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Original Article

Association between handgrip strength and cognitive impairment in elderly Koreans: a population-based cross-sectional study

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Abstract. [Purpose] The purpose of this study was to investigate the association between handgrip strength and mild cognitive impairment in elderly adults. [Subjects] Study participants included 2,982 adults (1,366 males and 1,616 females), aged 65 years or older. [Methods] This population-based cross-sectional study used the baseline database from the Korean Longitudinal Study of Ageing. [Results] The odds ratio for mild cognitive impairment showed a significant linear decrease in relation to the quartile of handgrip strength, independent of potential covariates, in both men and women. Moreover, after excluding incident cases of mild cognitive impairment, the results showed that greater handgrip strength was associated with higher cognitive function scores in the elderly. [Conclusion] The findings presented here suggest that handgrip strength is associated with a risk of mild cognitive impairment in the Korean elderly. Moreover, greater handgrip strength is associated with higher cognitive function in cognitively normal elderly individuals.
Key words: Handgrip strength, Cognitive function, Elderly

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INTRODUCTION

A decline in cognitive function is observed in most elderly people. Population-based studies suggest that mild cognitive impairment (MCI), at a level below what would be diagnosed as dementia, is more prevalent (10–20%) than dementia (5–6%). Annually, 10–15% of elderly people with MCI progress to dementia, compared with 1–2% of elderly people who progress to dementia from normal cognitive function[1, 2)]. MCI is also associated with functional impairment and decreased quality of life, and is linked to early mortality[3, 4)]. Thus, it is important to identify factors that may cause cognitive impairment.

Accumulating evidence suggests that higher levels of physical function are associated with preventing the reductions in cognitive function associated with aging[4–6)]. Handgrip strength is easy and safe to evaluate in the elderly and is used as a measure of whole-body muscular strength. In addition, changes in muscle strength may represent age-related changes in biological vitality and physical function[7, 8)]. Moreover, greater handgrip strength is associated with a lower risk of cardiovascular disease, all-cause and cardiovascular mortality, and physical function and frailty[9, 10)]. Therefore, handgrip strength may be an effective index for the early detection of decreased cognitive function.

Previous studies have evaluated the association between physical function and cognitive function[4, 5, 11, 12)]. However, data on the specific relationship between muscular strength and cognitive function are limited. Additionally, to the best of the authors' knowledge, handgrip strength has not been reported as a potential predictor of MCI in the elderly Korean population. Thus, the purpose of this study was to investigate whether muscular strength, based on handgrip strength, is associated with the risk of MCI in the elderly Korean population. The association between handgrip strength and cognitive function scores in cognitively healthy elderly subjects was also investigated.

SUBJECTS AND METHODS

This cross-sectional study used the baseline database from the Korean Longitudinal Study of Ageing, a nationwide study of community-dwelling adults aged ≥45 years. A baseline survey was conducted between August and December in 2006, using the Computer Assisted Personal Interviewing method, and 10,254 participants completed the interview. In the present study, data from 4,165 participants, aged ≥65 years, were used. Participants who had missing data for handgrip strength (n=644) were excluded, as were those who had missing data for covariates (n=539). Therefore, a

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total of 2,982 participants (1,366 males and 1,616 females) were analyzed in the present study. All participants provided written informed consent, and the survey protocol was approved by the Institutional Review Board of the Statistics Korea.

Cognitive function was measured using the Korea-Mini Mental Status Evaluation (K-MMSE). The K-MMSE comprises 11 questions in five areas of cognitive function (orientation, registration, attention and calculation, memory, and language)[13, 14]. Participants were divided into normal (≥24) and MCI (<24) groups based on their total K-MMSE score. Handgrip strength was measured twice to the nearest 0.1 kg using a dynamometer, with the participant in a seated or standing position, their elbow by their side and flexed at a right angle, and their wrist in a neutral position. The average of the maximum values from the left and right hand for each participant were analyzed. To examine the effect of different levels of handgrip strength on the risk of MCI, participants were divided into quartiles of handgrip strength and separated by sex (<25.0, 25.0–<29.0, 29.0–<32.5, and ≥32.5 kg for men, and <14.5, 14.5–<17.5, 17.5–<20.0, and ≥20.0 kg for women). Age, body mass index (BMI, kg/m^2), education level, household income, occupational status, marital status, physical activity, number of chronic diseases, and activities of daily living (ADL) scores were included as potential covariates. Household income was recorded as a quartile of the overall population. Education level was classified as ≤middle school, high school, or ≥College, and alcohol consumption was categorized as never, ≤once a week, 2–3 times/week, ≥4 times/week. BMI was calculated from body weight and height, and participants were classified into two groups (normal or obese) based on Korean Obesity Society values. The total number of chronic diseases was calculated based each participant's self-reported disease history as follows: hypertension, diabetes mellitus, cardiovascular disease, cerebrovascular diseases, and cancer. The number of diseases was categorized as none, one disease, and two or more diseases.

