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ORIGINAL RESEARCH

Impact of Low Hand Grip Strength on Quality of Life, Utilization of Healthcare, and Mental Health in Individuals with Airflow Limitation

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Purpose: A higher prevalence of sarcopenia has been demonstrated in individuals with airflow limitation (AFL). However, data on the impact of sarcopenia on quality of life, utilization of healthcare, and mental health in individuals with AFL are limited.

Patients and methods: We used data from the 2014–2019 Korea National Health and Nutrition Examination Survey (KNHANES), and participants with AFL were included. Sarcopenia was assessed using hand grip strength (HGS). The outcomes were health-related quality of life (HRQoL), utilization of healthcare, and mental health. The impact of low HGS and outcomes was assessed using multivariable logistic regression analysis.

Results: Among participants with AFL, 12.6% had low HGS and the median (interquartile range) of HGS was 22.5 (18.9–26.1) kg for women and 37.7 (32.9–42.6) kg for men. After adjusting for confounders, low HGS was associated with a decrease in HRQoL (usual activities: adjusted odds ratio [aOR], 1.70; 95% confidence interval [CI], 1.14–2.54; pain/discomfort: aOR, 1.44; 95% CI, 1.02–2.02, anxiety/depression: aOR, 1.59; 95% CI, 1.05–2.41), and increased perceived stress (aOR, 1.77; 95% CI, 1.24–2.53). In the subgroup analysis, the impact of low HGS on HRQoL, utilization of healthcare, and mental health was more evident in the reduced lung function and inactive physical activity groups.

Conclusion: Overall, low HGS was associated with decreased quality of life and worsening mental health in participants with AFL. Our findings underscore the importance of muscle strength for HRQoL, particularly in those with impaired lung function and sedentary lifestyles, suggesting that regular physical activity including muscle-strengthening exercises may improve HRQoL.

Plain Language Summary: People with chronic lung disease often have a higher prevalence of sarcopenia, but it is unclear how this affects their daily life and mental health. In this study, we analyzed national health data from Korea and found that among people with airflow limitation, low hand grip strength was more likely to be associated with poorer quality of life, higher stress levels, and increased use of healthcare services. These issues were more pronounced in people with reduced lung function and low physical activity. Our findings underscore the importance of muscle strength for better quality of life, particularly in those with impaired lung function and sedentary lifestyles, suggesting that regular physical activity including muscle-strengthening exercises may improve quality of life.

Keywords: chronic obstructive pulmonary disease, lung diseases, obstructive, sarcopenia, muscle strength

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Introduction

Chronic obstructive pulmonary disease (COPD) is one of the leading causes of morbidity, disability, and mortality worldwide.[1] The prevalence and burden of COPD are projected to increase in the coming decades as global life expectancy rises. Consequently, individuals with COPD will require lifelong management throughout their aging process. Along with the prevalent comorbidities among individuals with COPD,[2,3] progressive reduction in muscle strength eventually leads to decreased exercise capacity and further physical deconditioning.[4,5] Due to the complex and heterogeneous properties of the disease, the management of COPD involves not only pharmacological therapies but also interventions to improve the physical and psychological conditions of the patients.[6] Accordingly, a comprehensive assessment of the overall physical status of individuals with COPD beyond standard lung function measurements is essential.

Sarcopenia is a progressive and generalized skeletal muscle disorder that is recognized as an independent condition.[7] It is a clinical syndrome with multiple contributing factors, such as physical inactivity, malnutrition, and chronic diseases, including COPD.[8] Sarcopenia is observed more frequently in individuals with COPD than in age-matched controls.[9] Sarcopenia is associated with reduced functional performance, exercise capacity, and quality of life in individuals with COPD.[8] Given the heterogeneity of symptoms and pathophysiological features among individuals with COPD, the loss of muscle strength in individuals with COPD may differ despite a similar degree of airflow obstruction. However, limited data is available on the impact of sarcopenia on quality of life, utilization of healthcare, and mental health among individuals with COPD of similar severity.

