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Association between handgrip strength asymmetry and falls in elderly Koreans: A nationwide population-based cross-sectional study

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ABSTRACT

Purpose: This study aimed to investigate the association between handgrip strength (HGS) asymmetry and fall risk in elderly Koreans.

Methods: This study used data from the 2016–2018 Korea National Health and Nutrition Examination Survey. A total of 3407 participants aged ≥ 65 years were included. HGS asymmetry was defined as an HGS asymmetry ratio (nondominant HGS/dominant HGS) of ≥ 1.2 or ≤ 0.8. The presence of a fall was defined as a self-reported fall event that needed treatment at a hospital or emergency department in the previous year. Multivariate logistic regression analysis was performed to analyze the association between HGS asymmetry and fall risk.

Results: The odds ratio for falls was 1.89 times higher in the group with HGS asymmetry than in the group without HGS asymmetry after adjusting for age, sex, multimorbidity, obesity, current smoking, alcohol drinking, and physical exercise (95% confidence interval, 1.03–3.49; $P < 0.05$).

Conclusions: This study revealed that HGS asymmetry is significantly associated with an increased risk of falls in the Korean elderly population. Therefore, early identification and treatment of HGS asymmetry in the elderly could reduce the incidence of falls and be a potential preventive strategy.

1. Introduction

The population of older people is increasing (Dykes et al., 2019). One of the implications of aging is the increased frequency of falls and fall-related injuries among the elderly (Esain et al., 2017).

Falls are associated with pain, functional impairments, morbidity, negative psychological effects, and even mortality (Kannus et al., 2005; Dokuzlar O et al., 2020a; Dokuzlar O et al., 2020b). In particular, functional decline leads to frailty, which has negative effects on quality of life and disability (Kwang-Il et al., 2017), thereby placing a substantial burden on medical and social services (Florence et al., 2018). Therefore, optimizing screening tools for identifying individuals at a risk of falls is an urgent concern (Ganz et al., 2007).

The assessment of physical performance has been proposed as a cornerstone in the screening of individuals at a high risk of falls (Ganz et al., 2007; Dokuzlar O et al., 2020a; Dokuzlar O et al., 2020b). Among the physical performance measures, handgrip strength (HGS) is an indicator of overall muscle strength that is convenient to assess. HGS is largely based on neuromuscular function (Beaudart et al., 2019; Carson, 2018) and is a reliable measure of neuromuscular integrity and muscle function (Bhasin et al., 2020; Cruz-Jentoft et al., 2019). Low HGS is associated with decreased physical functionality (Taekema et al., 2010) and has been reported to increase the fall risk in the elderly (Bobowik & Wiszomirska, 2020). Moreover, HGS can also be a predictor of dynamic postural balance (Alonso et al., 2018). In particular, a large difference in strength between hands, as indicated by HGS asymmetry, has emerged as another marker of impaired muscle function (Mahoney et al., 2020). HGS asymmetry may represent asymmetric motor function, which leads to physical imbalance and functional limitations, resulting in falls (McGrath et al., 2020c). Several studies have reported that HGS asymmetry may contribute to future functional deficits in aging populations (McGrath et al., 2021) and that deteriorating function of the neuromuscular system could be reflected by HGS imbalance, which increases the risk of falls (Portegijs, 2021).

Abbreviations: BMI, body mass index; CI, confidence interval; HGS, handgrip strength; KNHANES, Korea National Health and Nutrition Examination Survey; OR, odds ratio.

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To our knowledge, no study has investigated the association between HGS asymmetry and falls in Asian elderly populations, and only one study has reported that HGS asymmetry is associated with future falls in older Americans (McGrath et al., 2020b). Therefore, in this study, we investigated the association between HGS asymmetry and fall risk in the Korean elderly population using nationally representative data from the Korea National Health and Nutrition Examination Survey (KNHANES).

2. Materials and methods

2.1. Study population

This cross-sectional study assessed data from the 2016–2018 KNHANES. The KNHANES is a nationwide population-based survey that examines the general health and nutrition status of the civilian, noninstitutionalized population in South Korea, conducted by the Korean Ministry of Health and Welfare and the Division of Chronic Disease Surveillance of the Korean Centers for Disease Control and Prevention. A multistage clustered probability design was used to sample survey participants (Hurh et al., 2021).

