



Original Article

Gender-Specific Relationship Between Executive Function and Self-Rated Health

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ABSTRACT

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Objectives: Self-rated health is a comprehensive measure of health. As gender difference in self-rated health is found, identifying gender-specific factors related to self-rated health is important. Poor executive functioning negatively affects an individual's independence and healthy lifestyle, but it is unknown relationships between executive function and self-rated health and gender differences in these relationships. Therefore, gender differences were examined in the relationship between executive function and self-rated health in the community.

Methods: Individuals completed questionnaires about their health status and subjective decline in executive function. Neuropsychological tests were also performed to assess objective executive functioning. Two separate multivariable linear regression analyses were conducted by gender.

Results: Better objective executive function was related to greater self-rated health scores (better self-rated health) in men alone ($\beta_s = 0.341$), while better subjective executive function was significantly associated with greater self-rated health scores in both men and women ($\beta_s = 0.385$ and 0.443 , respectively).

Conclusion: Gender differences are important when reporting perceived health status, in particular the different effects of subjective and objective executive function on self-rated health across genders. Clinicians need to be aware of the potential value of subjective executive function complaints when evaluating health status.

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Introduction

The aging society is a ubiquitous phenomenon worldwide although the aging process varies among countries [1]. Korea is one of the countries experiencing a dramatic demographic transition to decreased birth rates, and increased life expectancy. People 65 years or older, made up 12.8% of the Korean population in 2015, and the proportion of older people (≥ 65 years) is expected to reach 35.9% by 2050 [2].

In an aging society, healthy aging has emerged as a critical issue [3]. Self-rated health is a widely used, comprehensive

measure of health, capturing an individual perception of their state of well-being, beyond the absence of illness [4], and included as a component of healthy aging [5]. Self-rated health is an important predictor of health care service use, and mortality [4,6,7]. According to a meta-analysis, individuals who reported poor health were 1.92 times more likely to die compared to those who reported excellent health [6]. Self-rated health can be a proxy of future adverse health events, therefore, it is important to identify factors associated with self-rated health.

There have been studies suggesting that the relationship

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between self-rated health and mortality differs between men and women [4,8,9]. In the study where participants had follow-up for 59 years, self-rated health was lower in women than men up to 80 years of age, after which those differences disappeared [10]. These observations showed the importance of taking gender into account when investigating self-rated health. Thus, it is important to identify factors that are involved in the differences between men and women in self-rated health.

Maintenance of a good health status can be a significant challenge as people get older. This can be related to the decline in cognitive function, especially executive function where numerous self-regulatory processes require the ability to appropriately plan, initiate, sequence, and monitor complex tasks in daily activities [11]. Even a mild decline in executive function can negatively affect an individual's capacity to perform health-promoting behaviors, and maintain independence in daily life in individuals living without dementia [12,13], which may contribute to poor perceived health. Although executive function appears to be related to health status, there are few studies investigating the relationship between executive function and health status considering gender differences. Therefore, the purpose of this study was to examine whether executive function was associated with self-rated health in individuals in the community in Korea, and whether there are gender differences in the relationship between executive function and self-rated health.

Materials and Methods

1. Study design, participants, and setting

A cross-sectional study was conducted among individuals living without dementia recruited from community centers in Korea for 12 months from 2015 to 2016 (IRB no.: 2-1046881-A-N-01-201505-HR-021). Inclusion criteria were adults who were older than 20 years, lived independently, and were Korean-speaking. Exclusion criteria were having life-threatening conditions (e.g., renal failure, heart failure, and active cancer treatment), self-reported history of neurological and psychological conditions which lead to cognitive dysfunctions (e.g., stroke, dementia, mental retardation), or hearing or visual impairment that interferes with performing neuropsychological testing.

2. Ethical considerations and data collection

The conduct of this study was approved by the Institutional Review Boards at the researchers' affiliated university. This study conforms to the principles of the Declaration of Helsinki.

Eligible individuals were approached by trained research assistants in community centers, or were self-referred (via posted flyers). Participants gave signed written informed consent to participate in the study after research assistants had given a detailed explanation about the study. Neuropsychological tests to measure executive function were conducted by research assistants who had been trained by experts. Questionnaires were then administered to obtain data regarding health status, perceived effectiveness of executive functioning (i.e., subjective executive functioning), depressive symptoms, healthy behaviors, and sociodemographic information.

