

A cross-sectional study investigating the relationship between handgrip strength with multimorbidity in Korean adults

Findings from the Korea National Health and Nutrition Examination Survey VI-VII (2014–2017)

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Abstract

To date research investigating the associations between handgrip strength and multimorbidity when stratifying by age and sex is limited. Furthermore, this is the first study in a Korean population, and the first to include adults ≥ 19 years of age. Here we investigated the associations between handgrip strength and multimorbidity in Korean adults aged ≥ 19 years.

In this cross-sectional study data from the Korea National Health and Nutrition Examination Survey were used. Multimorbidity was defined as having 2 or more chronic diseases. A total of 19,779 participants were eligible for the study (8730 male and 11,049 female). We grouped and analysed participants based on age and sex (men and women aged 19–49 years, men and women aged 50–80 years) and examined the associations between handgrip strength and multimorbidity using multivariate logistic regressions using stratification by age, sex and body mass index (BMI).

Multivariate logistic regressions revealed a significant inverse association irrespective of sex, between relative handgrip strength and multimorbidity. Participants with the lowest handgrip strength had a significantly higher odds ratio (OR) of multimorbidity (men aged 19–49 years: 3.76 and aged 50 years to 80 years: 2.11; women aged 19 years to 49 years: 1.52 and aged 50–80 years: 2.15) when compared to those with highest handgrip strength after adjusting for confounding variables. The highest OR was observed in men aged 19 years to 49 years with a BMI ≥ 25 kg/m².

In the current study we observed a significant inverse relationship between handgrip strength and multimorbidity in males and females with 2 or more chronic diseases. Male participants with a low handgrip strength aged between 19 years to 49 years with a BMI ≥ 25 kg/m² may be at greater risk of multimorbidity. This study highlights the need for further longitudinal studies to investigate the effects of increasing handgrip strength combined with weight loss, as an effective strategy to reduce the incidence of multimorbidity.

Abbreviations: BMI = body mass index, KNHANES = Korean National Health and Nutrition Examination Survey, OR = odds ratio.

Keywords: age, handgrip strength, multimorbidity

1. Introduction

Multimorbidity can be defined as the presence of 2 or more chronic diseases in the same individual that can be clinically managed using medication and other interventions, but not cured.^[1] Age has a significant effect on the occurrence and incidence of multimorbidity, where 65% of 65 years to 84-year-

old's had multimorbidity, when compared with 81.5% of people aged ≥ 85 years in UK.^[2] Previous research has demonstrated that patients with multimorbidity are twice as likely to suffer from depression,^[3] have poor health related quality of life^[4] and an increased risk of mortality^[5] when compared to those without multimorbidity.

Editor: Andrea Giuseppe Maugeri.

This work was supported by the 2018 Inje University research grant. We thank our colleagues from Department of surgery, Ilsan-paik hospital who provided insight and expertise that greatly assisted the research, although they may not agree with all of the interpretations/conclusions of this paper.

The authors have no conflicts of interest to disclose.

The data that support the findings of this study are available from a third party, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are available from the authors upon reasonable request and with permission of the third party.

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How to cite this article: Lee MR, Jung SM. A cross-sectional study investigating the relationship between handgrip strength with multimorbidity in Korean adults: findings from the Korea National Health and Nutrition Examination Survey VI-VII (2014–2017). *Medicine* 2021;100:1(e23994).

Received: 30 July 2020 / Received in final form: 22 September 2020 / Accepted: 25 November 2020

<http://dx.doi.org/10.1097/MD.00000000000023994>

Handgrip strength is commonly used as a measure of physical fitness and muscle strength, both of which are related with all-cause, cardiovascular and cancer mortality.^[6] We provided evidence to substantiate this, where we were observed associations between handgrip strength, type 2 diabetes,^[7] depression,^[8] and cardiovascular disease.^[9] These data indicate that handgrip strength may be a useful, inexpensive and non-invasive method for assessing multimorbidity.

