RESEARCH ARTICLE

CYPRUS JOURNAL OF MEDICAL SCIENCES

DOI: 10.4274/cjms.2024.2024-3
Cyprus J Med Sci 2025;10(1):51-57

Association Between Handgrip Strength and Fatigability and Cognitive Performance in Adults Aged 65 and Older

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Abstract

BACKGROUND/AIMS: To explore the relationship between handgrip strength, fatigability, and cognitive function in older adults.

MATERIALS AND METHODS: This cross-sectional study included 89 adults aged 65-85 who were receiving services from a physical therapy and rehabilitation center. Handgrip strength and fatigability were assessed using the Biopac Student Laboratory, and cognitive function was evaluated using the Standardized Mini-Mental State Examination (SMMSE).

RESULTS: Handgrip strength was moderately correlated with cognitive function. There was no relationship between handgrip fatigability and cognitive function. The regression analysis indicated that an increase in grip strength would lead to a 0.59-point increase in the SMMSE score. It can be stated that the average SMMSE score of an individual with a secondary school education is 2.28, high school graduate is 2.94, and university graduate is 3.45 points higher than an individual with only a primary school education. These increases were found to be statistically significant.

CONCLUSION: Our findings indicate that the decline in cognitive functions associated with aging should be considered alongside motor functions like muscle strength, and various individual factors.

Keywords: Handgrip strength, fatigability, cognitive function, older age

INTRODUCTION

Age-related deteriorations in the central nervous and peripheral musculoskeletal systems in elderly individuals cause a decrease in motor and cognitive abilities; accordingly, weak muscle function constitutes a risk factor for poor senescence.[1,2]

Grip strength, a measure of body function, is predicted as a biological marker of aging and has been widely researched as an indicator of a person's current state and as a predictor of their future states.[3] Studies have shown that general health status is associated with weak grip strength, which is associated with morbidity, functional disability, and early mortality. In addition, weak grip strength was shown to be a stronger parameter of mortality than systolic blood pressure.[4-7]

The study also examined the increase in fatigue with age. Muscle motor fatigue is defined as a reduction in muscle power production.[8] Various factors can contribute to muscle fatigue, including the accumulation of metabolites in muscle fibers and inadequate motor command generation in the motor cortex.[8] Individual factors such as sex, age, body mass index (BMI), pain levels, overall health, active muscle groups, and task-specific characteristics (static or dynamic) influence fatigue and related performance declines in adults.[8]

Age-related functional decline may occur in motor function as well as in cognitive, motor, social, and psychological functions.[9] Elderly individuals often exhibit increased anxiety, poor memory and attention, slow processing speed, decreased motor ability and learning capacity, and variable behavioral changes.[9,10] It is known that there is a decrease

To cite this article: Gürsoy Karaman N, Koç E. Association between handgrip strength and fatigability and cognitive performance in adults aged 65 and older. Cyprus J Med Sci. 2025;10(1):51-57

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Received: 29.01.2024
Accepted: 25.11.2024
Publication Date: 14.03.2025

in neural behavioral functionality due to aging in individuals, and this effect is particularly evident in adults aged 65 years and over.[11]

Cognitive function plays a key role in motor skills. Studies have shown a strong relationship between decreased motor cognitive control and motor performance.[12] However, the association between low grip strength and regressed cognitive function remains unclear.[4] Cognitive demand for motor tasks, such as manual dexterity, increases with age. While these abilities are supported by the musculoskeletal and nervous systems, they also play a decisive role in grip strength.[5]

Age-related studies have shown that individuals experience both motor and cognitive decline. In some studies, the relationship between grip strength and cognitive function in elderly individuals has been investigated.[5,13] In our study, in addition to grip strength and cognitive functions, the relatively less evaluated fatigue during grip strength was also evaluated, and the relationship between motor and cognitive findings was investigated.

MATERIALS AND METHODS

This research is cross-sectional and was carried out in accordance with the Declaration of Helsinki. Ethics Committee approval was received from Dr. Burhan Nalbantoğlu State Hospital Scientific Research and Publication Ethics Committee (approval number: YTK. 1.01, date: 06.01.2021). The study was performed in accordance with the Good Clinical Practice guidelines.