3. Measures

3.1. Self-rated health assessment

Self-rated health was assessed using a Visual Analogue Scale (VAS) from the EuroQol [14]. Participants were asked to rate their current general health on the VAS, providing scores ranging from 0 (worst imaginable health status) to 100 (best imaginable health status).

3.2. Executive function

Performance on executive function (i.e., objective executive function) was measured using parts of neuropsychological tests [the Stroop Color/Word Interference Test (Stroop), the Trail Making Test Part B (Trails B)]. Perceived effectiveness in performing tasks supported by executive function (i.e., subjective executive function) was assessed using the Attentional Function Index (AFI) [15]. The Stroop and Trails B are the most commonly used tests to assess executive function [11,16].

To conduct the Stroop test, participants were shown the names of colors printed in different colored ink (e.g., the word "red" printed in blue ink), and asked to name the color of the ink as fast, and accurately as possible within 120 seconds [17]. The number of correct answers within the given time was counted. Trails B was administered by asking participants to connect numbers and letters in alternating orders, as quickly and accurately as possible [17]. When an error was made, the participants had to return to the number or letter where the error originated before continuing. The amount of time taken to complete the task was recorded.

Subjective executive function was measured using the AFI test [15] which consists of 13 items assessing perceived capacity to perform daily activities, supported by higher-level cognitive functions (e.g., planning and carry out activities). Each item is rated from 0 (not at all) to 10 (extremely well or a great deal) on a numeric rating scale. An average of the 13 items yields a total score, with higher scores indicating better executive functioning.

3.3. Depressive symptoms

To assess depressive symptoms the 9-item Patient Health Questionnaire (PHQ-9) was used [18,19]. The PHQ-9 consists of 9 items which correspond with the 9 diagnostic criteria for depressive disorder in the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition. Each item is rated with a 4-point scale from 0 (not at all) to 3 (nearly every day). Total scores can range from 0 to 27, with higher scores indicating higher levels of depressive symptoms. A PHQ-9 score of 5 or greater was interpreted as presence of depressive symptoms [19].

3.4. Healthy lifestyle

Data on smoking, alcohol consumption, and physical activity were collected by self-report assessments from items used in the Korean National Health and Nutrition Examination Survey [20]. Individuals who currently smoked were defined as such [21]. Participants who consumed at least 1 glass of alcohol every month over the last year were categorized as an "alcohol drinker" [21]. Participants were asked the number of days per week that they engaged in moderate levels of physical activity (e.g., walking very brisk) for ≥ 30 minutes [21].

3.5. Sociodemographic information

Data on sociodemographic information (e.g., age, gender, education level) were collected by self-report. Participants were asked to assign a category their financial status (as not enough to make ends meet to sufficient to make ends meet).

4. Statistical analysis

To form a composite score of objective executive function, raw scores on the Stroop and Trails B tests were transformed to Z-scores (means of 0 and SD of 1) by using the mean and standard deviation of all participants. Transformed scores of the 2 tests were subtracted from the Stroop to Trails B, and divided by 2 to yield the composite score of objective executive function. Greater composite scores indicated a better performance on executive function tasks because a better performance was represented by a greater Stroop score and lower Trails B score.

Chi-square test or independent *t* test was used to compare the characteristics between men and women. Separate multivariable linear regression models were constructed for total sample, men, and women, to determine whether executive function (composite scores of objective executive function and AFI scores) predicted self-rated health status, after controlling for relevant covariates (i.e., age, living arrangement, education, smoking, alcohol consumption, physical activity, and depressive symptoms). The significance level was set at $p < 0.05$. The data were analyzed using IBM SPSS 22.0 (IBM Corp., Armonk, NY, USA).

Results

1. Sample characteristics

The average age of the total sample was 64 years, ranging from 22 to 89 years. Of the 204 participants, the majority lived with someone, had less than high school level of education, and were unemployed (Table 1). Fewer than half of the participants currently smoked, and consumed alcohol more than once per month over the last year. Total scores of depressive symptoms were below 5, indicating no depressive symptoms.

Of the 204 participants, 53.9% were male. Compared with men, women were more likely to be younger, non-smokers, and consumed less alcohol [less than once per month (Table 1)]. There was a greater proportion of women who had above high school level of education, and perceived to earn enough income to make ends meet compared to men.

