studies which reported that as the period of education increased, cognitive function was found to be higher. In addition, a gradual decline in intellectual ability with increasing age occurred to a smaller degree in those who were continuously exerting intellectual ability through occupational roles [4]. It is thought that the group of white-collar workers scored higher than the group of blue collar workers because of a longer duration of education before occupational activities and continuous cognitive activities through occupational activities.

The emotional aspect is an important factor that influences the process of recall and cognition according to the encoding process [25]. In this study, regression analysis was conducted to identify emotional factors affecting cognitive function. As a result, reaction time and visual memory were found to be affected by depression, while executive function and K-MMSE were found to be influenced by depression and trait anxiety. Especially, depression showed a significant correlation with reaction time, visual memory, executive function, and K-MMSE. These results are consistent with the previous studies which reported that there was a close relationship between cognitive function and depression [5,7,8]. An increase in the depression tendency with increasing age is a common phenomenon [4], and is a major variable in determining the quality of life of elderly people since it influences cognitive function, physical health, and self-esteem [26]. In previous studies of the relationship between depression and specific domains of cognitive function, cognitive impairment associated with depression was consistently found to be dysfunctions related to frontal lobe functions, such as executive function, attention, memory, and psychomotor speed [27]. In particular, the most consistently observed phenomenon in depression patients was reduced executive function [27], and in this study as well, it was found that as the level of depression increased, executive function was reduced. Thus, the results of this study supported the claims of previous studies. In addition, the more severe depressive symptoms were, the poorer visual memory was. This result is similar to previous research findings that depressive patients had lower language learning and memory test results than those without depression and showed the most consistent lack especially in cognitive tasks involving concentration, work memory and decision-making [28]. Since emotions can reinforce the selection of a behavior negatively or positively and play an important role in memory [25], depression is thought to have influenced visual memory. Thus, more active development and application of an intervention program to improve executive function and memory need to be carried out in the future research on depression and cognitive function. Furthermore, Lee and Kahng [8] reported that cognitive function and depression in old age were closely related to each other, and that there was a bidirectional relationship between cognitive function and depression. Since there is a close relationship between depression and cognitive function, and they share many common characteristics [26], it is thought that future research on cognitive function and depression in old age should be carried out taking into mutual influences rather than simply considering unidirectional influences and careful observation of depression is required in understanding the cognitive function in old age.

On the other hand, in this study, as trait anxiety increased, the scores of executive function and K-MMSE were higher. This was an unexpected result given that previous studies reported that anxiety weakened thinking or concentration, and as a result, patients with anxiety were easily distracted and had difficulty in concentrating [25], and it is contradictory to the reports of decreases in executive function and anecdotal memory [29]. In addition, it is not consistent with previous studies which reported that individuals' anxiety levels had a significant impact on psychological test results, the influence was more prominent in older people, and thus, excessive anxiety or psychological strain led to lower intelligence test results [4]. In this study, the mean BDI was 10.38±9.28 points, which may be attributed to the fact that the subjects were not anxious enough to be diagnosed with anxiety, and it is possible that moderate anxiety helped the subjects to perform the task by making them become tense. In addition, because emotions are not the only factors that influence cognitive function, but cognitive, social, and physiological factors such as prior knowledge, personal history, and environmental culture have an important impact [25], factors other than anxiety may have an effect. Therefore, repeated research is required to confirm the clear relationship between emotions and specific cognitive functions, and further research on various factors other than emotions is considred necessary.

In this study, more detailed and objective results were derived through assessment of cognitive function of the elderly and identification of related factors of each cognitive item using CNSVS rather than conventional paper-pencil tests or interview surveys. The results may serve as the basic data for prevention of the decline of cognitive function and improvement of cognitive function of elderly people. However, since there has been no domestic study conducted using CNSVS, it is difficult to perform comparative analysis of cognitive function evaluation results and related factors. Therefore, we propose that evaluation of specific cognitive functions and identification of the influencing factors should be carried out using CNSVS with various types of subjects as well as older adults in the future research .

## CONCLUSION

The purpose of this study was to assess the cognitive function of the elderly living at home in the local community using CNSVS and identify the influencing factors to prevent the deterioration of cognitive function and to provide a basic data base for intervention studies for the early treatment of dementia. The results of this study were as follows: It was found that the reaction time was influenced by age and depression; verbal memory was influenced by age; visual memory was affected by age, occupation and depression; executive function was affected by age, education level, occupation, depression and trait anxiety; reasoning was influenced by age and education level; and K-MMSE was affected by age and education level, occupation, anxiety, and trait anxiety.

Therefore, it is considered necessary to conduct more detailed and accurate assessment of cognitive function and identification of each influencing factor through extensive and repeated research of the computer-based cognitive function test based on the results of this study. In addition, we suggest the development of a nursing intervention program that can improve the cognitive function by eliminating risk factors for cognitive decline for each specific domain of cognitive function on the basis of the results of this study.

## REFERENCES

1. Statistics Korea. 2015 estimated future population 2010-2060 [Internet]. Seoul: Statistics Korea. 2015 [cited 2017 January 31]. Available from: http://kostat.go.kr/portal/korea/kor_nw/2/1/index.board?bmode=read&aSeq=348565
2. Park SK, Ko JE, Lee YH. Gender differences in cognitive impairment related to the elderly. Journal of Wellness. 2012;7(3):85-95.
3. Kim EJ. Factors influencing cognitive impairment of the elderly residents. Journal of East-West Nursing Research. 2010;16(2):122-130.
4. Sung KW. Degree of cognitive function self-esteem and depression of the elderly by aging. Journal of Korean Academy of Nursing. 1997;27(1):36-48.
5. Min HS. Cognitive function among the elderly and its correlated factors. The Journal of Korean Academic Society of Adult Nursing. 2007;19(1):78-88.