Poor handgrip strength is commonly associated with a myriad of health problems; however, to date there is a lack of population-based studies investigating the associations between handgrip strength and multimorbidity. Two cross-sectional studies in Hong-Kong^[10] and Brazil^[11] both identified that men with a low handgrip strength were more likely to have multimorbidity, which was not the case in women. Contrastingly, a cross-sectional study in Germany observed that lower handgrip strength was significantly associated with multimorbidity among women but not in men.^[12] Interestingly, to date previous research surrounding sex specific analysis on handgrip strength and multimorbidity have reported inconsistent results. Furthermore, some studies using handgrip strength have failed to correct for body mass index (BMI) and weight and are not a true representation of a national data. Finally, to the best of our knowledge, there are few studies in subjects under the age of 50 years, and the effects of BMI on handgrip strength and multimorbidity remains poorly understood.

Therefore, the primary aim of the present study was to examine the association between handgrip strength and multimorbidity in a population-based data generated from the Korean National Health and Nutrition Examination Survey (KNHANES).

2. Methods

2.1. Study population

This is a cross-sectional study design of the Korean population from the KNHANES, an annual study that has been conducted since 2007. The study targets only Koreans and is based on a complex stratified multistage probability cluster survey of a cross-sectional and nationally representative sample of individuals from the non-institutionalized civilian population by the Division of Chronic Disease Surveillance, Korea Centres for Disease Control and Prevention.

Data from the KNHANES VI -VII (2014–2017), including data relating to handgrip strength was included. Participants were excluded from the study if they were <19 years of age (n=6,386), provided insufficient information of questionnaires relating to multimorbidity (n=2,975), and had no measurement of handgrip strength for the right or left hand (n=2,067). Following exclusion of these participants, a total of 19,779 participants (male: 8,730, female: 11,049) remained that were eligible for the study (Fig. 1).

2.2. Ethics statement and data available

Our study protocol was approved by the institutional review board of the ethics committee of Ilsan-paik hospital (approval number: ISPAIK 2020-05-022).

The data from KNHANES is available on request by email by visiting the *Korea National Health and Nutrition Examination Survey* website (<http://knhanes.cdc.go.kr>) and is free of charge for the purposes of academic research.

2.3. Definitions of multimorbidity

The KNHANES VI-VII questionnaires included 25 chronic diseases (hypertension, dyslipidaemia, stroke, myocardial infarction, angina, osteoarthritis, rheumatic arthritis, tuberculosis, asthma, allergic rhinitis, depression, kidney failure, atopic dermatitis, diabetes mellitus, thyroid disease, stomach cancer, liver cancer, colon cancer, breast cancer, cervical cancer, lung cancer, thyroid cancer, liver cirrhosis, hepatitis B, and hepatitis C). The chronic disease history of the KNHANES questionnaires consisted of 3 questions: whether the doctor has diagnosed it, whether you are currently suffering from it, and whether it is currently treated. The presence of chronic disease was determined whether the participants had ever been diagnosed with each disease by a doctor and either was still had the disease or the disease had been treated. People who did not have chronic diseases were those who had not been diagnosed with a doctor or who had been diagnosed in the past, but do not currently had them. Participants were defined as multimorbidity if they had two or more chronic diseases.

2.4. Measurement of handgrip strength

Handgrip strength was measured 3 times in each hand, using a digital grip strength dynamometer (TKK 5401; Takei Scientific Instruments Co., Ltd., Tokyo, Japan). Trained medical technicians instructed participants to hold the dynamometer with the distal interphalangeal finger joints of the hand at 90° to the handle and to squeeze the handle as firmly as they could whilst being seated. After participants had slowly stood up, handgrip strength was measured during expiration. Study participants conducted 3 attempts per hand, with a 1-minute rest period between each attempt to reduce the effects of fatigue. Handgrip strength of the participants' dominant hand was defined using questionnaires, and an average of the 3 measurements was used.^[13] Relative handgrip strength was defined as grip strength per unit of BMI.

