JOMH
Journal of Men's Health

J. Mens. Health **2022**; 18(10): 202
https://doi.org/10.31083/j.jomh1810202

Original Research

Multimorbidity and Health-Related Quality of Life in Korean Older Adults: A Mediation Analysis on Handgrip Strength

Jeonghyeon Kim[1], Inhwan Lee[1], Haeryun Hong[1], Hyunsik Kang[1,*]

[1]College of Sport Science, Sungkyunkwan University, 16419 Suwon, Republic of Korea
*Correspondence: hkang@skku.edu (Hyunsik Kang)
Submitted: 19 April 2022 Revised: 10 May 2022 Accepted: 13 May 2022 Published: 18 October 2022

Abstract

Background: The influence of handgrip strength on the relationship of multimorbidity with health-related quality of life (HRQoL) is unknown in geriatric populations. The current study investigated whether or not handgrip strength mediates the association between multimorbidity and HRQoL in a representative sample of Korean adults (3139 men/3753 women) aged 65 years and older. **Methods**: The data obtained from the 2014–2019 Korea National Health and Nutrition Examination Survey (KNHNES) were used in the current study. The EuroQoL group was used to assess HRQoL. Multimorbidity was defined as co-existence of more than one of the 26 diagnosed diseases specified in the KNHNES. A digital hand dynamometer was used to measure handgrip strength. The covariates included in this study were age, gender, parameters of body fatness, socio-demographics, and parameters of health behaviors. **Results**: Analysis of variance showed that HRQoL was inversely associated with number of chronic conditions and positively with relative handgrip strength. Particularly, a mediation analysis using the PROCESS macro in SPSS-PC showed that relative handgrip strength partially mediates the influence of multimorbidity on HRQoL. Bootstrapping showed that the indirect effect of comorbidity on HRQoL via relative handgrip strength was significant ($p < 0.001$) even after adjustments for all the covariates, explaining 8.1% the total effect. **Conclusions**: The findings of the study emphasize the importance of health-related physical fitness while managing and/or treating multiple chronic conditions for better HRQoL in geriatric populations.

Keywords: chronic conditions; muscular strength; quality of life; older adults

1. Introduction

Health-related quality of life (HRQoL) is a multidimensional concept consisting of an individual's physical, psychological, and social functioning over time and is greatly impacted by chronic conditions [1]. Measuring HRQoL can help evaluate the health outcomes of chronic conditions and provide additional and new information about the relationships between disease and risk factors [2].

Multimorbidity, which is defined as having two or more chronic illnesses, poses a serious burden to individuals, health care providers, and society [3]. In westernized countries, the prevalence of multimorbidity increases with age and is highest among the elderly [4]. The negative impact of multimorbidity on HRQoL has been observed in Chinse older adults [5] and European older adults [6]. Though multimorbidity is one of the most common health problems, it has not received much attention in health politics [7].

Handgrip strength, which is a convenient measure of maximum voluntary muscle strength, has prognostic value for many geriatric syndromes, including multimorbidity, cognitive impairments, impaired mobility, decreased functional capacity, and HRQoL [8]. Additionally, the association between handgrip strength and HRQoL has been reported in post-menopausal women [9], patients with arthritis [10], and cancer survivors [11].

Etiologically, handgrip strength was inversely related to multimorbidity in different populations. For example, low handgrip strength was independently associated with multimorbidity in German older women [12], Chinese adults and older living in Hong Kong [13], and Korean adults [14]. Analysis of the data obtained from 44,315 UK Biobank participants showed that multimorbidity was an independent predictor of decline in handgrip strength [15]. Together, the findings of these previous studies suggest that multimorbidity and low handgrip strength as biomarkers of HRQoL should be considered together because they are likely to be interconnected.

Korea is facing the fastest population aging among Organization for Economic Co-operation and Development (OECD) countries (https://data.oecd.org/pop/population.htm). As a result, the prevalence of geriatric syndromes, such as multimorbidity and functional impairments (i.e., limitations in mobility, strength, and cognition), has increased steadily, negatively contributing to HRQoL [13]. However, it is unknown whether or not the association between multimorbidity and HRQoL differs by handgrip strength. This study examined the mediating effect of handgrip strength on the relationship of multimorbidity with HRQoL in a representative sample of Korean older adults.