Among the 24,269 participants of the 2016–2018 KNHANES, the number of elderly individuals aged = 65 years was 4956. Of them, 3609 elderly participants remained after excluding those with limited activity; ambidexterity or ability to complete HGS assessments only on one hand; defects of the arm, hand, or thumb; defects or fractures of the fingers other than the thumb; paralysis of the hand; cast or bandage on the hand or wrist; history of a surgical procedure on the hand or wrist in the last 3 months; surgical history for arthritis or carpal tunnel syndrome; presence of, or worsening, hand pain, aching, or stiffness in the last 7 days; and falling due to intentional self-harm or violence from other people (i.e., nonaccidental falls). Participants without data on HGS and falls were further excluded. Finally, a total of 3407 participants were included in the analysis (Fig. 1).

All participants provided written informed consent before participation in the study, and the KNHANES was conducted with ethical approval from the institutional review board of the Korea Centers for Disease Control and Prevention (the KNHANES was exempt from research ethics review based on the Bioethics and Safety Act from 2016 to 2017 [Korea Centers for Disease Control and Prevention, 2016] and no. 2018-01-03-P-A in 2018).

2.2. Data collection

The participants were interviewed by trained staff using standardized health questionnaires collecting data on demographic information, medical history, and fall history. In addition, anthropometric measurements were also performed.

The presence of falls was assessed through self-reported interviews. The participants were asked if they had experienced a fall that needed treatment at a hospital or emergency department in the previous year. Those who reported that they visited a hospital because of a fall were considered to have experienced a fall event. The participants reported their hand dominance and ability to complete the HGS protocols before testing. HGS was measured three times for each hand by a skilled investigator, using a digital dynamometer (digital grip strength dynamometer, TKK 5401, Takei Scientific Instruments Co., Ltd., Tokyo, Japan). The participants were instructed to grip the instrument with their maximum strength for 3 s in the upright position, and a 60-s break was allowed after each measurement. The highest HGS measured on each hand was used to determine the HGS asymmetry ratio (nondominant HGS/dominant HGS). A previous study has reported that a degree of asymmetry of > 10% may be required to detect functional asymmetry between limbs (Kikkert et al., 2017). In this study, we defined HGS asymmetry based on the previously published cutoff value for HGS asymmetry of a 20% difference in HGS between hands (McGrath et al., 2020a; Parker et al., 2021). Participants with an HGS ratio within 0.8–1.2 were considered to have HGS symmetry, and those with an HGS ratio outside this range were considered to have HGS asymmetry.