Values are expressed as means ± standard deviation (SD) or as a percentage. All data were analyzed using SPSS (PASW Statistics 18 for Windows, IBM Inc., Chicago, IL, USA). P-values of <0.05 were considered statistically significant. Statistical significance levels for linearity in relation to levels of handgrip strength were evaluated using χ^2 tests for trends or linear regression models. Logistic regression models were used to predict the risk of MCI from the levels of handgrip strength. All logistic regression models considered the following covariates: age, education level, household income, marital status, number of chronic diseases, physical activity, and ADL score.

RESULTS

The general demographic characteristics of the participants are presented in Table 1. The mean age was 71.7±5.4 years for male participants, and 72.6±6.1 years for female participants. Overall, 27.5% of males and 57.6% of females had MCI. The prevalence of MCI was significantly higher in women than in men (p<0.001). The characteristics of participants according to the quartile of handgrip strength for each gender are shown in Table 2. For both men and women, significant differences were found in age, ADL score, physical activity, and cognitive function scores. In addition, the frequency of MCI was significantly different across level of handgrip strength in both males (p<0.001) and females (p<0.001) (Table 2).

The results of logistic regression models of handgrip strength associated with the odds ratio (OR) for MCI, for each gender, are shown in Table 3. Levels of handgrip strength were significantly and linearly correlated with a reduced risk for MCI in both males and females. Results of generalized linear models comparing cognitive function score across the quartiles of handgrip strength in the elderly without MCI are shown in Table 4. Greater handgrip strength was found to be associated with a higher K-MMSE score, even in cognitively healthy elderly subjects (p<0.001, for both males and females).

DISCUSSION

In the present study, the association between handgrip strength and the risk of MCI in an elderly Korean population was determined. The findings presented here suggest that greater muscle strength, as estimated by handgrip strength, is significantly associated with a lower risk of MCI in both males and females, independent of chronic disease, ADL score, physical activity, and other potential covariates. Moreover, after excluding incident cases of MCI, the results showed that greater handgrip strength was associated with higher cognitive function scores, as measured using the K-MMSE. These findings suggest that reduced handgrip strength may be a risk factor for declines cognitive function, even in elderly people with normal cognitive function.

In the present study, the prevalence of MCI was approximately 50–60% lower in the highest quartile of handgrip strength compared with the lowest quartile. The results presented here are consistent with previous studies showing that reduced objectively measured muscle strength and sarcopenia are associated with a risk of MCI[15–17]. For example, a community-based 3.5 year follow-up study reported that handgrip strength was linked to memory decline in the elderly[18]. In addition, another study reported that reduced handgrip strength was associated with an increased risk of Alzheimer's disease in cognitively healthy elderly individuals[6]. Several factors could explain the association between handgrip strength and the risk of MCI. Handgrip strength is often used as an indicator of whole-body muscle strength. In addition, a change in muscle strength may represent an age-related change in biological vitality and physical function[7, 8]. Moreover, a high level of skeletal muscle strength is associated with a lower risk of frailty, cardiovascular disease, and all-cause and cardiovascular mortality[9, 10]. In addition, many studies have shown that a decline in physical function and chronic disease are both associated with cognitive decline[4, 11, 16]. Overall, these studies provide a possible interpretation of the findings presented here showing an association between handgrip strength and the risk of MCI. Specifically, the decline of handgrip strength may represent an age-related change in physical function and frailty that is contributing to cognitive decline and increasing the risk

Table 1. Participant characteristics (n=2,982)