Data Collection

The study population consisted of individuals between the ages of 65 and 85 who received health care services from the Department of Physical Therapy and Rehabilitation, Dr. Burhan Nalbantoğlu State Hospital, Nicosia, North Cyprus. The study was conducted with the participation of 89 volunteers who applied to the department between April and June 2021 and did not have any orthopedic or neuromuscular problems affecting upper extremity function.

All participants were informed about the study, and an informed consent form was signed by each participant who agreed to participate prior to being included in the study. The physical and sociodemographic characteristics of the participants were recorded by mutual interview. In the study, grip strength and fatigability were measured using the Bio-Pac handgrip dynamometer and "Student Lab" software. The validity and reliability of the data collection tool have been demonstrated in other studies.[14,15]

The participants were positioned with their shoulders in the adduction neutral position, elbows at 90º flexion, forearms in the neutral position, and wrists in 0º to 30º extension, and were instructed to grip the dynamometer. Initially, a trial test was conducted, and the test was randomized. Subsequently, the patient was instructed to squeeze the dynamometer with maximum force upon command. Each measurement was repeated three times with a 30 s rest interval between each measurement. The maximum voluntary contraction exerted by the participant was used in the data analysis.

In this study, motor fatigue was measured by calculating the Fatigability index. The BioPac "Student Lab" measurement device was used for the measurements. During the measurement, the electrodes were placed as follows: negative electrode on the medial side of the proximal forearm, positive electrode on the lateral side of the distal forearm, and ground electrode on the medial side of the distal forearm.

The measurement was performed in the grip strength measurement position. Accordingly, the participants were positioned with their shoulders in the adduction neutral position, elbows at 90º flexion, forearms in the neutral position, and wrists in 0º to 30º extension, and were instructed to grip the dynamometer. Participants were asked to squeeze the dynamometer with maximum force and to maintain contraction for 30 s. When the maximum voluntary contraction time reached 30 s, the participant was prompted to end the contraction. The Fatigability index was calculated using the equation shown below (Figure 1):

$$\text{fatigability index} = 1 - \frac{\text{real area}}{\text{maximal voluntary contraction*time}} * 100\%$$

(Lou[15], 2012).

In this equation, the region referred to as the actual area represents the area under the curve during the period during which the participant can maintain maximum contraction. The Fatigability index can be calculated by subtracting from one the result obtained by dividing the real area by the product of maximum voluntary contraction and time and then taking the percentage. An increased Fatigability index indicates increased physical fatigue. The measurement was repeated for both hands.

Cognitive function was evaluated with the "Standardized Mini Mental State Examination", the validity and reliability of which has been proven in the diagnosis of mild dementia in the Turkish population.[16] The test comprises five main sections: orientation, registration, attention and calculation, recall, and language. The test is evaluated from a total of 30 points. Conducting tests according to standardized test manuals can increase consistency among administrators.

Statistical Analysis

The research data were analyzed with SPSS version 21.0 for Windows. Whether grip strength, fatigue, and cognitive function differ in terms of individual characteristics was tested using the t-test, one-way ANOVA when the assumptions of normal distribution were met, and Wilcoxon

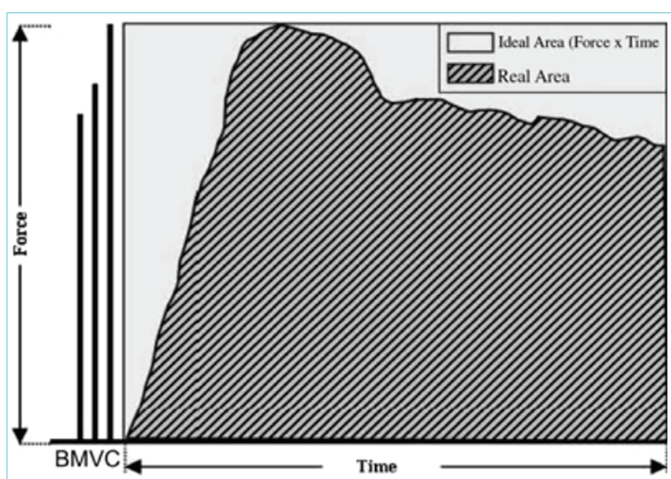

Figure 1. Fatigability index.

test, Mann-Whitney U test and Kruskal-Wallis test when the assumptions were not met, and the results were reported.