Korea has a nationally representative database that contains HGS, pre-bronchodilator lung function measurement, and questionnaires evaluating quality of life, utilization of healthcare, and mental health. Sarcopenia is closely associated with reduced handgrip strength (HGS), which is a widely recommended tool to assess sarcopenia.[10] Airflow limitation (AFL), defined by spirometry as reduced forced expiratory volume in 1s (FEV_1)/forced vital capacity (FVC) ratio, is a hallmark diagnostic criterion for COPD and reflects impaired respiratory function, making it an appropriate representative measure for assessing an association between sarcopenia and COPD-related health outcomes.[11] Therefore, our objective was to assess the impact of low HGS on health-related quality of life (HRQoL), utilization of healthcare, and mental health in individuals with AFL.

Methods

Study Population

The Korea National Health and Nutrition Examination Survey (KNHANES) is a nationwide government-administered survey. Participants were included using a multistage stratified probability sampling method. Several studies have been conducted on COPD and AFL using data from this survey.[12–15] We used KNHANES data from 2014 to 2019. In the KNHANES, lung function measurements were performed only in participants aged ≥40 years. AFL was defined as pre-bronchodilator FEV_1/FVC <0.7.

For 6 years, a total of 46,171 participants were included in this study. Of the 46,171 participants, 19,377 aged <40 years and 9,625 with missing baseline measurements were excluded. Among the remaining 17,169 adults aged >40 years, 14,777 participants without AFL were excluded. Finally, a total of 2,392 participants were included in the analysis (Figure 1).

Hand Grip Strength

The HGS was measured using a digital grip strength dynamometer (TKK 5401; Takei Scientific Instruments Co., Ltd., Tokyo, Japan). The maximum HGS was measured in kilogram (kg) on both left and right arms, three times each. The highest value among the six measurements was used to define the HGS. Low HGS was determined using Asian criteria from the Asian Working Group for Sarcopenia.[16] The cut-off values for low HGS were 28 kg for men and 18 kg for women. Normal HGS was defined as HGS values above the cut-off for low HGS.

Quality of Life, Utilization of Healthcare, and Mental Health

The outcomes assessed were HRQoL, utilization of healthcare, and mental health. We used the EQ-5D to assess HRQoL, which consists of five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression.[17] The