	Males (n=1,366)	Females (n=1,616)
Age (years, mean ± SD)	71.7±5.4	72.6±6.1
Age group (%)		
<75 years	73.3	66.7
≥75 years	26.7	33.3
Education (%)		
≤Middle school	64.4	92.1
High school	21.9	6.2
≥College	13.7	1.7
Household income (%)		
Low	22.0	27.3
Lower-middle	19.9	21.0
Upper-middle	32.4	27.2
High	25.6	24.6
Marital status (%)		
Married (living together)	90.5	47.6
Separated/widowed/never married	9.5	52.4
Number of disease (%)		
None	53.5	47.4
One disease	33.7	35.6
Two or more diseases	12.8	17.0
Physical activity (%)		
<150 min/week	69.0	79.6
≥150 min/week	31.0	20.4
ADL (score, mean ± SD)	0.12±0.73	0.13±0.67
K-MMSE (score, mean ± SD)	24.8±4.4	21.2±6.1
Cognitive function (%)		
Normal (K-MMSE ≥24)	72.5	42.5
MCI (K-MMSE <24)	27.5	57.6

Values are means ± SD or percentage. ADL: activities of daily living; K-MMSE: Korea-Mini Mental Status Evaluation; MCI: mild cognitive impairment

of MCI. However, the findings of the present study also show that handgrip strength is associated with the risk of MCI independent of the ADL scores. Changes in nervous system function associated with aging could explain this association[19]. Declining central nervous system function associate with age may be an important mechanism in the association of handgrip strength with cognitive function in the elderly. Specifically, a slow reaction time is associated with cognitive function in the elderly[20]. Moreover, another study, based on data from a population-based 20 year follow-up, reported that longitudinal changes in grip strength were associated with changes in cognitive ability[21]. Thus, muscle strength might be an early marker of a decrease in nervous system function associated with aging, which is reflected in cognitive function.

Previous studies have described associations between muscle function or mass and cognitive function. The current results are consistent with several recent studies in which grip strength or sarcopenia, defined as a loss of skeletal muscle mass, was associated with a risk of MCI in elderly adults. However, information about the effect of grip strength on cognitive function in the cognitively healthy elderly population is lacking. Therefore, in the current study, the mean difference in cognitive function scores measured using K-MMSE in relation levels of handgrip strength was also determined, excluding incident cases of MCI. Higher means K-MMSE scores were significantly related to greater handgrip strength. These findings suggest that reduced grip strength may contribute to the process of cognitive decline with aging, even in cognitively healthy elderly. However, further longitudinal research on this potential association is necessary.

Some limitations of the present study must be acknowledged. A major limitation was that it was not possible to infer causality the direction of the effect because of the cross-sectional design. Moreover, handgrip strength was assessed, but not physical performance or other muscle strength parameters that have been shown to predict cognitive decline[5, 11, 22]. However, the present study included a large, randomly sampled dataset that may be considered as nationally representative of Korean adults, and the analyses controlled for important potential covariates. Thus, the current findings can be generalized to the Korean population.

Handgrip strength is easy and safe to evaluate in the elder-

Table 2. Participant characteristics according to the quartile of grip strength for each gender (n=2,982)

	Handgrip strength				p-value for trend
	Q1	Q2	Q3	Q4	
Males (n=1,366)					
Age (mean ± SD)	74.4±6.0	72.2±5.2	71.0±4.9	69.4±4.0	***
ADL score (mean ± SD)	0.34±1.3	0.07±0.5	0.05±0.5	0.02±0.3	***
Chronic disease (two or more, %)	16.7	13.4	12.4	9.3	*
Physical activity (≥150 min/week, %)	19.1	27.1	35.9	40.2	***
K-MMSE (mean ± SD)	22.6±5.2	24.7±4.5	25.6±3.5	26.2±3.5	***
MCI (K-MMSE <24, %)	48.7	28.8	18.9	15.5	***
Females (n=1,616)					
Age (mean ± SD)	75.6±6.7	73.5±6.2	71.3±5.1	69.9±4.5	***
ADL score (mean ± SD)	0.23±0.87	0.16±0.78	0.07±0.52	0.04±0.30	***
Chronic disease (two or more, %)	17.9	20.1	16.2	14.4	
Physical activity (≥150 min/week, %)	12.5	21.4	22.9	24.0	***
K-MMSE (mean ± SD)	18.3±6.6	21.0±5.7	22.5±5.4	23.2±5.5	***
MCI (K-MMSE <24, %)	74.9	61.8	48.5	44.4	***