2. Self-rated health and executive function assessments

The average score of self-rated health was 72.8 (SD 17.1) from 0 (worst imaginable health status) to 100 (best imaginable health status) on the VAS scale (Table 2). Women's scores (76.7 ± 16.2) indicated that they had better health than men (69.5 ± 17.3 ; $p < 0.05$).

Composite scores of objective executive function were higher in women (0.4 ± 0.8), than men (-0.2 ± 0.9 ; $p < 0.05$). Compared with the raw scores for the Stroop and Trails B tests in men, women had greater scores on the Stroop test, and lower scores on the Trails B test, indicating better performances in both tests in women than men ($p < 0.05$). There was no significant difference in scores for the AFI, which measured subjective executive function.

3. Relationship between self-rated health and executive function

Results of linear regression analyses are presented in Tables 3 and 4. Self-rated health was predicted by the composite scores for objective executive function and AFI scores (standardized β s = 0.341 and 0.385, respectively; both $p < 0.05$) in the regression model using the total sample (Table 3). This relationship remained significant after adjusting for socio-demographic information, healthy behaviors, and depressive symptoms. Participants who were current smokers and had depressive symptoms were significantly associated with poor self-rated health scores (standardized β s = -0.130 and -0.217, respectively; both $p < 0.05$).

In the regression models (Table 4), both the composite scores of objective executive function and AFI scores predicted the level of self-rated health in men (standardized β s = 0.341 and 0.385, respectively; both $p < 0.05$). However, scores for AFI (standardized β = 0.443, $p < 0.05$), but not the composite of

Table 1. Sample characteristics.

	Total (N = 204)	Males (n = 110)	Females (n = 94)	p
Age (y)	64 ± 11.2	68 ± 10.3	59 ± 10.2	< 0.001
Living alone	29 (14.2)	18 (16.4)	11 (11.7)	0.342
Education level				< 0.001
≤ High school	141 (69.1)	91 (82.7)	50 (53.2)	
> High school	63 (30.9)	19 (17.3)	44 (46.8)	
Perceived level of financial status (n = 165)				0.042
Not enough	68 (41.2)	51 (46.8)	17 (30.4)	
Just about to sufficient to make ends meet	97 (58.8)	58 (53.2)	39 (69.6)	
Employed	86 (42.2)	46 (41.8)	40 (42.6)	0.916
Currently smoking	23 (11.3)	21 (19.1)	2 (2.1)	< 0.001
Alcohol consumption				0.003
≤ 1/mo	107 (52.5)	47 (42.7)	60 (63.8)	
> 1/mo	97 (47.5)	63 (57.3)	34 (36.2)	
Moderate levels of physical activity (d/wk)	2.1 ± 2.3	2.0 ± 2.4	2.1 ± 2.2	0.855
Depressive symptoms	4.2 ± 4.4	4.5 ± 4.3	3.8 ± 4.5	0.254

Data are presented as mean ± SD or n (%).

Table 2. Self-reported health and objective and subjective executive function.

	Total (N = 204)	Males (n = 110)	Females (n = 94)	p
Self-rated health score	72.8 (17.1)	69.5 (17.3)	76.7 (16.2)	0.002
Composite of objective executive function	0.1 (0.9)	-0.2 (0.9)	0.4 (0.8)	< 0.001
No. of correct responses to the Stroop Color/Word Interference test	85.8 (26.5)	75.2 (27.3)	98.3 (19.0)	< 0.001
Total time to complete Trail Making test, Part B, (s)	140.1 (112.7)	161.5 (111.0)	115.1 (110.1)	0.003
Attention-Function Index score	6.9 (1.2)	6.7 (1.3)	7.0 (1.2)	0.051

Data are presented as mean (SD).

Composite of objective executive function was the subtraction of Z-scores of the Stroop Color/Word Interference Test and Trail Making Test Part B, and divided by two. Higher scores indicate better performance.

objective executive function, predicted the level of self-rated health in women. After adjusting for covariates, composite scores of objective executive function and AFI remained significantly related to self-rated health in men (standardized β s = 0.291 and 0.254, respectively; both $p < 0.05$), whilst only AFI scores (standardized $\beta = 0.373$, $p < 0.05$) were related to self-rated health in women. Among the covariates included in the models, scores of depressive symptoms predicted self-rated health in both males and females (standardized β s = -0.268 and -0.224, respectively; both $p < 0.05$).