The relationship between grip strength, grip fatigue, and cognitive function was investigated using Pearson's correlation analysis. Regression analysis was performed using the independent variables of grip strength, fatigue, and individual characteristics, which are thought to explain the change in cognitive function, the dependent variable. The statistical significance level was set as $p<0.05$ in the study.

RESULTS

The average age of the participants was 72.25±5.05 and their average BMI was 28.53±4.27 (Table 1).

Eighty-three participants were right-handed, while 6 were left-handed. The Wilcoxon test revealed no statistically significant difference in grip strength between the dominant and non-dominant hands ($Z=-0.897$; $p>0.05$). Consequently, the grip strength of the dominant hand was used in the analysis.

Intergroup comparison methods were used to evaluate whether the mini-mental test showing the level of cognitive function and its sub-headings differed according to individual characteristics. The level of cognitive function represented by the SMMSE differed according to gender, education, and employment status. In the analysis, which evaluated sub-headings in terms of individual characteristics, it was determined that the orientation subheading differed in terms of gender and age, while the attention calculation sub-heading differed in terms of gender, education, and employment status. The language sub-heading differed only in terms of education status. On the other hand, the subheading recall and registration did not show a statistically significant difference in terms of any characteristics (Table 2).

Table 1. Descriptive characteristics of the participants

Variables		
Gender	**n**	**%**
Female	43	48.30
Male	46	51.70
Age		
Youngest old (65-74 years)	59	66.30
Middle old (75-84 years)	28	31.50
Oldest old (≥85 years)	2	2.20
BMI		
Normal (<25)	16	18.00
Overweight (25< BMI <30)	47	52.80
Obese (>30)	26	29.20
Martial status		
Single	15	16.90
Married	73	83.10
Education status		
Primary school	37	41.60
Secondary school	7	7.90
High school	22	24.70
University	23	25.80
Employment status		
Never worked	20	22.50
Retired	67	75.30
Working	2	2.20
Total participants	**89**	**100.00**

BMI: Body mass index.

The grip strength assessment between the groups revealed a statistically significant difference in handgrip strength according to gender and employment status. In contrast, grip strength did not differ significantly according to age, BMI, and educational status (Table 3).

The association between the mini-mental test and its subcomponents, which assess grip strength and cognitive function, was examined through correlation analysis. This analysis revealed a statistically significant but moderate correlation between the overall SMMSE score and grip strength ($r=0.31$; $p<0.01$). Additionally, a statistically significant moderate correlation was observed between grip strength and attention and calculation subtest ($r=0.34$; $p<0.01$). No statistically significant correlations were observed between grip strength and the other sub-components (Table 4).

There was no statistically significant relationship between Fatigability index values and general scores or SMMSE subheadings.

The SMMSE score used to evaluate cognitive function was included in the regression equation as a dependent variable. The analysis, in which all independent variables were included, showed that the regression model established with the dominant handgrip strength and education variable, which had statistically significant coefficients, was all significant. Examination of the corrected R^2 value showed that only 37% of the variance in the mental test was explained by the variables of grip strength and education. The grip strength coefficient was observed to be statistically significant, and a unit change in grip strength resulted in an increase of 0.59 points in the mini-mental test score.

From the model, it can be stated that the average SMMSE score of an individual with a secondary school education is 2.28, that of a high school graduate is 2.94, and that of a university graduate is 3.45 points higher than that of an individual with only a primary school education. These increases are found to be statistically significant which is a categorical variable, with primary school graduation as the reference category.

DISCUSSION

Age-related deterioration is known to occur in the central nervous and musculoskeletal systems.[1] Age-related neurological decline has cognitive and non-cognitive consequences.[17] Although decreases in muscle strength in aging adults are attributed to physiological changes in the muscular system, previous studies have shown that it is a product of decreased nervous system functioning.[17] Grip strength is an easy-to-use, inexpensive, and applicable screening tool for evaluating age-related muscle weakness.[4] The main purpose of this study was to evaluate the relationship between cognitive functionality and non-cognitive parameters such as handgrip strength and fatigue due to aging.