2.5. Covariates

The self-reported questionnaire provided information relating to participants education, smoking status, alcohol consumption, and physical activity. As education levels are lower in the elderly, education was divided into two categories of ≤ 9 and > 9 years of school. Smoking status was classified as never smoking, former smokers and currently smoking. Current smokers self-reported that they smoked > 100 cigarettes in their lifetime and were currently still smoking. Past smokers self-reported that they had a history of smoking. Participants who consumed alcohol were defined as those who drink at least 1 glass of alcohol every month over the last year. Physically activity participants were defined as those who had performed exercise for least 150 minutes per week at a moderate intensity (fast walking, carrying light objects, cleaning, parenting, etc.); 75 minutes per week at a high intensity (lifting or carrying heavy items, digging, labor at construction sites, carrying objects on stairs) (or a combination of medium and high-intensity physical activity (where 1 minute of high-intensity activity=two minutes of medium intensity activity). BMI was calculated as weight divided by height squared (kg/m^2). BMI was categorized into 2 groups according to the Asian-Pacific cutoff points: obese ($\geq 25 \text{ kg}/\text{m}^2$), non-obese ($< 25 \text{ kg}/\text{m}^2$).^[14]

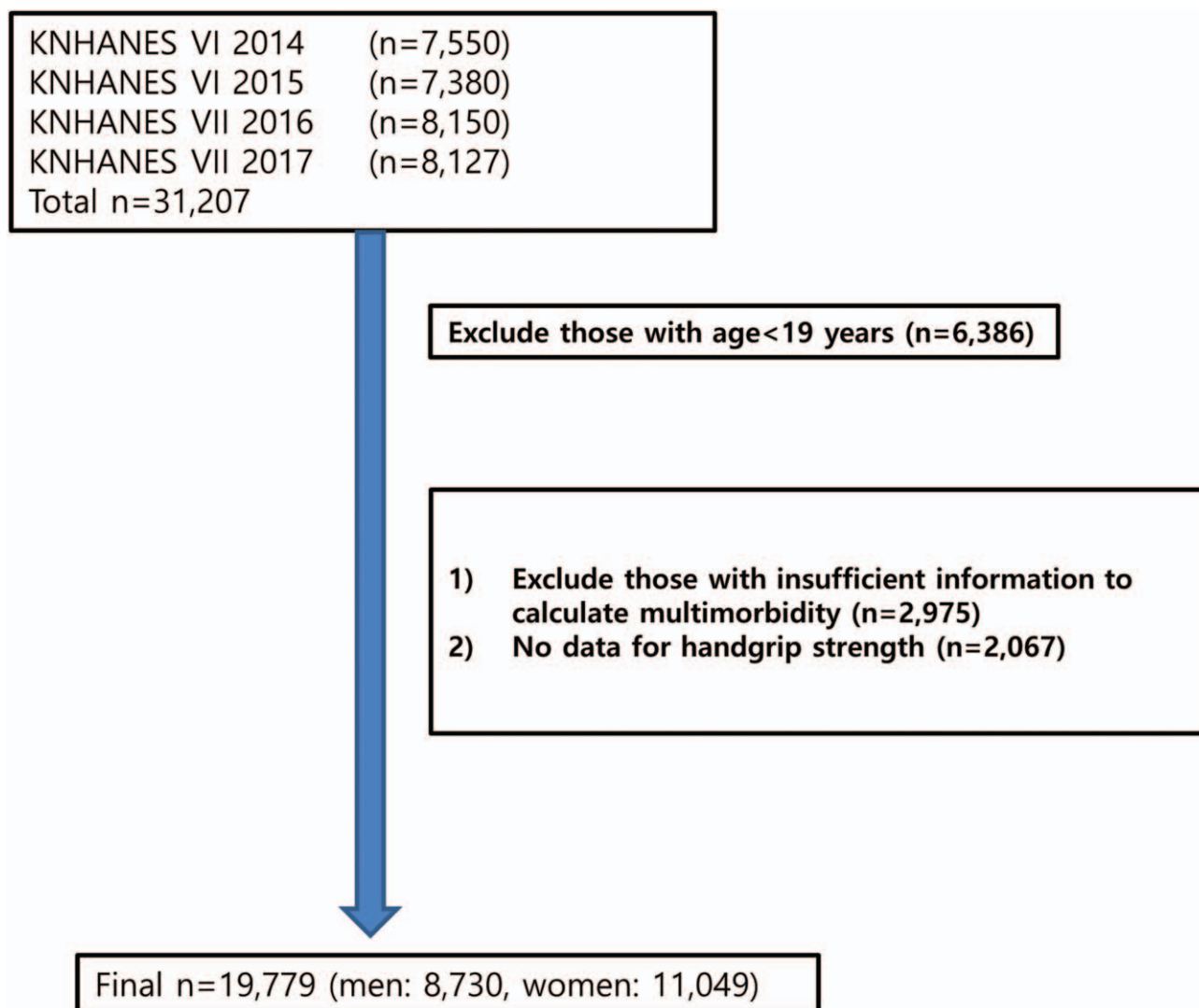


Figure 1. Participant flow diagram illustrating the number of patients excluded by various criteria, and the number of patient data sets analysed.

2.6. Statistical analyses

Statistical guidance was provided by the Korean Centre for Disease Control and Prevention, raw data from the VI-VII (2014–2017) were combined and complex sample analysis was utilised using the weighting data from KNHANES. Sex and age were used to divide participants when investigating associated between handgrip strength and multimorbidity. The groups utilised were 19 years to 49 years and 50 years to 80 years old, for both male and female participants.