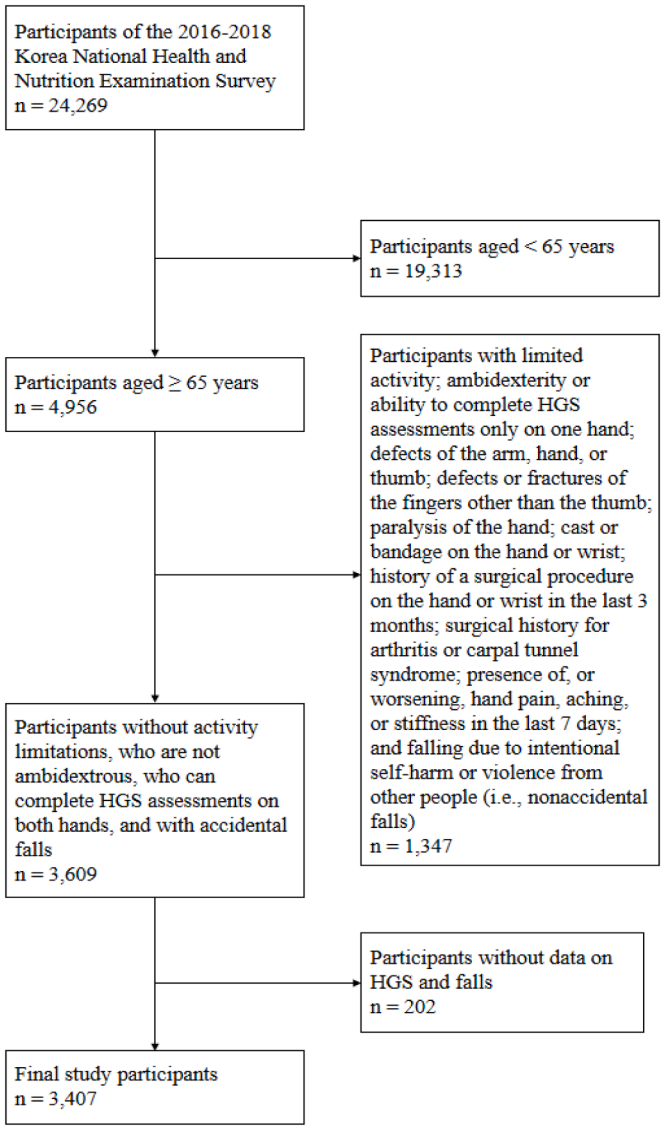

Fig. 1. Flow diagram of the selection of study participants. HGS, handgrip strength

The participants were asked if they had been diagnosed with diabetes mellitus, stroke, myocardial infarction, cancer (stomach, liver, colon, lung, breast, or cervix), chronic obstructive pulmonary disease, renal failure, and liver cirrhosis by a physician, and multimorbidity was defined using Charlson Comorbidity Index (C. Melfi et al., 1995). Current smoking and alcohol drinking were defined as having smoked > 100 cigarettes in the lifetime and continued smoking and drinking at least one drink per month for the last year, respectively. Physical exercise was defined as 150 min of moderate-intensity physical activity or 75 min of high-intensity physical activity, or an equivalent time of mixed moderate- and high-intensity physical activities per week. Obesity was defined as a body mass index (calculated by dividing weight [kg] by the square of height [m^2]) of ≥ 25 kg/m^2.

2.3. Statistical analysis

The characteristics of the participants classified according to the presence of falls are expressed as means and standard deviations for continuous variables and as numbers and percentages for categorical

variables. The participant groups were compared using an independent t-test for continuous variables and the chi-square test for categorical variables.

Multivariate logistic regression analysis was performed to analyze the association between HGS asymmetry and falls. Relative risks were estimated in terms of odds ratios (ORs) and 95% confidence intervals (CIs). We adjusted for multiple variables that showed significant associations in the univariate analysis and those based on clinical relevance. After calculating the crude ORs (model 1), model 2 was adjusted for age and sex. Model 3 was further adjusted for multimorbidity, obesity, current smoking, alcohol drinking, and physical exercise.

All variables entered into logistic regression analysis were examined for multicollinearity, and only variables with a variance inflation factor of < 5 were used. All statistical analyses were performed using IBM SPSS (version 25; IBM, Armonk, NY, USA). The level of statistical significance was set at $P < 0.05$, and all P values were two tailed.

3. Results

3.1. Demographic characteristics of the participants

A total of 3407 participants were included in this study (Fig. 1). Table 1 shows the demographic characteristics of the participants according to the presence or absence of falls. The number of participants who experienced falls was 105 (3.08%). In the fall group, the mean age was 72.63 ± 0.58 years and the number of women was 76 (67.9%). The group with falls showed a higher proportion of women, left-hand dominance, and HGS asymmetry than the group without falls (all $P <$ 0.05).

3.2. Association between HGS asymmetry and falls

Table 2 shows the ORs and 95% CIs for falls according to HGS asymmetry in 3407 elderly Koreans aged ≥ 65 years. The model was adjusted for age, sex, multimorbidity, obesity, current smoking, alcohol drinking, and physical exercise. The results showed that the OR of falls was 1.89 times higher in the group with HGS asymmetry than in the group without HGS asymmetry (95% CI, 1.03–3.49 for model 3).

Table 1
Demographic characteristics according to the presence of falls in elderly Koreans aged ≥ 65 years

Variables	Fall (+) (n = 105)	Fall (–) (n = 3302)	*P* value
Age (years)	72.63 ± 0.58	72.59 ± 0.12	0.948
Female sex (%)	76 (67.9)	1769 (54.2)	0.021
BMI (kg/m^2)	24.32 ± 0.33	24.12 ± 0.07	0.570
Obesity* (%)	44 (43.5)	1209 (36.5)	0.236
Hand dominance			0.012
Right	96 (88.3)	3138 (95.1)	
Left	9 (11.7)	164 (4.9)	
Maximal HGS (KgF)	24.81 ± 1.11	25.89 ± 0.22	0.340
Multimorbidity†	1.55 ± 0.13	1.49 ± 0.03	0.669
Current smoking‡ (%)	9 (9.3)	298 (9.3)	0.993
Alcohol drinking§ (%)	36 (36.1)	1201 (37.2)	0.834
Physical exercise‖ (%)	36 (41.2)	995 (32.2)	0.114
HGS asymmetry¶ (%)			0.022
< 20%	75 (72.9)	2708 (84.1)	
≥ 20%	22 (27.1)	520 (15.9)	