The decline in cognitive function in elderly individuals leads to decreased individual independence and dementia, affects public health, and imposes a serious economic burden.[18] A considerable number of studies have shown the correlation of handgrip strength with cognitive

Table 2. Individual characteristics and cognitive functioning parameters

Variables		Orientation				Registration				Attention and calculation				Recall				Language				SMMSE			
Gender	**n**	**Min.**	**Max.**	**Med.**	**Z**	**Min.**	**Max.**	**Med.**	**Z**	**Min.**	**Max.**	**Med.**	**Z**	**Min.**	**Max.**	**Med.**	**Z**	**Min.**	**Max.**	**Med.**	**Z**	**Min.**	**Max.**	**Med.**	**Z**
Female	43	9	10	10	**-1.034**	3	3	3	-0.967	9	10	10	**-4.013****	0	3	2	-1,298	5	9	8	-1.523	19	30	23	-3.184*
Male	46	10	10	10		1	3	3		10	10	10		0	3	2		7	9	8		19	30	26	
Age		**Min.**	**Max.**	**Med.**	**KW-H[1]**	**Min.**	**Max.**	**Med.**	**KW-H**	**Min.**	**Max.**	**Med.**	**KW-H**	**Min.**	**Max.**	**Med.**	**KW-H**	**Min.**	**Max.**	**Med.**	**KW-H**	**Min.**	**Max.**	**Med.**	**KW-H**
Younger old (65-74 years)	59	10	10	10	**43,500****	3	3	3	2,179	10	10	10	0.938	0	3	1.50	1,631	10	10	10	0.248	19	30	24	0.256
Middle old (75-84 years)	28	10	10	10		1	3	3		10	10	10		0	3	1.50		10	10	10		19	30	24	
Oldest old (≥85 years)	2	9	10	10		3	3	3		9	10	10		1	2	1.50		9	10	10		21	22	21.50	
BMI																									
Normal	16	10	10	10	0.504	1	3	3	2,938	10	10	10	0.933	0	3	1	2,938	6	9	8	0.933	19	28	25	2.938
Overweight	47	10	10	10		3	3	3		10	10	10		0	3	2		5	9	8		19	30	25	
Obese	26	9	10	10		3	3	3		9	10	10		0	3	2		6	9	8		21	30	24	
Edu. status																									
Primary school	37	10	10	10	0.704	3	3	3	0.704	0	5	1	**22,958****	0	3	2	2,955	5	9	7	**25,835****	19	29	23	**31,746****
Secondary school	7	10	10	10		3	3	3		0	5	1		1	3	2		7	9	8		23	29	24	
High School	22	10	10	10		3	3	3		0	5	5		0	3	2		7	9	8		22	30	25.50	
University	23	10	10	10		3	3	3		1	5	5		0	3	2		6	9	9		23	30	27	
Emp. status																									
Never worked	20	9	10	10	3,450	3	3	3	0.328	0	5	0	**24,165****	0	3	2	1,371	5	9	7.50	4,694	19	29	23	**15,819****
Retired	67	10	10	10		3	3	3		0	5	4		0	3	2		6	9	8		19	30	25	
Working	2	10	10	10		3	3	3		5	5	5		2	2	2		8	9	8.50		28	29	28.50	
Total	**89**																								

KW-H[1]: Kruskas-Wallis H test statistic. *p<0.05, **p<0.0, BMI: Body mass index, Min.: Minimum, Max.: Maximum, Med.: Median, SMMSE: Standardized Mini-Mental State Examination, Edu.: Educational, Emp.: Employment.