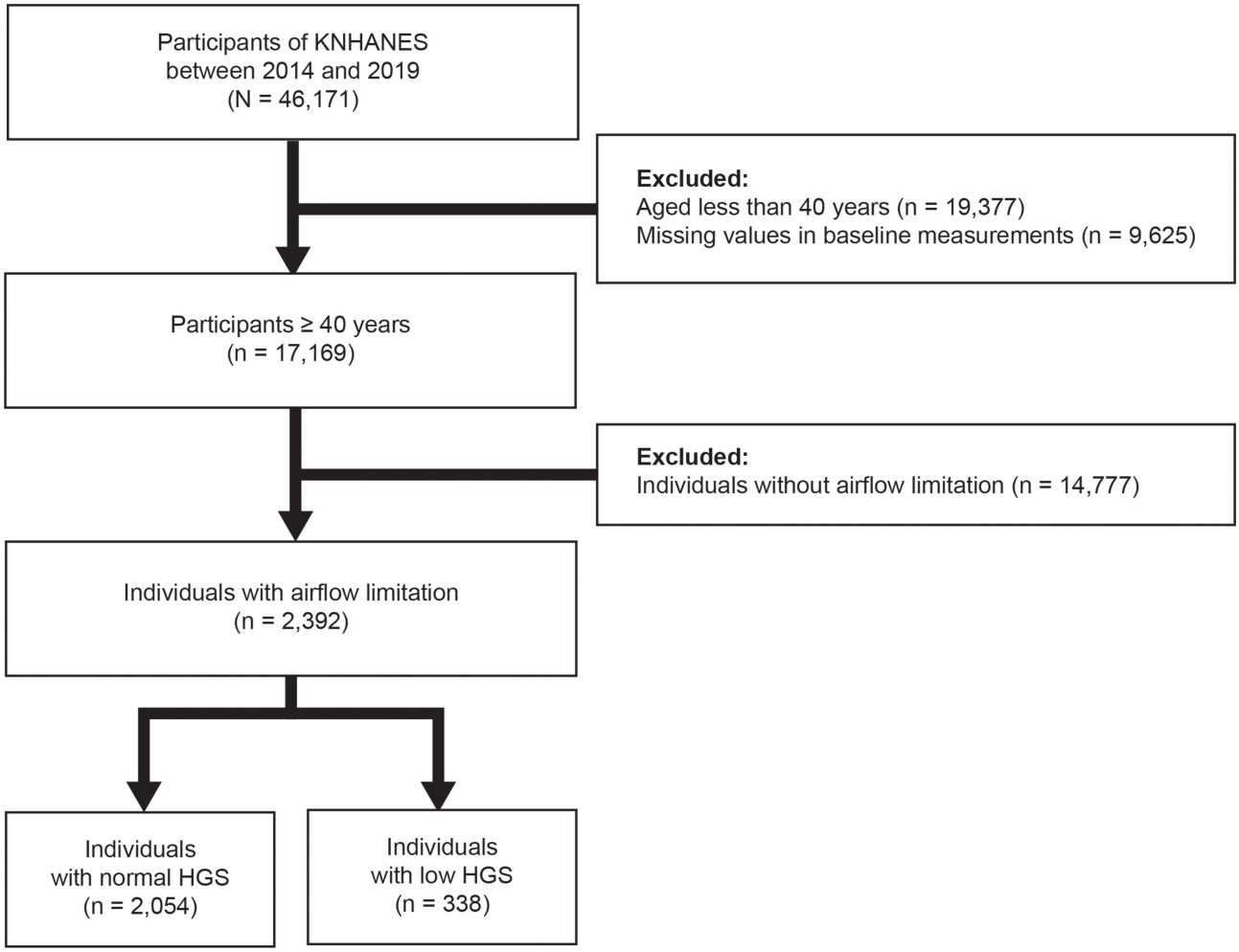

Figure 1 Flow chart of the study population.
Abbreviations: KNHANES, Korea National Health and Nutrition Examination Survey; HGS, hand grip strength.

decrease in HRQoL was defined when the participant responded that he/she had a problem in each dimension. Hospital admission was used to investigate healthcare utilization, defined as any hospitalization in the last year. Among mental health items, perceived stress was assessed using a questionnaire.

Adjustment for Covariates

Body mass index (BMI) was calculated by dividing weight (kg) by the square of height (m^2). BMI (kg/m^2) was categorized as follows: normal weight (18.5 to <24.9), underweight (<18.5), and overweight/obesity (≥25) according to the classifications of the Korean Society for the Study of Obesity.[18] Income was defined as low, intermediate, or high corresponding to the lowest, second to third, and highest quartiles of monthly income, respectively. Pulmonary function was assessed using a spirometer (Vyntus Spiro; Care Fusion, SanDiego, CA, USA) or a dry rolling seal spirometer (model 2130; SensorMedics Corporation, Yorba Linda, CA, USA) according to the American Thoracic Society/European Respiratory Society guidelines.[19] Since KNHANES does not include post-bronchodilator spirometry, pre-bronchodilator values were used. Predicted FVC and FEV_1 were calculated using the Korean reference equations.[20] The Korean formula for the predicted values was used to calculate the predicted FVC and FEV_1. Respiratory symptoms (chronic cough and sputum production), physical limitations, and comorbidities were assessed using self-questionnaires.[13] Physical activity was assessed using the Global Physical Activity Questionnaire (GPAQ) and presented as metabolic equivalent of task (MET) minutes per week.[21]