2. Methods and Materials

2.1 Data Source and Study Participants

This study used the data obtained from the 2014–2019 Korea National Health and Nutrition Examination Survey (KNHNES), which is an ongoing surveillance system to generate nationwide statistics about the health condition, health behaviors, and nutritional status of Koreans (https://knhanes.kdca.go.kr/knhanes/sub03/sub03_01.do). The survey sampling method is described elsewhere in a detailed manner [16]. Briefly, we selected 10,484 adults aged ≥65 years from a total of 37,491 survey participants aged ≥19 years. Those who had no data available about handgrip strength (n = 1557), health-related parameters (n = 741), HRQoL (n = 457), or covariates (n = 837) were then excluded. The remaining 6892 participants were included for the final data analyses (Fig. 1).

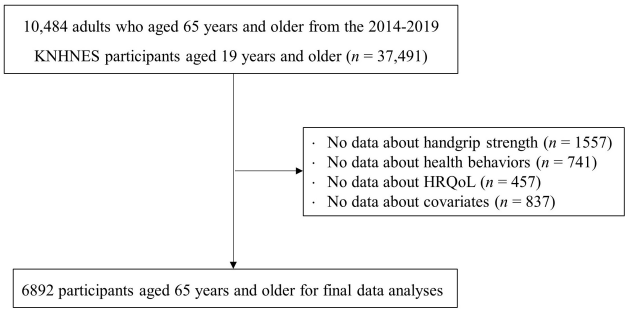

Fig. 1. A flowchart for selection of study participants. KNHNES, Korea National Health and Nutritional Examination Survey; HRQoL, health related-quality of life.

2.2 Study Variables

2.2.1 Assessment of HRQoL (Dependent Variable, DV)

HRQoL was assessed using the EuroQoL group consisting of a health-status descriptive system (EQ-5D) and a visual analogue scale (EQ-VAS). The EQ-5D assesses self-reported problems in 5 dimensions (i.e., mobility, selfcare, usual activities, pain/discomfort, and anxiety/depression) using a 3-point Likert scale (1 = no problems, 2 = some problems, and 3 = extreme problems). A summary index of the EQ-5D was produced based on the rating of the 5 dimensions, ranging from 0 (representing death) to 1 (representing full health). The participants were asked to self-rate "his/her health today" using a 0–100 scale (from worst imaginable health to best imaginable health) using the EQ-VAS. The validity and reliability of the EuroQoL group were tested and reported in a previous study involving Korean populations [17].

2.2.2 Chronic Diseases (Independent Variable, IV)

Multimorbidity was defined as having two or more of 16 chronic conditions specified in the KHNANES. The health conditions were hypertension, dyslipidemia, stroke, cardiomyopathy/angina, arthritis, asthma, diabetes mellitus, depression, liver cirrhosis, kidney failure, thyroid disease, liver cancer, stomach cancer, colon cancer, lung cancer, and tuberculosis. The presence of chronic condition(s) was self-declared based on doctor diagnosis.

2.2.3 Relative Handgrip Strength (Mediating Variable, MV)

Handgrip strength was measured with a digital hand dynamometer (TKK 5401, Takei Scientific Instruments Co., Ltd., Tokyo, Japan). The measurement of right and left handgrip strengths was performed in a standing position with feet shoulder width apart and the forearm held away from the body at the level of the thigh. Each participant conducted 3 attempts per hand, with a 1-minute rest between attempts. Relative handgrip strength was obtained by dividing the average of the three attempts by body mass index (BMI).

2.2.4 Covariates

Covariates were assessed using a self-reported questionnaire. Socio-demographics included age, gender (male or female), BMI (kg/m^2), waist circumference (WC), monthly household income, marital status (having a spouse or separated/divorced or never married), living condition (live with someone or alone), region (urban vs. rural), type of housing (apartment of general house), and education (elementary school or lower, middle/high school, or college or higher). Health behaviors included smoking (never or past/current), heavy alcohol consumption (≥15 weekly drinks for men per week and ≥8 drinks for women per week), and physical activity (PA). PA was assessed in units of METs using the global physical activity questionnaire (https://www.who.int/teams/noncommunicable-diseases/surveillance/systems-tools/physical-activity-surveillance).

2.3 Statistical Analyses

The Kolmogorov–Smirnov test was conducted to assess the normality of all data, and an appropriate transformation was performed if necessary. Analysis of variance was used to test linear trends in the variables by number of comorbidities and to test handgrip strength-based subgroup differences in the variables. Finally, the mediating effect of relative handgrip strength on the association between multimorbidity and HRQoL was tested based on the mediation paths proposed by Baron and Kenny [18], as illustrated in Fig. 2. The PROCESS macro in SPSS-PC (version 23.0, IBM Corporation, Armonk, NY, USA) was used to carry out the mediation analyses. A robustness p-value for the mediating effect was confirmed via the bootstrapping process. All statistical significances were tested at p = 0.05.