Discussion

In this cross-sectional study of individuals recruited from communities in Korea, executive function was observed to be associated with self-rated health. Objectively measured executive function was related to self-rated health in men, whilst subjective executive function was associated with self-rated health in both men and women. This observation may shed light on the gender differences associated with perception of health, and the potential value of subjective cognitive function for individuals to evaluate their health status for both men and women.

Table 3. Multivariable linear regressions to predict self-rated health using the total sample ($N = 204$).

	Step 1			Step 2		
	Standardized β	95% Confidence Interval	p	Standardized β	95% Confidence Interval	p
Composite of Executive Function	0.308	3.662, 8.348	< 0.001	0.242	1.629, 7.787	0.003
Attention-Function Index	0.385	3.654, 6.974	< 0.001	0.322	2.760, 6.142	< 0.001
Age (y)				-0.019	-0.305, 0.247	0.835
Living alone				0.021	-5.065, 7.077	0.744
> High school education				0.029	-4.546, 6.657	0.711
Currently smoking				-0.130	-13.692, -0.385	0.038
Alcohol consumption > 1/mo				0.041	-2.696, 5.535	0.497
Moderate levels of physical activity				0.008	-0.852, 0.966	0.902
Depressive symptoms				-0.217	-1.334, -0.347	0.001
Model adjusted R^2 , p	0.247 ($p < 0.001$)			0.290 ($p < 0.001$)		

Note. Composite of objective executive function was the subtraction of Z-scores of the Stroop Color/Word Interference Test and Trail Making Test Part B, and divided by two. Higher scores indicate better performance.
CI = confidence interval.

Table 4. Multivariable linear regressions to predict self-rated health by gender.

	Males ($n = 110$)				Females ($n = 94$)			
	Step 1		Step 2		Step 1		Step 2	
	Standardized β	95% CI	Standardized β	95% CI	Standardized β	95% CI	Standardized β	95% CI
Composite of Executive Function	0.341	2.374, 6.805†	0.291	2.044, 9.441*	0.115	-1.495, 6.434	0.140	-3.031, 9.048
Attention-Function Index	0.385	4.345, 10.839†	0.254	1.165, 5.666*	0.443	3.562, 8.686†	0.373	2.381, 7.927†
Age (y)			-0.079	-0.498, 0.232			0.075	-0.366, 0.603
Living alone			-0.058	-10.519, 5.122			0.057	-8.448, 14.141
> High school education			0.015	-7.676, 9.029			0.048	-6.508, 9.604
Currently smoking			-0.139	-14.376, 0.883			-0.007	-22.717, 21.111
Alcohol consumption > 1/mo			-0.132	-13.923, 1.728			0.024	-5.599, 7.186
Moderate levels of physical activity			0.110	-0.395, 1.992			-0.135	-2.505, 0.471
Depressive symptoms			-0.268	-1.792, -0.359*			-0.224	-1.583, -0.017*
Model adjusted R^2 , p	0.249 ($p < 0.001$)		0.334 ($p < 0.001$)		0.192 ($p < 0.001$)		0.182 ($p = 0.002$)	

Note. Composite of objective executive function was the subtraction of Z-scores of the Stroop Color/Word Interference Test and Trail Making Test Part B, and divided by two. Higher scores indicate better performance.

CI = confidence interval.
* = $p < 0.05$; † = $p < 0.001$.

Executive function accounted for large variances in self-rated health (24.7%). Changes in variances of self-rated health accounted for by executive function, with and without other factors related to self-rated health (e.g., age, healthy habits) were small (4.3%) in this study. This result suggested that a decrease in executive function would be a sensitive indicator that may be used to detect the deterioration in health status of individuals who reside in the community. Executive function is the mental ability required to perform basic and instrumental activities of daily living and pursue health-promoting behaviors [12,13]. Previous studies show that executive dysfunction predicts functional decline and mortality in adults without cognitive impairments, such as dementia [12,22]. Although we did not measure the functional status of our sample group, it is possible to infer that the negative impact of poor executive function on perception of health, may occur through an increase in functional dependency that is linked with reduced executive functioning.