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Statistical Analyses

Data are expressed as weighted percentages (standard errors). Differences between participants based on the presence of low HGS were assessed using Pearson's chi-square test. Multivariate logistic regression analysis was used to assess the impact of low HGS on HRQoL, utilization of healthcare, and mental health. In the adjustment, age, sex, categorized BMI, smoking status, income, education, respiratory symptoms, FEV_1%predicted, and comorbidities (a history of pulmonary tuberculosis, asthma, hypertension, and diabetes mellitus) were included. A subgroup analysis was performed for clinically significant variables–lung function (FEV_1%predicted) and physical activity (METS-min/week)–in management of individuals with AFL. The cut-off for FEV_1 and physical activity was determined as 80%predicted and 600 METS-min/week according to the severity grade of AFL and physical activity level recommended by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) and World Health Organization (WHO).[22,23]

We performed a post-hoc analysis among individuals with low HGS to examine whether activity physical activity could reduce the burden of HRQoL, utilization of healthcare, and mental health. We used the "survey" package of R to adjust the sampling weights, and those adjustments were used in all analyses. Data for participants in the single primary survey unit were centered on the grand mean instead of the stratum mean. A two-sided p-value of <0.05 was considered statistically significant. All analyses were performed with R version 4.1.2 (R Core Team 2021; R Foundation for Statistical Computing, Vienna, Austria).

Results

Baseline Characteristics

The baseline characteristics of the study population are presented in Table 1. The weighted mean age was 64.9 years; 73.9% were men and 67.6% were ever smokers. Of the total individuals, 12.6% had a low HGS. Individuals with low HGS were older (72.9 years vs 63.7 years, $p < 0.001$), and the proportion of men (56.7% vs 76.4%, $p < 0.001$) and

Table 1 Baseline Characteristics of the Study Population

Variables	Total (N = 2,392)	With Normal HGS (n = 2,054)	With Low HGS (n = 338)	*P*
Age	64.9 (0.3)	63.7 (0.3)	72.9 (0.5)	<0.001
Males	73.9 (1.0)	76.4 (1.0)	56.7 (2.9)	<0.001
BMI, kg/m^2				0.001
Underweight (<18.5)	2.1 (0.3)	1.7 (0.3)	4.4 (1.3)	
Normal weight (18.5–24.9)	65.4 (1.1)	64.7 (1.2)	70.6 (2.7)	
Overweight/obesity (≥25)	32.5 (1.1)	33.6 (1.2)	25.0 (2.5)	
Smoking status				<0.001
Never smoker	32.4 (1.1)	30.8 (1.2)	43.7 (2.9)	
Ex-smoker	38.6 (1.2)	39.5 (1.3)	32.6 (2.8)	
Current smoker	29.0 (1.1)	29.7 (1.2)	23.7 (2.8)	
Income				<0.001
Low	26.0 (1.1)	25.1 (1.2)	32.8 (2.8)	
Intermediate	49.5 (1.2)	49.3 (1.3)	50.5 (3.1)	
High	24.5 (1.2)	25.6 (1.3)	16.8 (2.4)	
Education				<0.001
Elementary school graduate	34.6 (1.3)	30.6 (1.3)	61.7 (3.0)	
Middle/high school graduate	45.1 (1.2)	46.8 (1.3)	32.9 (2.9)	
College graduate	20.4 (1.1)	22.6 (1.2)	5.4 (1.5)	
Symptoms				
Any respiratory symptoms	11.0 (0.8)	9.9 (0.8)	18.8 (2.3)	<0.001
Cough	5.0 (0.5)	4.2 (0.5)	10.5 (1.8)	0.001
Sputum	9.5 (0.7)	8.6 (0.7)	15.5 (2.1)	0.002

(*Continued*)

Table 1 (Continued).