Differences in demographic and anthropometric characteristics were compared using the Student *t*-test or Chi-square test, as appropriate. Complex sample multivariate logistic regression was performed to analyse the relationship between relative handgrip strength and multimorbidity, and odds ratio (OR) and 95% confidence intervals were calculated. Model 1 adjusted for age and Model 2 adjusted for age, education (≤ 9 , > 9 years of school), alcohol consumption (yes vs no), smoking status (never, former, current), and physical activity (yes vs no). Relative handgrip strength was divided into quartiles. ORs were calculated using complex samples logistic regression analysis

to examine associations between the quartile of relative handgrip strength and the presence of multimorbidity based on the highest quartile. Logistic regression analysis was repeated for all age groups using a stratified approach with a BMI < 25 kg/m² and a BMI ≥ 25 kg/m². Statistical significance was defined as $P < .05$. Continuous and categorical variables were expressed as mean \pm standard deviation and number (n) (%), respectively. All statistical analysis was performed using SPSS software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). All graphical representations were prepared using the R software suite, version 3.3.3 (The Comprehensive R Archive Network: <http://cran.r-project.org>).

3. Results

A total of 19,779 participants were included in the study, of which there were 4075:5256 (male:female) 19–49 year olds, and 4655:5793 (male:female) aged 50–80 years. The mean (\pm standard deviation) age of the 19–49 years old, and 50–80 years, was 35.67 (± 8.69) years old (male: 35.53 (± 8.74), female:

Table 1
Participants' sociodemographic and clinical characteristics by sex and age group (n = 19779).