Table 1. Characteristics of study participants.

Variable	Men	Women	Total	*p*
	(*n* = 3139)	(*n* = 3753)	(*n* = 6892)	
Physical characteristics				
Age (year)	71.8 ± 5.2	71.9 ± 5.2	71.8 ± 5.2	0.582
Waist circumference (cm)	87.2 ± 8.7	84.4 ± 8.9	85.7 ± 9.0	<0.001
Body mass index (kg/m^2)	23.8 ± 2.9	24.5 ± 3.3	24.2 ± 3.1	<0.001
Socio-demographic status				
Income (10,000 won/month)	255.8 ± 263.0	218.8 ± 251.0	235.7 ± 257.2	<0.001
Education, n (%)				<0.001
Lower than elementary	1194 (38.0)	2603 (69.4)	3797 (55.1)	
Middle/high	1405 (44.8)	956 (25.5)	2361 (34.3)	
Over than college	540 (17.2)	194 (5.2)	734 (10.6)	
Living condition, n (%)				0.826
Live with someone	3117 (99.3)	3725 (99.3)	6842 (99.3)	
Alone	22 (0.7)	28 (0.7)	50 (0.7)	
Marital status, n (%)				<0.001
Married	2768 (88.2)	2024 (53.9)	4792 (69.5)	
Widow/divorced	349 (11.1)	1701 (45.3)	2050 (29.8)	
Unmarried	22 (0.7)	28 (0.7)	50 (0.7)	
Region, n (%)				0.498
Urban	2284 (72.8)	2758 (73.5)	5042 (73.2)	
Rural	855 (27.2)	995 (26.5)	1850 (26.8)	
Type of housing, n (%)				0.945
Apartment	1212 (38.6)	1446 (38.5)	2658 (38.6)	
General house	1927 (61.4)	2307 (61.5)	4234 (61.4)	
Health behaviors				
Smoking, n (%)	2478 (78.9)	181 (4.8)	2659 (38.6)	<0.001
Heavy alcohol, n (%)	390 (12.4)	77 (2.1)	457 (6.8)	<0.001
Physical activity (METs)	846.5 ± 1480.3	526.6 ± 929.0	672.3 ± 1222.0	<0.001
Health related quality of life				
EQ-5D dimensions				
Mobility, n (%)	786 (25.0)	1542 (41.1)	2328 (33.8)	<0.001
Self-care, n (%)	185 (5.9)	386 (10.3)	571 (8.3)	<0.001
Usual activities, n (%)	391 (12.5)	792 (21.1)	1183 (17.2)	<0.001
Pain/discomfort, n (%)	765 (24.4)	1588 (42.3)	2353 (34.1)	<0.001
Anxiety/depression, n (%)	311 (9.9)	640 (17.1)	951 (13.8)	<0.001
EQ-5D index	0.926 ± 0.12	0.869 ± 0.16	0.895 ± 0.15	<0.001
Number of chronic conditions, n (%)				<0.001
0	765 (24.4)	527 (14.0)	1292 (18.7)	
1	1031 (32.8)	955 (25.4)	1986 (28.8)	
≥2	1343 (42.8)	2271 (60.6)	3614 (52.5)	
Relative handgrip strength (kg/BMI)	1.31 ± 0.3	0.76 ± 0.2	1.01 ± 0.4	<0.001

EQ-5D, EuroQol five-dimensional; BMI, body mass index.

3. Results

Table 1 describes the study participants by gender. Overall, men had higher WC ($p < 0.001$), higher BMI ($p < 0.001$), stronger handgrip strength ($p < 0.001$), higher income ($p < 0.001$), and longer education ($p < 0.001$) and were more likely to be married ($p < 0.001$) compared to women. Additionally, men had higher rates of smoking ($p < 0.001$) and alcohol consumption ($p < 0.001$) and higher levels of physical activity ($p < 0.001$) compared to women. Men also had a better HRQoL ($p < 0.001$) compared to women.

Table 2 compares the measured parameters according to multimorbidity. There were positive linear trends in age ($p < 0.001$), WC ($p < 0.001$), and BMI ($p < 0.001$), in conjunction with negative linear trends in income ($p < 0.001$), marital status ($p < 0.001$), and education ($p < 0.001$) according to increasing number of comorbidities. There were inverse linear trends in smoking ($p < 0.001$), alcohol con-

Table 2. Comparison of measurement variables according to number of chronic conditions (Mean ± SD).