Variables	Total (N = 2,392)	With Normal HGS (n = 2,054)	With Low HGS (n = 338)	*P*
Physical activity, MET-min/week				<0.001
<600	56.1 (1.2)	54.1 (1.3)	69.5 (1.3)	
≥600	43.9 (1.2)	45.9 (2.7)	30.5 (2.7)	
Comorbidities				
Pulmonary tuberculosis	9.7 (0.7)	9.7 (0.8)	9.9 (2.0)	0.928
Asthma	7.3 (0.6)	6.5 (0.6)	13.3 (2.1)	0.001
Hypertension	48.0 (1.2)	46.0 (1.3)	61.8 (2.9)	<0.001
Diabetes mellitus	19.1 (1.0)	18.4 (1.0)	24.2 (2.5)	0.031
Lung function				
FVC, L	3.6 (0.0)	3.7 (0.0)	2.8 (0.0)	<0.001
FVC, %predicted	88.3 (0.4)	89.1 (0.4)	82.4 (1.0)	<0.001
FEV_1, L	2.3 (0.0)	2.4 (0.0)	1.7 (0.0)	<0.001
FEV_1, %predicted	77.1 (0.4)	77.5 (0.4)	73.8 (1.1)	0.001
FEV_1/FVC, %	63.7 (0.2)	63.9 (0.2)	62.0 (0.5)	<0.001

Notes: The data are expressed as weight percentages with standard errors.
Abbreviations: HGS, handgrip strength; BMI, body mass index; MET, metabolic equivalent of task; TB, tuberculosis; FVC, forced vital capacity; FEV_1, forced expiratory volume in 1s.

college graduates (5.4% vs 22.6%, $p < 0.001$) was lower compared to those with normal HGS. Furthermore, individuals with low HGS were more likely to be underweight (4.4% vs 1.7%, $p < 0.001$), never smokers (43.7% vs 30.8%, $p < 0.001$), and have lower income (32.8% vs 25.1%, $p < 0.001$), more respiratory symptoms (18.8% vs 9.9%, $p < 0.001$), and limited physical activity (< MET-min/week: 69.5% vs 54.1%, $p < 0.001$) than those with normal HGS.

Regarding comorbidities, the proportions of asthma (13.3% vs 6.5%, $p = 0.002$), hypertension (61.8% vs 46.0%, $p < 0.001$), and diabetes mellitus (24.2% vs 18.4%, $p = 0.031$) were higher in individuals with low HGS than in those with normal HGS. However, the proportion of a history of pulmonary tuberculosis did not differ between individuals with low HGS and those with normal HGS (9.7% vs 9.9%, $p = 0.928$). Regarding lung function, FVC (82.4%predicted vs 89.1%predicted, $p < 0.001$), FEV_1 (73.8%predicted vs 77.5%predicted, $p < 0.001$), and FEV_1/FVC (62.0% vs 63.9%, $p < 0.001$) were significantly lower in individuals with low HGS than in those with normal HGS. However, the magnitude of these differences was small and may not be clinically relevant.

Impact of HGS on HRQoL

Overall, participants with low HGS showed a decreased quality of life compared to those with normal HGS (Table 2). In the multivariable model, individuals with low HGS showed a significantly higher risk of decreased HRQoL in self-care (adjusted odds ratio [aOR], 1.70; 95% CI, 1.03–2.83) usual activities (aOR, 1.70; 95% CI, 1.14–2.54), pain/discomfort (aOR, 1.44; 95% CI, 1.02–2.02), and anxiety/depression (aOR, 1.57; 95% CI, 1.03–2.39) than those with normal HGS.

In the stratified analysis based on FEV_1, low HGS was associated with decreased HRQoL in usual activities (aOR, 1.74; 95% CI, 1.08–2.79) among those with FEV_1 <80%predicted. In individuals with FEV_1 ≥80%predicted, low HGS was associated with a decreased HRQoL in self-care (aOR, 2.49; 95% CI, 1.11–5.60). In individuals with physical activity level <600 MET-min/week, low HGS was associated with a decreased HRQoL in self-care (aOR, 1.87; 95% CI, 1.05–3.31), usual activities (aOR, 1.90; 95% CI, 1.18–3.07), pain/discomfort (aOR, 1.59; 95% CI, 1.05–2.41), and anxiety/depression (aOR, 1.76; 95% CI, 1.05–2.94). However, in individuals with a physical activity level ≥600 MET-min/week, low HGS did not show a significant association with a decrease in HRQoL after full adjustment.