Variable	19–49 yr			P	50–80 yr			P
	Men	Women	Total		Men	Women	Total	
n	4075	5256	9331		4655	5793	10448	
Age, yr, mean ± SD	35.5 ± 8.7	35.8 ± 8.7	35.7 ± 8.7	.202	64.4 ± 8.9	64.2 ± 9.1	64.3 ± 9.0	<.001*
Education (years), n (%)								
<9 years	162 (3.9%)	203 (3.9%)	365 (3.9%)	.91	2093 (40.5%)	3702 (60.7%)	5798 (50.9%)	<.001*
≥9 years	3902 (96.1%)	5047 (96.1%)	8949 (96.1%)		2521 (59.5%)	2037 (39.3%)	4558 (49.1%)	
Not response	11	6	17		38	54	92	
Smoking status, n (%)								
Never smoker	1186 (30.5%)	4471 (84.8%)	5657 (56.8%)	<.001*	858 (18.4%)	5355 (93.4%)	6213 (57.1%)	<.001*
Former smoker	1081 (25.6%)	451 (8.5%)	1532 (17.3%)		2464 (51.6%)	188 (3.2%)	2652 (26.6%)	
Current smoker	1794 (43.9%)	327 (6.6%)	2121 (25.9%)		1279 (30.1%)	169 (3.4%)	1448 (16.3%)	
Not response	14	7	21		54	81	135	
Alcohol consumption, n (%)								
Non-drinker	883 (21.9%)	2333 (43.9%)	3216 (32.5%)	<.001*	1551 (31.1%)	4145 (70.5%)	5696 (51.5%)	<.001*
Alcohol drinker	3178 (78.1%)	2916 (56.2%)	6094 (67.5%)		3054 (68.9%)	1574 (29.5%)	4628 (48.5%)	
Not response	14	7	21		50	74	124	
Physical activity, n (%)								
No	1708 (40.8%)	2535 (46.5%)	4243 (43.5%)	<.001*	2565 (53.4%)	3609 (61.1%)	6174 (57.4%)	<.001*
Yes	2350 (59.2%)	2710 (53.5%)	5060 (56.5%)		2047 (46.6%)	2112 (38.9%)	4159 (42.6%)	
Not response	17	11	28		43	72	115	
Number of chronic disease, n (%)								
0	2972 (73.4%)	3653 (69.1%)	6625 (71.3%)	<.001*	1781 (42.1%)	1783 (33.4%)	3564 (37.6%)	<.001*
1	850 (20.7%)	1328 (25.6%)	2178 (23.1%)		1406 (29.6%)	1683 (29.6%)	3089 (29.6%)	
2	203 (4.7%)	221 (4.3%)	424 (4.5%)		829 (16.3%)	1215 (19.7%)	2044 (18.1%)	
3	42 (1.0%)	44 (0.8%)	86 (0.9%)		404 (7.9%)	680 (10.5%)	1084 (9.2%)	
4+	8 (0.2%)	10 (0.2%)	18 (0.2%)		235 (4.2%)	432 (6.8%)	667 (5.5%)	
Dominant hand, kg, mean ± SD	41.7 ± 7.3	24.4 ± 4.8	32.0 ± 10.5	<.001*	35.1 ± 7.8	21.2 ± 5.3	27.4 ± 9.5	<.001*
Dominant hand/BMI, kg/kg/m ² , mean ± SD	1.7 ± 0.3	1.1 ± 0.2	1.4 ± 0.4	<.001*	1.5 ± 0.3	0.9 ± 0.2	1.2 ± 0.4	<.001*
BMI, kg/m ² , n (%)								
<25	2337 (58.4%)	4146 (79.5%)	6483 (68.6%)	<.001*	2945 (62.0%)	3597 (63.1%)	6542 (62.5%)	.332
≥25	1738 (41.6%)	1110 (20.6%)	2848 (31.4%)		1710 (38.1%)	2196 (36.9%)	3906 (37.5%)	

Chi-squared test was used for categorical variable. And Student t test was used for continuous variables.

BMI = body mass index, SD = standard deviation.

* $P < .05$.

35.77 (± 8.66), and 64.28 (± 9.02) years old (male: 64.44 (± 8.87), female: 64.15 (± 9.13)), respectively.

In all participants, 21.86% reported as having 2 or more chronic diseases with the mean number of chronic disease in multimorbidity participants being 2.68 (± 1.01).

The proportion of participants with multimorbidity increased with age, where 19 years to 49 year old's had 5.66% compared to 36.32% in 50 years to 80-year-olds.