Variables	Number of chronic conditions			*p for trend*
	0 (n = 1292)	1 (n = 1986)	≥2 (n = 3614)	
Physical characteristics				
Age (year)	70.6 ± 5.1	71.8 ± 5.2	72.3 ± 5.2	<0.001
Waist circumference (cm)	82.8 ± 8.6	84.7 ± 8.8	87.3 ± 8.8	<0.001
Body mass index (kg/m^2)	23.0 ± 2.8	23.8 ± 3.0	24.8 ± 3.1	<0.001
Socio-demographic status				
Income (10,000 won/month)	268.6 ± 275.4	231.2 ± 253.4	226.4 ± 251.5	<0.001
Education, n (%)				<0.001
Lower than elementary	596 (46.1)	1057 (53.2)	2144 (59.3)	
Middle/high	463 (35.8)	725 (36.5)	1173 (32.5)	
Over than college	233 (18.1)	204 (10.3)	297 (8.2)	
Living condition, n (%)				<0.001
Live with someone	1283 (99.3)	1974 (99.4)	3585 (99.2)	
Alone	9 (0.7)	12 (0.6)	29 (0.8)	
Marital status, n (%)				<0.001
Married	1006 (77.9)	1469 (74.0)	2317 (64.1)	
Widow/divorced	277 (21.4)	505 (25.4)	1268 (35.1)	
Unmarried	9 (0.7)	12 (0.6)	29 (0.8)	
Region, n (%)				0.320
Urban	950 (73.5)	1415 (71.2)	2677 (74.1)	
Rural	342 (26.5)	571 (28.8)	937 (25.9)	
Type of housing, n (%)				0.713
Apartment	526 (40.7)	722 (36.4)	1410 (39.0)	
General house	766 (59.3)	1264 (63.6)	2204 (61.0)	
Health behaviors				
Smoking, n (%)	602 (46.6)	862 (43.4)	1195 (33.1)	<0.001
Heavy alcohol, n (%)	111 (8.6)	149 (7.5)	207 (5.7)	<0.001
Physical activity (METs)	826.0 ± 1394.7	708.8 ± 1245.1	597.2 ± 1134.1	<0.001
Health related quality of life	–			
EQ-5D problems				
Mobility, n (%)	227 (17.6)	599 (30.2)	1502 (41.6)	<0.001
Self-care, n (%)	39 (3.0)	128 (6.4)	404 (11.2)	<0.001
Usual activities, n (%)	97 (7.5)	280 (14.1)	806 (22.3)	<0.001
Pain/discomfort, n (%)	278 (21.5)	597 (30.1)	1478 (40.9)	<0.001
Anxiety/depression, n (%)	108 (8.4)	239 (12.0)	604 (16.7)	<0.001
EQ-5D index	0.94 ± 0.1	0.90 ± 0.1	0.87 ± 0.2	<0.001
Relative handgrip strength (kg/BMI)	1.2 ± 0.4	1.0 ± 0.4	0.9 ± 0.3	<0.001

EQ-5D, EuroQol five-dimensional; BMI, body mass index.

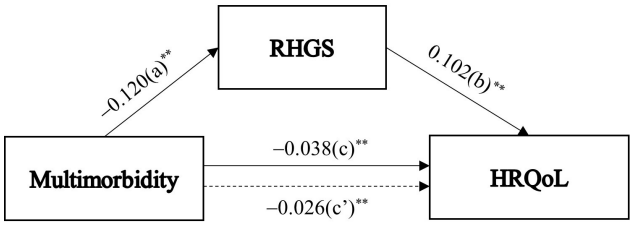

Fig. 2. A mediation analysis for the relationship of multimorbidity and relative handgrip strength (RHGS) with health-related quality of life (HRQoL). $^{**}p < 0.001$.

sumption ($p < 0.001$), physical activity ($p < 0.001$), and HRQoL ($p < 0.001$) according to increasing number of comorbidities.

Table 3 presents the descriptive statistics of measured parameters by relative handgrip strength. Individuals with high handgrip strength were younger ($p < 0.001$), had lower WC ($p < 0.001$) and lower BMI ($p < 0.001$) in conjunction with higher income ($p < 0.001$), longer education ($p < 0.001$), and higher rates of marriage ($p = 0.003$) and living in an urban area ($p < 0.001$) compared to individuals with low handgrip strength. Individuals with high handgrip strength were more physically active ($p < 0.001$) and had fewer chronic conditions ($p < 0.001$) in conjunction with better HRQoL ($p < 0.001$) compared to individuals with low handgrip strength.