Values are means ± SD or percentage. ADL: activities of daily living; K-MMSE: Korea-Mini Mental Status Evaluation; MCI: mild cognitive impairment. *p<0.05, **p<0.01, ***p<0.001

Table 3. Multivariable OR (95% CI) for the risk of MCI in relation to handgrip strength in elderly Korean subjects (n=2,982)

Handgrip strength	Males (n=1,366)		Females (n=1,616)	
	No. of MCI/ participants	OR (95% CI)	No. of MCI/ participants	OR (95% CI)
Q1	163/335	1.00 (Reference)	293/391	1.00 (Reference)
Q2	86/299	0.52 (0.37–0.74)***	229/369	0.72 (0.52–1.00)*
Q3	68/354	0.38 (0.26–0.54)***	189/376	0.50 (0.36–0.69)***
Q4	59/378	0.38 (0.25–0.57)***	219/480	0.51 (0.36–0.72)***

Values are odds ratio (95% CI); adjusted for age, body mass index, education level, household income, occupation status, marital status, physical activity, number of chronic diseases, and ADL score. *p<0.05, **p<0.01, ***p<0.001
ADL: activities of daily living; MCI: mild cognitive impairment

Table 4. Multivariable mean differences in cognitive function scores (K-MMSE) in relation to handgrip strength in participants without MCI (n=1,676)

Handgrip strength	Males (n=990)	Females (n=686)
	β-coefficients (95% CI)	β-coefficients (95% CI)
Q1	0 (Reference)	0 (Reference)
Q2	0.403 (0.075 to 0.732)*	0.096 (–0.332 to 0.523)
Q3	0.318 (0.003 to 0.632)*	0.209 (–0.201 to 0.618)
Q4	0.638 (0.320 to 0.956)***	0.676 (0.278 to 1.074)**

Values are mean differences (95% CI) adjusted for age, body mass index, education level, household income, occupation status, marital status, physical activity, number of chronic diseases, and ADL score. *p<0.05, **p<0.01, ***p<0.001
ADL: activities of daily living; K-MMSE: Korea-Mini Mental Status Evaluation; MCI: mild cognitive impairment

ly. It is also used to represent whole-body muscular strength and it may be an effective index for the early detection of decreases in cognitive function. Recently, a randomized controlled trial showed that exercise intervention improved both physical and cognitive function in the elderly[23]. Hence, the findings of the present study are important from a public health perspective, particularly in strategies for designing interventions aimed at preventing cognitive impairment in

the Korean population[24, 25].

In conclusion, the current study found that handgrip strength was strongly associated with the risk of MCI in a Korean elderly population. Moreover, greater handgrip strength was associated with higher cognitive function in cognitively normal elderly subjects. Further investigation of the prospective association between handgrip strength and cognitive function is warranted.