Impact of HGS on Mental Health and Healthcare Utilization

Table 3 shows the effect of HGS on mental health and healthcare utilization. In the multivariable model, individuals with low HGS had increased odds of perceived stress (aOR, 1.77; 95% CI, 1.24–2.53) compared to those with normal HGS.

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Table 2 Impact of Hand Grip Strength on HRQoL in individuals with Airflow Limitation

		Mobility		Self-Care		Usual Activities		Pain/Discomfort		Anxiety/Depression	
		Unadjusted OR (95% CI)	**Adjusted OR (95% CI)**	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)**	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)**	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)**	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)**
Total											
With normal HGS	2,054	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
With low HGS	338	**3.12 (2.32–4.20)**	1.25 (0.89–1.76)	**3.56 (2.28–5.55)**	**1.70 (1.03–2.83)**	**3.85 (2.70–5.48)**	**1.70 (1.14–2.54)**	**2.16 (1.62–2.90)**	**1.44 (1.02–2.02)**	**2.38 (1.64–3.44)**	**1.57 (1.03–2.39)**
FEV_1, %predicted											
≥80											
With normal HGS	951	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
With low HGS	120	**3.47 (2.22–5.40)**	1.42 (0.82–2.46)	**4.65 (2.34–9.25)**	**2.49 (1.11–5.60)**	**4.12 (2.26–7.53)**	1.69 (0.87–3.27)	**2.05 (1.30–3.24)**	1.26 (0.73–2.16)	1.74 (0.90–3.35)	1.17 (0.55–2.52)
<80											
With normal HGS	1,103	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
With low HGS	218	**2.94 (2.03–4.26)**	1.22 (0.81–1.83)	**3.06 (1.68–5.57)**	1.28 (0.65–2.54)	**3.57 (2.37–5.39)**	**1.74 (1.08–2.79)**	**2.26 (1.57–3.24)**	1.52 (0.99–2.34)	**2.81 (1.78–4.43)**	1.66 (0.98–2.81)
Physical activity (MET-min/week)											
≥600											
With normal HGS	916	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
With low HGS	101	**2.62 (1.54–4.46)**	0.97 (0.52–1.84)	2.50 (0.92–6.75)	0.96 (0.33–2.75)	**2.56 (1.32–4.95)**	1.05 (0.49–2.24)	**1.90 (1.15–3.15)**	1.18 (0.67–2.08)	**2.47 (1.31–4.65)**	1.38 (0.67–2.83)
<600											
With normal HGS	1,138	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
With low HGS	237	**3.10 (2.19–4.37)**	1.34 (0.90–1.99)	**3.46 (2.10–5.72)**	**1.87 (1.05–3.31)**	**4.11 (2.70–6.27)**	**1.90 (1.18–3.07)**	**2.22 (1.57–3.13)**	**1.59 (1.05–2.41)**	**2.42 (1.52–3.86)**	**1.76 (1.05–2.94)**

Notes: Low HGS was determined using the Asian criteria from the Asian Working Group for Sarcopenia (< 28 kg for men and < 18 kg for women). The aOR and 95% CI were analyzed using multivariable logistic regression. Multivariable model was adjusted for age, sex, categorized BMI, smoking status, income, education, respiratory symptoms, FEV_1%predicted, and comorbidities (a history of pulmonary tuberculosis, asthma, hypertension, and diabetes mellitus). The text in **bold** indicates the factors that were statistically associated with hand grip strength.

Abbreviations: HRQoL, health-related quality of life; FEV_1, forced expiratory volume in 1s; HGS, hand grip strength; MET, metabolic equivalent of task; OR, odds ratio; CI, confidence interval; BMI, body mass index.