As shown in Table 4 and Fig. 2, the mediating effect of RHS on the association between comorbidity and HRQoL was tested using the PROCESS macro with a bootstrapping

Table 3. Baseline characteristics according to relative handgrip strength.

Variables	Relative handgrip strength		*p* value
	Low (*n* = 3443)	High (*n* = 3449)	
Physical characteristics			
Age (year)	72.1 ± 5.5	71.5 ± 4.9	<0.001
Waist circumference (cm)	88.2 ± 9.0	83.2 ± 8.2	<0.001
Body mass index (kg/m^2)	25.1 ± 3.2	23.2 ± 2.7	<0.001
Socio-demographic status			
Income (10,000 won/month)	223.9 ± 254.2	247.4 ± 259.6	<0.001
Education, n (%)			<0.001
Lower than elementary	2091 (60.7)	1706 (49.5)	
Middle/high	1037 (30.1)	1324 (38.4)	
Over than college	315 (9.2)	419 (12.1)	
Living condition, n (%)			0.460
Live with someone	3411 (99.1)	3431 (99.5)	
Alone	32 (0.9)	18 (0.5)	
Marital status, n (%)			<0.001
Married	2302 (66.9)	3490 (72.2)	
Widow/divorced	1109 (32.2)	941 (27.3)	
Unmarried	32 (0.9)	18 (0.5)	
Region, n (%)			0.003
Urban	2464 (71.6)	2578 (74.7)	
Rural	979 (28.4)	871 (25.3)	
Type of housing, n (%)			0.433
Apartment	1312 (38.1)	1346 (39.0)	
General house	2131 (61.9)	2103 (61.0)	
Heath behaviors			
Smoking, n (%)	1347 (39.1)	1312 (38.0)	0.356
Heavy alcohol, n (%)	246 (7.1)	221 (6.4)	0.223
Physical activity (METs)	562 ± 1130	783 ± 1298	<0.001
Health related quality of life			
EQ-5D problems			
Mobility, n (%)	1370 (39.8)	958 (27.8)	<0.001
Self-care, n (%)	391 (11.4)	180 (5.2)	<0.001
Usual activities, n (%)	717 (20.8)	466 (13.5)	<0.001
Pain/discomfort, n (%)	1302 (37.8)	1,051 (30.5)	<0.001
Anxiety/depression, n (%)	537 (15.6)	414 (12.0)	<0.001
EQ-5D index	0.87 ± 0.2	0.92 ± 0.1	<0.001
Number of comorbidities, n (%)			<0.001
0	532 (15.5)	760 (22.0)	
1	908 (26.3)	1078 (31.3)	
≥2	2003 (58.2)	1611 (46.7)	

EQ-5D, EuroQol five-dimensional.

procedure. Mediation analysis showed that comorbidity had a direct effect on HRQoL independent of relative handgrip strength (β for path c' = –0.026, $p < 0.001$). However, comorbidity also had an indirect effect on HRQoL through its effect on RHS. Comorbidity was negatively associated with relative handgrip strength (β for path a = –0.120, $p < 0.001$), and relative handgrip strength was positively associated with HRQoL (β for path b = 0.102, $p < 0.001$). Additionally, comorbidity and relative handgrip strength remained significant predictors of HRQoL even after adjusting for all the covariates in Model 2 (β for path c' = –0.021, $p < 0.001$; β for a = –0.024, $p < 0.001$; β for path b = 0.064, $p < 0.001$). Bootstrapping showed that the indirect effect of comorbidity on HRQoL via relative handgrip strength remained significant ($p < 0.001$) even after adjustments for all the covariates, explaining 8.1% the total effect (partial mediation).

4. Discussion

This population-based study examined the relationships between relative handgrip strength, multimorbidity, and HRQoL in 6892 Korean older adults. Overall, our findings suggest that multimorbidity and relative handgrip strength are significantly related to HRQoL. To the

Table 4. A mediating analysis of relative handgrip strength for the relationship between multimorbidity and health-related quality of life.