functions and health conditions that pose a risk of cognitive decline in middle-aged and older adults.[4] While some studies are cross-sectional in nature, there are also significant longitudinal studies.[17,19-21] Our study initially focused on the evaluation of the correlation between grip strength and SMMSE over the total score, while its correlation with the sub-titles of SMMSE was evaluated later. According to the results obtained, there is a moderate positive correlation between grip strength and SMMSE total score. While there was a moderate positive correlation between attention, calculation, and grip strength between grip strength and SMMSE sub-headings; no significant correlation was found between orientation, recall, memory, and language and grip strength. In a cross-sectional pilot study conducted by Klawitter et al.[19] in 2020, the relationship between different grip strength measurements and cognitive function in elderly individuals was evaluated. It was stated that elderly individuals with cognitive impairment had weaker grip strength measurements, but no statistically significant differences were observed between these measurements and cognitive functions. Shaughnessy et al.[4] conducted a systematic literature review on this topic in 2020. In a cross-sectional study included in this review, 70 elderly individuals with a mean age of 70±4.7 years participated in the study, and a significant relationship was found between grip strength and cognitive function.[20] In another study, the relationship between grip strength and cognitive function in elderly Americans was investigated longitudinally.[17] According to this study, the relationship between decreased grip strength and decreased cognitive function was determined, and it was suggested that with each increased amount of 5 kg grip strength, cognitive dysfunction that would occur in the future would decrease by 3%. In a four-year longitudinal study that included 1,514 and 1,223 women, a 0.233 point increase in SMMSE was predicted for every 6.14 kg grip strength increase in men, while a 0.197 SMMSE score increase was predicted for every 4.12 kg grip strength increase in women.[22] In their study, Alfaro-Acha et al.[23] monitored 2,160 elderly Mexican Americans for 7 years and concluded that the SMMSE scores of individuals in the lowest grip strength range showed a decline of 1.28 within 7 years. In a prospective cohort study by Turusheva et al.[21], unlike other studies, no relationship was found between grip strength and cognitive function in elderly individuals.

Decreased attention, memory, and processing speed are observed in older individuals. It is known that behavioral selection, particularly a more active lifestyle, reduces the negative effects of aging on motor and cognitive decline.[9] In our study, it was determined that according to employment status, attention and calculation, which are the sub-title of the SMMSE, differantiated. From this perspective, the ways in which the cognitive functions of elderly individuals with active working life are affected should be investigated in more detail. Furthermore, according to the results of the study, attention and calculation subheading differ in terms of education level. During the aging process within the life cycle, changes occur in individuals' functional capacity. These functional changes depend on individuals' personal genetic differences, lifestyles, motivations, sociocultural backgrounds, exercise, and learning experiences.[9] In light of this information, it is believed that these distinct characteristics of individuals with active working life and advanced education have a positive reflection on cognitive function. In this study, in addition to education and employment status, attention and calculation subheadings of the SMMSE differ according to gender. Gender can affect dementia risk and cognitive function.[17] Again, in the study of McGrath et al.[17], while evaluating the relationship between grip strength and cognitive functions, gender differences were noted. At this point, health care providers should consider the role of gender when examining the relationship between grip strength and cognitive function.

The decrease in strength with aging causes instability during muscle contractions. This instability is also associated with fatigue.[19] The Fatigability index and the relationship between statically evaluated results and SMMSE scores were investigated. According to the results obtained, no correlation was found between the Fatigue index and cognitive function. While evaluating the relationship between grip strength and cognitive function in elderly individuals, the hand grip strength was evaluated under various conditions, and its relationship with fatigue was investigated. As a result of this study, no correlation was found between hand fatigability and SMMSE scores, which evaluate cognitive functions. Although the fatigability of the hand is frequently evaluated in the literature, studies evaluating its correlation with cognitive functions are limited.

In this study, grip strength, fatigue level, and cognitive function were analyzed using a multiple regression model. Accordingly, approximately only the 37% of the variance in the mental test can be explained by the dominant handgrip strength and education level variables. The length of formal education years completed by an individual is positively associated with cognitive function throughout adulthood and is predicted to reduce the risk of dementia later in life.[24] The observations obtained as a result of multiple cohort studies and meta-analyses have led to the suggestion that prolonging education may affect cognitive ability and reduce aging-related declines in cognitive functions.[24] The results obtained in the regression model of this study also support these propositions. In addition to these, although the relationship between grip strength and cognitive function has been mentioned many times, it was also found in the regression model.

Our findings indicate that the decline in cognitive functions associated with aging should be considered alongside motor functions like muscle strength, and various individual factors.

In this study, we observed a relationship between grip strength and cognitive function in elderly individuals. Continuing to unravel the relationship between muscle strength, nervous and muscular system integrity, and cognitive functioning will assist in the provision of new resources for future research. In line with the novel information to be obtained, a guide should be created for healthcare professionals to maintain muscle strength and cognitive abilities in aging adults.