BMI, body mass index; HGS, handgrip strength.
Data were obtained from the 2016–2018 Korean National Health and Nutrition Examination Survey.
P values were calculated using an independent t-test or the chi-square test.
Continuous variables are expressed as means and standard deviations, whereas categorical variables are expressed as numbers and percentages.
* Defined as a body mass index of ≥ 25 kg/m^2.
† Defined using Charlson Comorbidity Index
‡ Defined as having smoked > 100 cigarettes in the lifetime and continued smoking.
§ Defined as drinking at least one drink per month in the last year.
‖ Defined as 150 min of moderate-intensity physical activity or 75 min of high-intensity physical activity, or an equivalent time of mixed moderate- and high-intensity physical activities per week.
¶ Defined as a handgrip strength asymmetry ratio (nondominant handgrip strength/dominant handgrip strength) of ≥ 1.2 or ≤ 0.8.

Table 2
Unadjusted and adjusted odds ratios and 95% confidence intervals for falls according to handgrip strength asymmetry in elderly Koreans aged ≥ 65 years

Multivariate model	Model 1OR (95% CI)	Model 2OR (95% CI)	Model 3OR (95% CI)
Handgrip strength asymmetry			
< 20%	Reference	Reference	Reference
≥ 20%	1.96 (1.09–3.53) *P* = 0.024	1.84 (1.04–3.25) *P* = 0.037	1.89 (1.03–3.49) *P* = 0.040

OR, odds ratio; CI, confidence interval.
Data from the 2016–2018 Korean National Health and Nutrition Examination Survey.
Model 1 was the crude model.
Model 2 was adjusted for age and sex.
Model 3 was adjusted for multimorbidity, obesity, current smoking, alcohol drinking, physical exercise, and the variables adjusted in model 2.

4. Discussion

This cross-sectional study of data from the 2016–2018 KNHANES showed that HGS asymmetry increased the OR for falls in elderly Koreans aged ≥ 65 years. To our knowledge, this is the first study to quantitatively evaluate the association between HGS asymmetry and fall risk in an Asian elderly population. The results of this study will provide insights for future research.

Although the underlying mechanisms of the association between HGS asymmetry and falls are still not clearly defined, a deterioration in the function of the neuromuscular system has been proposed as a possible mechanism. HGS is intricately connected to the neural systems that mediate the control of coordinated movement (Carson, 2018). Several studies have reported that a large difference in HGS between hands may reflect lower functioning and morbidity-related dysfunction in the brain hemisphere (McGrath et al., 2020a; Parker et al., 2021), and HGS asymmetry could represent abnormal neural system functioning and brain hemisphere activation (Mahoney et al., 2020). Other studies have shown that age-related muscle coordination deficits occur with aging (Carson, 2018), and low neuromuscular function, as indicated by HGS asymmetry, could represent the onset of the disabling process (Xue, 2011). Moreover, other studies have reported that more than half of falls in older adults are linked to impaired motor function (Robinovitch et al., 2013) and that falls are related to an imbalance in HGS (Howcroft et al., 2013) and low levels of muscular strength (Pruitt et al., 1995; Dokuzlar O et al., 2020a). Therefore, HGS asymmetry represents reduced neural and motor system function (Carson, 2018) and deterioration in neuromuscular system functioning, leading to physical and functional limitations that increase risk of falls (McGrath et al., 2020b).

A recent study reported that HGS asymmetry is associated with future falls in older Americans (McGrath et al., 2020b). This study showed that participants with HGS asymmetry > 10%, > 20%, and > 30% had greater odds of future falls than those with HGS asymmetry ≤ 10%. This previous study defined a fall as the occurrence of any fall event, whereas we defined falls as accidental fall events that required treatment at a hospital or emergency department in this study. Therefore, our study did not include minor cases that did not need treatment at a hospital and nonaccidental falls. In addition, the cutoff of HGS asymmetry in the previous study was 10%, whereas we used a cutoff of 20% in our study. When we performed an analysis using the 10% cutoff used in the previous study, no significant results were obtained

(Supplementary Table 1). This may be because of differences in the fall definition, HGS, and fall prevalence across different countries depending on ethnic (genetic) and lifestyle (environmental) factors (Hurh et al., 2021). HGS and HGS asymmetry ratios may vary between hands at an individual level (Lathrop-Lambach et al., 2014), and the necessary degree of asymmetry for predicting falls remains unclear. Generating robust HGS asymmetry cutoff points may provide more clarity with respect to the association between HGS asymmetry and falls (Parker et al., 2021). Therefore, defining standardized HGS asymmetry cutoff points is warranted (McGrath et al., 2020b).