The proportion of females with multimorbidity was higher when compared with males in the 50 years to 80 years olds (female vs male: 40.17% vs 31.54%). In contrast, in the 19 years to 49 age group, male participants had a higher proportion of multimorbidity when compared with females (6.21% vs. 5.23%, respectively).

Age, education, smoking status, alcohol consumption, physical activity, number of chronic diseases and dominant handgrip strength were significantly different between sexes in the 50 years to 80-year-old group (Table 1). Similar findings were observed in the 19 years to 49-year-old group; however, age and education were not significantly different (Table 1). After adjusting for age, education, physical activity, smoking status, and alcohol consumption, relative handgrip strength were inversely associated with multimorbidity in both men and women in both age groups (Table 2).

In participants with the lowest quartile of handgrip strength, the ORs of having multimorbidity was 3.76 (19–49 years) and

2.11 (50–80 years) compared to those with the highest quartile of handgrip strength, ORs were 1.52 (19–49 years) and 2.15 (50–80 years) compared to those in the highest quartile. Male participants had a higher OR than females in the 19–49-year-old age group, whereas male and female participants were similar in 50–80-year-old age group (Fig. 2).

In men <50, the association between handgrip strength and multimorbidity was significantly higher in participants with a BMI ≥ 25 kg/m². In men ≥ 50 years old participants with a BMI < and ≥ 25 kg/m² were significant. (Table 3)

4. Discussion

The primary aim of the present study was to examine the association between handgrip strength and multimorbidity in a population-based data generated from the Korean National Health and Nutrition Examination Survey (KNHANES). In our study, we observed that the prevalence of multimorbidity increased with age and the proportion of female participants with multimorbidity was higher than male participants aged ≥ 50 years. Similar findings have previously been reported, where an S-shaped curve was observed for prevalence by age.^[15] In the US National Health and Nutrition Examination Survey (NHANES), multimorbidity was higher in female than male

Table 2
Multivariate logistic regression associations between continuous relative handgrip strength and multimorbidity.

	n	Model 1		Model 2	
		OR (95% CI)	P	OR (95% CI)	P
19–49 yr					
Men	4075	0.21 (0.14–0.33)	<.001*	0.24 (0.15–0.38)	<.001*
Women	5256	0.48 (0.24–0.92)	.028*	0.47 (0.24–0.91)	.026*
50–80 yr					
Men	4655	0.38 (0.29–0.49)	<.001*	0.40 (0.31–0.52)	<.001*
Women	5793	0.24 (0.18–0.34)	<.001*	0.25 (0.18–0.35)	<.001*

BMI=body mass index, CI=confidence interval, OR=odds ratio.
 Model 1 is adjusted for age. Model 2 is adjusted for age, education, drinking alcohol, smoking status, and physical activity.
 *P < .05.

participants, and in all adults aged ≥20, 60% had 2 or more multimorbidities compared with 92% in participants aged ≥65 years old from 11 possible conditions.^[16]

The data presented here confirms previously published literature, where handgrip strength and multimorbidity are related when stratifying the analysis by age and sex. However, we were not able to find any effect of sex alone in the general Korean population. Two previously published cross-sectional studies by Cheung et al^[10] and Amaral et al^[11] in Hong Kong and Brazil, respectively, reported that handgrip strength was an effective marker for identifying male participants with multimorbidity, which may have been due to sex-related hormone differences as no association was observed in females. Contrastingly, Volaklis et al.^[12] reported that in a German population handgrip strength was inversely and independently associated with multimorbidity in women ≥65 years of age, but not in men. However, in a recent Brazilian study, men without myopenia aged >60 years with a low handgrip strength were more likely to have multimorbid-

ity.^[17] Furthermore, in a recent cross-sectional study conducted across 6 countries (China, Ghana, India, Mexico, Russia, South Africa), the authors failed to report any sex associations in adults >50 years of age, but did report an association between low handgrip strength and an increasing number of chronic conditions.^[18]