Table 3. Individual characteristics and handgrip strength

Variables		**Handgrip strength**			
Gender	**n**	**Min.**	**Max.**	**X̄ ± SD**	**t**
Female	43	5.78	47.92	13.68±4.38	**-7.827****
Male	46	4.22	21.44	25.53±9.23	
Age		**Min.**	**Max.**	**Med.**	**KW-H**
Youngest old	59	4.22	47.92	16.60	3,072
Middle old	28	5.78	36.46	21.39	
Oldest old	2	10.49	12.20	11.34	
BMI					
Normal (<25)	16	5.78	35.47	17.75	2,248
Overweight (25< BMI <30)	47	5.96	42.06	19.47	
Obese (>30)	26	4.22	47.92	16.22	
Education status					
Primary school	37	4.22	47.92	15.92	3,478
Secondary school	7	9.29	27.37	19.65	
High school	22	5.78	35.75	18.85	
University	23	7.60	42.06	21.44	
Employment status		**Min.**	**Max.**	**X̄ ± SD**	
Never worked	20	7.25	19.65	13.40	**12,976****
Retired	67	4.22	47.92	21.74	
Working	2	14.77	21.53	18.15	
Total	**89**				

BMI: Body mass index, Min.: Minimum, Max.: Maximum, SD: Standard deviation, Med.: Median, X̄:Mean, KW-H: Kruskas-Wallis H test.

Table 4. Correlations between dominant handgrip strength measurements and cognitive functioning parameters

		SMMSE	**Orientation**	**Registration**	**Attention and calculation**	**Recall**	**Language**
Dominant handgrip strength	r	**0.31****	0.12	-0.02	**0.34****	-0.07	0.16
	p	**0.004**	0.261	0.847	**0.001**	0.500	0.11

SMMSE: Standardized Mini-Mental State Examination.

Determining measurable indicators of cognitive impairment in healthy older adults will facilitate the early identification and potential prevention of pathological cognitive decline, such as mild cognitive impairment.

Therefore, intervention programs that aim to manage cognitive processes and contribute to an independent aging process can be created.

Study Limitations

Our study was a cross-sectional study, and as the next step, a long-term evaluation and observation of the changes that may occur in muscle strength, fatigue, and cognitive functions over time will provide us with valuable information. In this study, the relationship between cognitive function and grip strength, a physiological and measurable parameter, was investigated. Additionally, numerous studies have shown that various factors, such as the general health status of elderly individuals, genetic and environmental factors that can influence aging, and cardiometabolic diseases, also affect cognitive function. From this perspective, the causality and underlying mechanisms of the relationship between muscle strength and cognitive function require further investigation. In addition, fatigue was evaluated statically. In future studies, incorporating dynamic fatigue into the study and measuring the fatigue of elderly individuals during activities will contribute to our understanding of the problems experienced in daily life activities.

CONCLUSION

Our results show that educational attainment has a positive effect on cognitive function in the later years of life by contributing to individual differences in cognitive skills that emerge in early adulthood but continue at later ages. Therefore, the positive effect of extensive educational development on cognitive aging is a factor that should be emphasized for healthy cognitive aging and public health.

MAIN POINTS

- There is a significant relationship between the level of education, attention and computation in aged people.
- Cognitive functions due to aging are closely related to motor functions such as muscle strength.
- Educational attainment will have a positive effect on cognitive function in elderly people.

ETHICS

Ethics Committee Approval: Ethics Committee approval was received from Dr. Burhan Nalbantoğlu State Hospital Scientific Research and Publication Ethics Committee (approval number: YTK. 1.01, date: 06.01.2021).

Informed Consent: All participants were informed about the study, and an informed consent form was signed by each participant who agreed to participate prior to being included in the study.

Footnotes

Acknowledgements

This study was presented as a poster communications in the 47th National Turkish Society of Physiological Sciences Congress in Antalya, 2022.

Authorship Contributions

Concept: N.G.K., E.K., Design: N.G.K., E.K., Data Collection and/or Processing: N.G.K., Analysis and/or Interpretation: N.G.K., Literature Search: N.G.K., E.K. Writing: N.G.K., E.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study had received no financial support.

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