This study had some limitations. First, as this was a cross-sectional study, a causal relationship could not be established. Prospective and longitudinal studies with larger sample sizes are needed. Second, the self-report method of reviewing fall events can result in a recall bias. Although biases from self-reports may have influenced our estimates (Parker et al., 2021), self-reports are common in population-based studies (Kalisch et al., 2006). Third, the prevalence of falls requiring hospital visits was as low as 3.08% in our study, which may have been underreported. However, another study found that 6.93% of people aged $\geq$ 65 years in the United States experience fall-related injuries that require medical treatment (Bergen et al., 2016). Accordingly, our study is meaningful as it analyzed falls that required a visit to the hospital, which can lead to fall-related injuries in the elderly. Fourth, cognitive impairment, gait disorder, visual or hearing impairment, malnutrition, sarcopenia and environmental hazards are known to affect the risk of falls (McGrath et al., 2020b). In our study, we were unable to collect detailed information on variables that might have influenced the risk of falls because structured cross-sectional KNHANES data were used. Therefore, studies minimizing the effects of various additional covariates are needed in the future.

Nevertheless, to our knowledge, this study is the first to quantitatively analyze the association between HGS asymmetry and fall risk in the elderly using nationally representative data from a large sample. Preventing falls in the elderly is a health-care priority, and early identification of individuals at risk is the first step in fall prevention (Kikkert et al., 2017). Therefore, identifying potentially vulnerable groups in a large, nationally representative study is important to prevent, manage, and decrease the burden of this condition. Moreover, as HGS asymmetry is a novel potential risk factor and marker for impaired neuromuscular function, its detection is crucial to prevent fall-related morbidity and mortality (Ames et al., 2016). We suggest that screening for HGS asymmetry is a convenient, simple, and noninvasive test that can be easily performed in primary care settings (Korea Centers for Disease Control and Prevention, 2016) and could be useful in predicting falls and providing insights for fall risk assessments (McGrath et al., 2020b). Furthermore, HGS asymmetry can signify impaired muscle function that occurs before weakness (Parker et al., 2021). Therefore, identifying HGS imbalances could improve the early detection a high fall risk in the elderly (Mahoney et al., 2020).

In conclusion, this quantitative cross-sectional analysis of data from the 2016–2018 KNHANES revealed that HGS asymmetry is significantly associated with falls. The findings of this study indicate that identifying and treating HGS asymmetry in the elderly may be a potential preventive strategy against the occurrence of falls.

Declarations of Competing Interest

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Ethical approval

All participants provided written informed consent before participation in the study, and the Korea National Health and Nutrition Examination Survey (KNHANES) was conducted with ethical approval from the institutional review board of the Korea Centers for Disease Control and Prevention (the KNHANES was exempt from research ethics review based on the Bioethics and Safety Act from 2016 to 2017 and no. 2018-01-03-P-A in 2018).

Consent to participate

All participants provided written informed consent before participation in the study.

Consent to publish

Not applicable.

Data Availability

Data were obtained from the 2016–2018 KNHANES. The KNHANES is a nationwide population-based survey conducted by the Korean Ministry of Health and Welfare and the Division of Chronic Disease Surveillance of the Korean Centers for Disease Control and Prevention. All data are fully available without restriction. All data files are available from the KNHANES database (https://knhanes.cdc.go.kr/knhanes/index.do).

Code availability

Not applicable.

Author contributions

Young Joo Go: conceptualization, data curation, formal analysis, investigation, methodology, resources, software, visualization, and writing - original draft. Duk Chul Lee: conceptualization, project administration, supervision, validation, and writing - review & editing. Hye Jun Lee: conceptualization, data curation, methodology, project administration, supervision, validation, and writing - review & editing.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.archger.2021.104470.

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