6. Ministry of Health and Welfare. 2013 report data [Internet]. Sejong: Ministry of Health and Welfare. 2013 [cited 2017 January 31]. Available from: http://www.mohw.go.kr/front_new/al/sal0301vw.jsp?PAR_MENU_ID=04&MENU_ID=0403&CONT_SEQ=286138
7. Sheline YI, Barch DM, Garcia K, Gersing K, Pieper C, Welsh-Bohmer K, et al. Cognitive function in late life depression: Relationships to depression severity, cerebrovascular risk factors and processing speed. Biological Psychiatry. 2006;60(1):58-65. https://doi.org/10.1016/j.biopsych.2005.09.019
8. Lee HJ, Kahng SK. The reciprocal relationship between cognitive functioning and depressive symptom: Group comparison by gender. Korean Journal of Social Welfare Studies. 2011;42(2):179-203.
9. Rhee HS. A review of the evaluation tools for cognitive perceptual performance ability. The Journal of Occupational Therapy for the Aged and Dementia. 2010;4(2):35-46.
10. Lee HK, Sakong J, Kim GY, Lee HY, Cho YN. Assessment of cognitive function with Korean computerized neuro-psychological test in the patients of brain damage. Journal of Korean Society of Occupational Therapy. 2002;10(2):15-25.
11. Sakong J, Chung JH, Jeon MJ, Shin MS. Evaluation of reliability of traditional and computerized neurobehavioral tests. Annals of Occupational and Environmental Medicine. 2000;12(4):494-500.
12. Kane RL, Kay GG. Computerized assessment in neuropsychology: A review of tests and test batteries. Neuropsychology Review. 1992;3(1):1-117. https://doi.org/10.1007/BF01108787
13. Gualtieri CT, Johnson LG. Reliability and validity of a computerized neurocognitive test battery, CNS Vital Signs. Archives of Clinical Neuropsychology. 2006;21(7):623-643. https://doi.org/10.1016/j.acn.2006.05.007
14. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state": A practical method for grading the cognitive state of patients for the clinician. Journal of Psychiatric Research. 1975;12(3):189-198.
15. Kang YW, Na DL, Hahn SH. A validity study on the Korean Mini-Mental State Examination (K-MMSE) in dementia patients. Journal of the Korean Neurological Association. 1997;15(2):300-308.
16. Kim DH, Na DL, Yeon BG, Kang Y, Min KB, Lee SH, et al. Prevalence of dementia in the elderly of an urban community in Korea. Journal of Preventive Medicine and Public Health. 1999;32(3):306-316.
17. Beck AT, Steer RA, Carbin MG. Psychometric properties of the beck depression inventory: Twenty-five years of evaluation. Clinical Psychology Review. 1988;8(1):77-100. https://doi.org/10.1016/0272-7358(88)90050-5
18. Lee YH, Song JY. A study of the reliability and the validity of the BDI, SDS, and MMPI-D scales. Korean Journal of Clinical Psychology. 1991;10(1):98-113.
19. Spielberger CD, Gorsuch RL, Lushene R, Vagg PR, Jacobs G. Manual for the State-Trait Anxiety Inventory (Form Y): (self-evaluation questionnaire). Palo Alto CA: Consulting Psychologists Press; 1983. 36 p.
20. Hahn DW, Lee CH, Chon KK. Korean adaptation of Spielberger's STAI (K-STAI). Korean Journal of Health Psychology. 1996;1(1):1-14.
21. Godin O, Dufouil C, Ritchie K, Dartigues JF, Tzourio C, Pérès K, et al. Depressive symptoms, major depressive episode and cognition in the elderly: the three-city study. Neuroepidemiology. 2007;28(2):101-108. https://doi.org/10.1159/000101508
22. Lee HJ, Kahng SK. Age and gender differences in cognitive functioning among elderly. Mental Health & Social Work. 2011;37:255-278.
23. Iverson GL, Brooks BL, Ashton Rennison VL. Minimal gender differences on the CNS vital signs computerized neurocognitive battery. Applied Neuropsychology Adult. 2014;21(1):36-42. https://doi.org/10.1080/09084282.2012.721149
24. Shin CH, Kim SY, Lee YS, Cho YC, Lee TY, Lee DB. A study on the factors related to the cognitive function and depression among the elderly. Journal of Preventive Medicine and Public Health. 1996;29(2):199-214.
25. Gargo D, Martins de Almeida RM. Effects of pleasant visual stimulation on attention, working memory, and anxiety in college students. Psychology & Neuroscience. 2013;6(3):351-355. https://doi.org/10.3922/j.psns.2013.3.12
26. Kim HS, You SJ, Han KR. The relation of cognitive function, physical health, self-esteem, social support and depression of elderly women in the community. Journal of Korean Gerontological Nursing. 2002;4(2):163-175.
27. Lee KU, Cho SM, Park JI. Cognitive dysfunction and improvement after antidepressant treatment in patients with non-psychotic major depressive disorder in mild to moderate severity: A prospective study. The Korean Journal of Psychopharmacology. 2008;19(5):283-292.
28. Burt DB, Zembar MJ, Niederehe G. Depression and memory impairment: A meta-analysis of the association, its pattern, and specificity. Psychological Bulletin. 1995;117(2):285-305. https://doi.org/10.1037/0033-2909.117.2.285
29. Airaksinen E, Larsson M, Forsell Y. Neuropsychological functions in anxiety disorders in population-based samples: Evidence of episodic memory dysfunction. Journal of Psychiatric Research. 2005;39(2):207-214. https://doi.org/10.1016/j.jpsychires.2004.06.001Getrights and content