Path	Model 1		Model 2	
	β	95% CI	β	95% CI
Multimorbidity → RHGS, a	–0.120**	–0.131 to –0.109	–0.024**	–0.032 to –0.016
RHGS → HRQoL, b	0.102**	0.093 to 0.111	0.064**	0.051 to 0.077
Total effect, c	–0.038**	–0.042 to –0.033	–0.023**	–0.030 to –0.018
Direct effect, c'	–0.026**	–0.023 to –0.021	–0.021**	–0.026 to –0.017
Indirect effect, ab	–0.012	–0.014 to –0.011	–0.002	–0.002 to –0.001
Ratio of indirect to total effect mediated (%)	31.5		8.6	

Model 1 unadjusted.

Model 2 adjusted for age, sex, income, education, marital status, smoking, heavy alcohol, physical activity, iron intake, protein intake, vitamin C intake, and hemoglobin.

Number of bootstrap samples for bias-corrected bootstrap confidence intervals: 10,000.

RHGS, relative hand grip strength; HRQoL, health related quality of life; CI, confidence interval.

*$p < 0.05$, **$p < 0.001$.

In the mediation model, the indirect effect is the product of path coefficients a (multimorbidity → RHGS) and b (RHGS → HRQoL). The direct effect is the coefficient c' (multimorbidity → HRQoL). The total effect (c) is equal to the sum of the direct and indirect (c' + ab).

best of our knowledge, we are the first to report that relative handgrip strength partially mediates the relationship of multimorbidity and HRQoL in Korean older adults; along with multimorbidity itself, decline in muscular strength attributable to chronic condition(s) can have an impact on HRQoL.

The current findings are in the line with previous study reports of multimorbidity as a biomarker for HRQoL. In a cross-sectional study, Bao *et al.* [19] showed that HRQoL was inversely related to increasing number of chronic conditions in 18,137 Chinese middle-aged and elderly adults, with co-occurrence of chronic pain and bone disease having the greatest impact. Coexistence of hypertension and arthritis had the highest negative impact on HRQoL in Korean older adults who participated in the 2013–2014 Korean National Health and Nutrition Examination Survey [20]. Furthermore, multimorbidity was inversely related to HRQoL of patients with mental health problems [21], patients undergoing total hip arthroplasty or total knee arthroplasty [22], and primary care users [23].

Additionally, the current findings support an association between handgrip strength and HRQoL. In a cross-sectional study, handgrip strength was positively related to HRQoL in 176 older community dwellers [24]. In a study involving 38 elderly women and 11 elderly men, handgrip strength at baseline was a predictor for decline in HRQoL during a 3-month detraining period following a 9-month intervention [25]. Hart [26] showed that handgrip strength was positively and independently related to HRQoL in a subgroup of physically inactive individuals who participated in the 2013–2014 National Health and Nutrition Examination Survey. In Korea, handgrip strength was also positively related to HRQoL of patients with chronic diseases [8–10].

With respect to multimorbidity and handgrip strength as biomarkers of HRQoL, we conducted a causal mediation analysis in which total effect is divided into direct and indirect effects. This is the first study to report that decline in handgrip strength attributable to multimorbidity partially mediates the direct impact of the chronic condition on HRQoL in Korean older adults.

The current findings support previous studies examining the associations between physical fitness, chronic diseases, and HRQoL in different populations. In our previous study, for example, we showed that cardiorespiratory fitness mediates the impact of comorbidities on HRQoL in patients with diabetes [27]. By conducting a survey study involving 3243 rural older adults, Hao *et al.* [28] showed that physical disability and physical inactivity mediate the relationship of physical frailty with HRQoL. By analyzing the data obtained from the 2014–2016 Confucius Hometown Aging Project, She *et al.* [5] showed that the relationship between multimorbidity and HRQoL differed by functional dependence and depressive symptoms in Chinese older adults. Together, the current and previous findings suggest that decline in muscular strength attributable to chronic condition(s) may act as a partial mediator in determining the impact of multimorbidity on HRQoL.

Out study has some limitations. First, the relationship between multimorbidity and low handgrip strength can be bidirectional [29]. Multimorbidity can result in physical and functional declines, which can impact the severity and burden of multimorbidity. Unfortunately, however, any causal inference about the relationship between multimorbidity and relative handgrip strength cannot be possible due to the cross-sectional nature of the study. Second, it is reasonable to speculate that diseases belonging to the most common combination of multiple chronic diseases

interact, curtailing compensatory mechanisms, resulting in physical and cognitive declines, and consequently impairing HRQoL [20]. This should be further investigated in a well-designed prospective study. Third, predisposed conditions, enabling, need factors, and other health behaviors can contribute to impaired HRQoL [30], and they should be considered in a future study so that the relationships between risk factors and HRQoL can be better delineated.