Several biological mechanisms have been reported that may be responsible for the relationship between handgrip strength and multimorbidity. For example, the production and release of several cytokines and peptides from skeletal muscle during contractions termed ‘myokines’ has been associated with metabolic pathways, body fat regulation, anti-inflammatory effects, improved insulin sensitivity, suppression of tumour growth and improved cognitive function.^[19] Previous research from our group has also demonstrated a relationship between handgrip strength and the inflammatory marker high sensitivity C-reactive protein^[9] Furthermore, reactive oxygen species produced by skeletal muscle are increased during exercise,

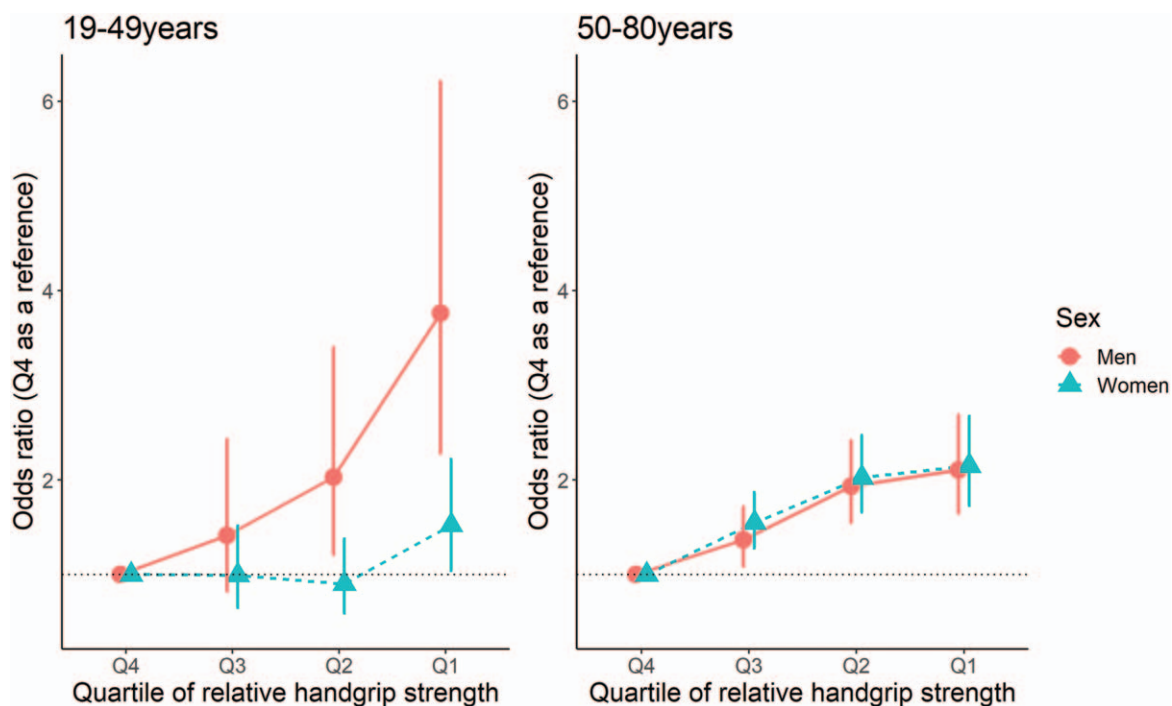


Figure 2. Multivariate logistic regression association between relative handgrip strength quartile and risk of multimorbidity. The analysis was adjusted for age, education, alcohol consumption, smoking status, and physical activity.

Table 3
Multivariate logistic regression association between quartile of relative handgrip strength and multimorbidity using stratified analysis by body mass index.