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REFERENCES

1) Ferri CP, Prince M, Brayne C, et al. Alzheimer's Disease International: Global prevalence of dementia: a Delphi consensus study. Lancet, 2005, 366: 2112–2117. [Medline] [CrossRef]
2) Mathers CD, Loncar D: Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med, 2006, 3: e442. [Medline] [CrossRef]
3) Murad K, Goff DC Jr, Morgan TM, et al.: Burden of comorbidities and functional and cognitive impairments in elderly patients at the initial diagnosis of heart failure and their impact on total mortality: the cardiovascular health study. JACC Heart Fail, 2015, 3: 542–550. [Medline] [CrossRef]
4) Nishiguchi S, Yamada M, Fukutani N, et al.: Differential association of frailty with cognitive decline and sarcopenia in community-dwelling older adults. J Am Med Dir Assoc, 2015, 16: 120–124. [Medline] [CrossRef]
5) Auyeung TW, Lee JS, Kwok T, et al.: Physical frailty predicts future cognitive decline—a four-year prospective study in 2737 cognitively normal older adults. J Nutr Health Aging, 2011, 15: 690–694. [Medline] [CrossRef]
6) Boyle PA, Buchman AS, Wilson RS, et al.: Association of muscle strength with the risk of Alzheimer disease and the rate of cognitive decline in community-dwelling older persons. Arch Neurol, 2009, 66: 1339–1344. [Medline] [CrossRef]
7) Bohannon RW: Hand-grip dynamometry predicts future outcomes in aging adults. J Geriatr Phys Ther, 2008, 31: 3–10. [Medline] [CrossRef]
8) Rantanen T, Guralnik JM, Foley D, et al.: Midlife hand grip strength as a predictor of old age disability. JAMA, 1999, 281: 558–560. [Medline] [CrossRef]
9) Guadalupe-Grau A, Carnicero JA, Gómez-Cabello A, et al.: Association of regional muscle strength with mortality and hospitalisation in older people. Age Ageing, 2015, 44: 790–795. [Medline] [CrossRef]
10) Kamiya K, Masuda T, Tanaka S, et al.: Quadriceps strength as a predictor of mortality in coronary artery disease. Am J Med, 2015. [Medline] [CrossRef]
11) Auyeung TW, Kwok T, Lee J, et al.: Functional decline in cognitive impairment—the relationship between physical and cognitive function. Neuroepidemiology, 2008, 31: 167–173. [Medline] [CrossRef]
12) Ohsugi H, Murata S, Kubo A, et al.: Verification of the correlation between cognitive function and lower limb muscle strength for the community-dwelling elderly. J Phys Ther Sci, 2014, 26: 1861–1863. [Medline] [CrossRef]
13) Kim J-M, Shin I-S, Yoon J-S, et al.: Comparison of diagnostic validities between MMSE-K and K-MMSE for screening of dementia. J Korean Neuropsychiatr Assos, 2003, 42: 124–130.
14) Folstein MF, Folstein SE, McHugh PR: "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res, 1975, 12: 189–198. [Medline] [CrossRef]
15) Huang CY, Hwang AC, Liu LK, et al.: Association of dynapenia, sarcopenia and cognitive iImpairment among community-dwelling older Taiwanese. Rejuvenation Res, 2015. [Medline] [CrossRef]
16) Rosano C, Simonsick EM, Harris TB, et al.: Association between physical and cognitive function in healthy elderly: the health, aging and body composition study. Neuroepidemiology, 2005, 24: 8–14. [Medline] [CrossRef]
17) Sandroff BM, Pilutti LA, Benedict RH, et al.: Association between physical fitness and cognitive function in multiple sclerosis: does disability status matter? Neurorehabil Neural Repair, 2015, 29: 214–223. [Medline] [CrossRef]
18) Christensen H, Mackinnon AJ, Korten AE, et al.: An analysis of diversity in the cognitive performance of elderly community dwellers: individual differences in change scores as a function of age. Psychol Aging, 1999, 14: 365–379. [Medline] [CrossRef]
19) Baltes PB, Lindenberger U: Emergence of a powerful connection between sensory and cognitive functions across the adult life span: a new window to the study of cognitive aging? Psychol Aging, 1997, 12: 12–21. [Medline] [CrossRef]
20) Salthouse TA: The processing-speed theory of adult age differences in cognition. Psychol Rev, 1996, 103: 403–428. [Medline] [CrossRef]
21) Sternäng O, Reynolds CA, Finkel D, et al.: Grip strength and cognitive abilities: associations in old age. J Gerontol B Psychol Sci Soc Sci, 2015. [Medline] [CrossRef]
22) Mielke MM, Roberts RO, Savica R, et al.: Assessing the temporal relationship between cognition and gait: slow gait predicts cognitive decline in the Mayo Clinic Study of Aging. J Gerontol A Biol Sci Med Sci, 2013, 68: 929–937. [Medline] [CrossRef]
23) Sun J, Kanagawa K, Sasaki J, et al.: Tai chi improves cognitive and physical function in the elderly: a randomized controlled trial. J Phys Ther Sci, 2015, 27: 1467–1471. [Medline] [CrossRef]
24) Kim HH: Effects of experience-based group therapy on cognitive and physical functions and psychological symptoms of elderly people with mild dementia. J Phys Ther Sci, 2015, 27: 2069–2071. [Medline] [CrossRef]
25) Cho M, Kim D, Chung J, et al.: Effects of a cognitive-enhancement group training program on daily living activities, cognition, and depression in the demented elderly. J Phys Ther Sci, 2015, 27: 681–684. [Medline] [CrossRef]