Even with the limitations, this study has some strengths. First, this is a population-based study using a large sample size of Korean older adults. Second, to the best of our knowledge, we are the first to report that the negative impact of multimorbidity on HRQoL may be attenuated by muscular strength in Korean older adults.

5. Conclusions

Even though multimorbidity is one of the most common health conditions of industrialized countries, treatment of people with chronic diseases has gained much attention in health politics. From a public health perspective, the associations between handgrip strength, multimorbidity, and HRQoL observed in the current study emphasizes the importance of health-related physical fitness while managing and/or treating multiple chronic conditions, and this should be prioritized when developing future healthcare policies of HRQoL for Korean older adults.

Abbreviations

HRQoL, health related quality of life; KNHNES, Korea National Health and Nutrition Examination Survey; OECD, Organization for Economic Co-operation and Development (OECD); EQ-5D, a health-status descriptive system; EQ-VAS, a visual analogue scale; DV, dependent variable; IV, independent variable; MV, mediating variable; PA, physical activity; BMI, body mass index; WC, waist circumference.

Availability of Data and Materials

The datasets used and/or analysed during the current study are publicly available from the Korea Disease Control and Prevention Agency (https://knhanes.kdca.go.kr/knhanes/sub03/sub03_01.do).

Author Contributions

Conceptualization—JK and HK; methodology—JK and HK; validation—IL, HH, and HK; investigation—JK, IL, and HK; data curation—JK, IL, HH, and HK; writing-original draft preparation—JK and HK; supervision—HH and HK; and project administration—HH and HK. All authors have read and approved the final manuscript.

Ethics Approval and Consent to Participate

The Institutional Review Board of the Korea Centre for Disease Control and Prevention in accordance with the Declaration of Helsinki reviewed and approved the KNHANES (2013-12EXP-03-5C and 2018-01-03-P-A). Informed consent was obtained from all the participants.

Acknowledgment

We would like to thank the Korea Center for Disease Control and Prevention for approving my application to access the data.

Funding

This study was supported by a National Research Foundation grant funded by the Korean government (NRF-2020R1A2C1009365).

Conflict of Interest

The authors declare no conflict of interest. HK is serving as one of the Editorial Board members of this journal. We declare that HK had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to Daniel A. Marinho.

References

[1] The WHOQOL Group. The World Health Organization Quality of Life Assessment (WHOQOL). Development and psychometric properties. Social Science & Medicine. 1998; 46: 1569–1585.

[2] Raina S. State of the Globe: Health-related quality of life as health status measure: Time to move on. Journal of Global Infectious Diseases. 2019; 11: 89.

[3] Navickas R, Petric V, Feigl AB, Seychell M. Multimorbidity: what do we Know? What should we do? Journal of Comorbidity. 2016; 6: 4–11.

[4] Makovski TT, Schmitz S, Zeegers MP, Stranges S, van den Akker M. Multimorbidity and quality of life: Systematic literature review and meta-analysis. Ageing Research Reviews. 2019; 53: 100903.

[5] She R, Yan Z, Jiang H, Vetrano DL, Lau JTF, Qiu C. Multimorbidity and Health-Related Quality of Life in Old Age: Role of Functional Dependence and Depressive Symptoms. Journal of the American Medical Directors Association. 2019; 20: 1143–1149.

[6] Makovski TT, Le Coroller G, Putrik P, Choi YH, Zeegers MP, Stranges S, *et al*. Role of clinical, functional and social factors in the association between multimorbidity and quality of life: findings from the Survey of Health, Ageing and Retirement in Europe (SHARE). PLoS ONE. 2020; 15: e0240024.

[7] Marengoni A, Angleman S, Melis R, Mangialasche F, Karp A, Garmen A, *et al*. Aging with multimorbidity: a systematic review of the literature. Ageing Research Reviews. 2011; 10: 430–439.

[8] Rijk JM, Roos PR, Deckx L, van den Akker M, Buntinx F. Prognostic value of handgrip strength in people aged 60 years and older: a systematic review and meta-analysis. Geriatrics & Gerontology International. 2016; 16: 5–20.

[9] Hong YS, Kim H. Hand grip strength and health-related quality of life in postmenopausal women: a national population-based study. Menopause. 2021; 28: 1330–1339.