In this study subjective executive function was consistently associated with self-rated health in men and women. However, objective executive function was associated with self-rated health in men. This finding may indicate that both performance on executive function tests and subjective perception of executive functioning are important factors for men to evaluate their health status, whilst subjective perception is more important for women compared to objective performance. Although this finding shows gender differences in cognitive factors that are related to perception of health status, this finding is insufficient to explain how gender affects the relationship between executive function and health status. Future research is needed to further investigate this aspect.

It is interesting that subjective executive function was associated with the perception of health in both men and women. Why does subjective cognitive function appear to be more sensitive compared with objective function in predicting self-rated health? It is worth mentioning that in the preclinical stage of Alzheimer's disease, there is evidence of biomarkers for Alzheimer's disease (e.g., amyloid β) and subjective cognitive decline, but there is no cognitive impairment observed in neuropsychological tests [23]. Maybe very subtle changes in cognitive decline could be captured more efficiently with self-reporting of cognitive decline, rather than reduced performance on neuropsychological tests [24]. Jessen and colleagues observed that self-experienced cognitive decline with normal performance on neuropsychological tests, was associated with pathological changes of brain and increased risk of mild cognitive impairment and Alzheimer's disease [25].

In our study individuals who were diagnosed with mild cognitive impairment and Alzheimer's disease were excluded. Because moderate to severe levels of impaired performance on cognitive tests (which is not a part of the normal aging process)

were not an expected observation, subjective cognitive function would be a more relevant predictor of self-rated health than objective cognitive function in our sample.

Similarly, in the study by Song and colleagues [26], subjective cognitive function, but not objective cognitive function, was related to daily functioning in patients receiving dialysis who did not have cognitive impairment. It is worth considering that the assessment of perceived executive function can be a useful tool to predict health status in both males and females in the community. Thus, the effectiveness of self-reporting for executive function should be considered in conjunction with neuropsychological tests (which are the gold standard to assess performance on executive function), to identify individuals who may have difficulties in maintaining a good health status due to mild changes in executive function.

In this study women perceived themselves to have a better health compared with men, which is different from previous findings [10,27-29]. This conflict may be related to gender difference in age, education, and health behaviors (e.g., alcohol consumption and smoking) which are factors that are commonly reported to be significantly associated with self-reported health in previous studies [27,29,30].

This study is a cross-sectional design, where the relationship between executive function and self-rated health should be interpreted cautiously. Because we relied on participants self-reported diagnosis of mild cognitive impairment, or Alzheimer's disease, it is possible that there may be participants with mild cognitive impairment that have not yet been recognized or diagnosed. Regardless of these limitations, to our knowledge, this may be the first study to identify the role of executive function in an individual's perception of health, and effects of objective and subjective executive function on health status by gender.

Conclusion

Self-rated health may enable prediction of future health status, and may contribute to healthy aging. Executive function was observed in this study to be an important factor influencing self-reported health. This result suggests that clinicians should pay attention to self-reported decline in executive function (e.g., difficulty making decision and performing healthy lifestyle), which could be an indicator of a decline in health. Gender differences in subjective reporting of executive function decline was related to self-rated health in both men and women, while performance of objective executive function testing was only related to self-rated health in men. This finding stresses the importance of understanding gender differences in reporting a decrease in executive function, regardless of objective executive function

performance, and the value of perceived cognitive impairment, along with objectively measured poor cognition.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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Appendix

STROBE Statement—Checklist of items that should be included in reports of cross-sectional studies

	Item No	Recommendation	Location
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Abstract
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Introduction
Objectives	3	State specific objectives, including any prespecified hypotheses	Introduction
Methods			
Study design	4	Present key elements of study design early in the paper	Methods
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Methods
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	Methods
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Methods
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Methods
Bias	9	Describe any efforts to address potential sources of bias	In limitation
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	In background
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Methods
		(b) Describe any methods used to examine subgroups and interactions	Methods
		(c) Explain how missing data were addressed	No missing data
		(d) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(e) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	N/A
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders	Results
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	

Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Results N/A N/A
Other analyses	17	Report other analyses done e.g. analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	Discussion
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Discussion
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	
Generalisability	21	Discuss the generalisability (external validity) of the study results	Discussion
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Acknowledgement

*Give information separately for exposed and unexposed groups.

N/A = not applicable.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.