		Quartile	BMI (<25kg/m ²)			BMI (≥25 kg/m ²)		
			OR	95% CI	P	OR	95% CI	P
19–49 yr	Men	Q4	1.00			1.00		
		Q3	1.00	0.51–1.97	.996	2.74	0.86–8.74	.089
		Q2	1.16	0.59–2.26	.672	3.47	1.12–10.76	.031*
	Women	Q1	1.86	0.87–3.97	.107	5.65	1.88–16.93	.002*
		Q4	1.00			1.00		
		Q3	0.88	0.55–1.41	.604	0.96	0.29–3.21	.951
		Q2	1.04	0.66–1.65	.861	0.30	0.09–1.00	.050
50–80 yr	Men	Q1	1.24	0.77–2.00	.376	0.89	0.31–2.58	.837
		Q4	1.00			1.00		
		Q3	1.31	1.00–1.73	.052	1.24	0.83–1.87	.298
	Women	Q2	1.80	1.37–2.37	<.001*	1.68	1.12–2.53	.013*
		Q1	1.92	1.39–2.63	<.001*	1.73	1.14–2.63	.010*
		Q4	1.00			1.00		
		Q3	1.34	1.07–1.67	.010*	1.20	0.78–1.84	.410
	Q2	1.69	1.31–2.18	<.001*	1.35	0.88–2.06	.165	
	Q1	1.48	1.09–2.02	.013*	1.43	0.93–2.21	.102	

BMI=body mass index, CI=confidence interval, OR=odds ratio, Q=quartile.

The analysis was adjusted for age, education, drinking alcohol, smoking status, and physical activity.

*P<.05.

leading to increased expression of antioxidants.^[20] In chronic degenerative diseases such as chronic obstructive pulmonary disease, chronic cardiovascular disease, metabolic diseases, and neurodegeneration have all been shown to be affected by chronic oxidative stress,^[21] suggesting a potential protective effect of exercise

The findings presented here demonstrate that males in the 19 to 49 years old group with a BMI ≥25 kg/m² combined with a low handgrip strength had the highest OR. Supporting these findings, in a Canadian study population, the incidence of multimorbidity was higher in obese participants, but not in those with normal BMI.^[22] Obesity and a lack of physical activity have previously been identified to be a significant predictor of multimorbidity in adults aged >55 years in New Zealand.^[23] Furthermore, in a cohort study from Iran, obese participants had an OR that was 2.33-fold higher than participants with a normal BMI.^[24] Obesity is a well-established risk factor for chronic diseases, and has been shown to cause systemic inflammation and activate well-known pathways for cancer, cardiovascular disease and type 2 diabetes mellitus.^[25] The results from the current study amongst others may provide the basis for further management of participants with a high BMI and low handgrip strength for the early onset of non-communicable diseases and multimorbidity.

The present study has several important strengths. First, this is the first study to investigate the relationship between handgrip strength and multimorbidity in a large nationally representative sample size from Korea. Secondly, we were able to stratify the analysis between handgrip strength and multimorbidity by age and sex. Third, this is the first study to investigate the impact of handgrip strength on multimorbidity in adults between 19 and 80 years of age. Finally, we were able to identify that a combination of an increased BMI and low handgrip strength had a more pronounced effect on multimorbidity in 19 years to 49-year-olds.

This study is not without limitations. First, all participants were Korean, meaning that our findings cannot be extrapolated to other ethnicities. Second, information relating to medical

conditions was based on self-reporting questionnaires, which may cause recall biases. Finally, this study is cross-sectional and any attempt to determine causality or temporality in the association between handgrip and multimorbidity is not possible.

5. Conclusion

In the current study we observed a significant inverse relationship between handgrip strength and multimorbidity in males and females with 2 or more chronic diseases. Male participants with a low handgrip strength aged between 19 to 49 years with a BMI ≥25 kg/m² may be at greater risk of multimorbidity. This study highlights the need for further longitudinal studies to investigate the effects of increasing handgrip strength combined with weight loss, as an effective strategy to reduce the incidence of multimorbidity.

Author contributions

All authors involved in the conceptualization and design of the study. MRL carried out the analysis. All authors contributed to the manuscript. The final version of the manuscript was read and approved by all authors.

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