[10] Chang S-Y, Hand B-D, Han K-D, Park H-J, Kang S. Relation between handgrip strength and quality of life in patients with

arthritis in Korea: the Korea National Health and Nutrition Examination Survey, 2015-2018. Medicina. 2022; 58: 172.
[11] Paek J, Choi YJ. Association between hand grip strength and impaired health-related quality of life in Korean cancer survivors: a cross-sectional study. BMJ Open. 2019; 9: e030938.
[12] Volaklis KA, Halle M, Thorand B, Peters A, Ladwig KH, Schulz H, *et al*. Handgrip strength is inversely and independently associated with multimorbidity among older women: Results from the KORA-Age study. European Journal of Internal Medicine. 2016; 31: 35–40.
[13] Cheung C, Nguyen UDT, Au E, Tan KCB, Kung AWC. Association of handgrip strength with chronic diseases and multimorbidity: a cross-sectional study. AGE. 2013; 35: 929–941.
[14] Lee M, 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: e23994.
[15] Hurst C, Murray JC, Granic A, Hillman SJ, Cooper R, Sayer AA, *et al*. Long-term conditions, multimorbidity, lifestyle factors and change in grip strength over 9 years of follow-up: Findings from 44,315 UK biobank participants. Age and Ageing. 2021; 50: 2222–2229.
[16] Oh K, Kim Y, Kweon S, Kim S, Yun S, Park S, *et al*. Korea National Health and Nutrition Examination Survey, 20th anniversary: accomplishments and future directions. Epidemiology and Health. 2021; 43: e2021025.
[17] Kim SH, Hwang JS, Kim TW, Hong YS, Jo M. Validity and reliability of the EQ-5D for cancer patients in Korea. Supportive Care in Cancer. 2012; 20: 3155–3160.
[18] Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. Journal of Personality and Social Psychology. 1986; 51: 1173–1182.
[19] Bao X, Xie Y, Zhang X, Peng X, Huang J, Du Q, *et al*. The association between multimorbidity and health-related quality of life: a cross-sectional survey among community middle-aged and elderly residents in southern China. Health and Quality of Life Outcomes. 2019; 17: 107.
[20] Park B, Ock M, Lee HA, Lee S, Han H, Jo M, *et al*. Multimorbidity and health-related quality of life in Koreans aged 50 or older using KNHANES 2013–2014. Health and Quality of Life Outcomes. 2018; 16: 186.
[21] Gonzalez-Chica DA, Hoon E, Stocks N. Multimorbidity, health-related quality of life and health service use among individuals with mental health problems: Urban-rural differences in South Australia. Australian Journal of Rural Health. 2020; 28: 110–119.
[22] Zhang L, Lix LM, Ayilara O, Sawatzky R, Bohm ER. The effect of multimorbidity on changes in health-related quality of life following hip and knee arthroplasty. the Bone & Joint Journal. 2018; 100-B: 1168–1174.
[23] Peters M, Kelly L, Potter CM, Jenkinson C, Gibbons E, Forder J, *et al*. Quality of life and burden of morbidity in primary care users with multimorbidity. Patient Related Outcome Measures. 2018; 9: 103–113.
[24] Halaweh H. Correlation between Health-Related Quality of Life and Hand Grip Strength among Older Adults. Experimental Aging Research. 2020; 46: 178–191.
[25] Esain I, Rodriguez-Larrad A, Bidaurrazaga-Letona I, Gil SM. Health-related quality of life, handgrip strength and falls during detraining in elderly habitual exercisers. Health and Quality of Life Outcomes. 2017; 15: 226.
[26] Hart PD. Grip Strength and Health-Related Quality of Life in U.S. Adult Males. Journal of Lifestyle Medicine. 2019; 9: 102–110.
[27] Lee I, Kim S, Kang H. Non-Exercise Based Estimation of Cardiorespiratory Fitness Mediates Associations between Comorbidities and Health-Related Quality of Life in Older Korean Adults with Diabetes. International Journal of Environmental Research and Public Health. 2020; 17: 1164.
[28] Hao W, Li J, Fu P, Zhao D, Jing Z, Wang Y, *et al*. Physical frailty and health-related quality of life among Chinese rural older adults: a moderated mediation analysis of physical disability and physical activity. BMJ Open. 2021; 11: e042496.
[29] Ryan A, Wallace E, O'Hara P, Smith SM. Multimorbidity and functional decline in community-dwelling adults: a systematic review. Health and Quality of Life Outcomes. 2015; 13: 168.
[30] Lee E, Cha S, Kim GM. Factors affecting health-related quality of life in multimorbidity. Healthcare. 2021; 9: 334.