Table 3 Impact of Hand Grip Strength on Mental Health and Healthcare Utilization in individualswith Airflow Limitation

		Perceived Stress		Admission	
	N	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Total					
With normal HGS	2,054	Ref.	Ref.	Ref.	Ref.
With low HGS	338	1.31 (0.95–1.82)	**1.77 (1.24–2.53)**	**1.63 (1.16–2.30)**	1.40 (0.96–2.03)
FEV_1, %predicted					
≥80					
With normal HGS	951	Ref.	Ref.	Ref.	Ref.
With low HGS	120	1.21 (0.66–2.20)	1.49 (0.75–2.95)	1.36 (0.79–2.36)	1.04 (0.54–2.01)
<80					
With normal HGS	1,103	Ref.	Ref.	Ref.	Ref.
With low HGS	218	1.31 (0.89–1.95)	**1.95 (1.26–3.03)**	**1.80 (1.17–2.78)**	**1.64 (1.03–2.61)**
Physical activity, MET-min/week					
≥600					
With normal HGS	916	Ref.	Ref.	Ref.	Ref.
With low HGS	101	1.47 (0.82–2.65)	**1.94 (1.03–3.65)**	1.12 (0.52–2.41)	1.17 (0.52–2.63)
<600					
With normal HGS	1,138	Ref.	Ref.	Ref.	Ref.
With low HGS	237	1.19 (0.80–1.77)	**1.66 (1.08–2.57)**	**1.75 (1.17–2.61)**	1.41 (0.90–2.20)

Notes: Low HGS was determined using the Asian criteria from the Asian Working Group for Sarcopenia (< 28 kg for men and < 18 kg for women). The aOR and 95% CI were analyzed using multivariable logistic regression. Multivariable model was adjusted for age, sex, categorized BMI, smoking status, income, education, respiratory symptoms, FEV_1%predicted, and comorbidities (a history of pulmonary tuberculosis, asthma, hypertension, and diabetes mellitus). The text in **bold** indicates the factors that were statistically associated with hand grip strength.

Abbreviations: FEV_1, forced expiratory volume in 1s; HGS, hand grip strength; MET, metabolic equivalent of task; OR, odds ratio; CI, confidence interval; BMI, body mass index.

Among individuals with FEV_1 ≥80%predicted, low HGS did not increase the odds of perceived stress. However, in individuals with FEV_1 <80%predicted, low HGS was associated with a higher probability of perceived stress (aOR, 1.95; 95% CI, 1.26–3.03). Stratified analysis based on physical activity showed that low HGS was related to increased perceived stress regardless of activity level (aOR, 1.94; 95% CI, 1.03–3.65 for ≥600 MET-min/week and aOR, 1.66; 95% CI, 1.08–2.57 for <600 MET-min/week).

Regarding utilization of healthcare, hospital admission was not associated with low HGS. Among individuals with FEV_1 ≥80%predicted, low HGS did not increase the odds of hospital admission. However, in participants with FEV_1 <80%predicted, low HGS was associated with higher odds of hospital admission (aOR, 1.64; 95% CI, 1.03–2.61). Stratified analysis based on physical activity showed that low HGS was not associated with utilization of healthcare in individuals with <600 MET-min/week or ≥600 MET-min/week.

Impact of Physical Activity on HRQoL, Mental Health, and Healthcare Utilization Among Individuals with AFL and Low HGS

Among individuals with AFL and low HGS, engaging in active physical activity was significantly associated with better HRQoL in the domains of self-care (aOR, 0.38; 95% CI, 0.15–0.98) and usual activities (aOR, 0.45; 95% CI, 0.22–0.92), compared to those who were not physically active (Table 4). However, physical activity did not significantly affect mental health or healthcare utilization in individuals with AFL and low HGS (Table 5).

Discussion

In this study, we found that 12.6% of individuals with AFL in Korea exhibited low HGS. Low HGS was associated with decreased HRQoL and increased perceived stress. These associations were more evident in individuals with reduced lung function and inactive physical activity, underscoring the combined importance of lung function and muscle strength. Furthermore, engaging in physical activity was significantly associated with better HRQoL in the domains of self-care and usual activities, compared to those who were not physically active among individuals with AFL and low HGS. Furthermore, in

Table 4 Impact of Physical Activity on HRQoL in individuals with Airflow Limitation and Low HGS

		Mobility		Self-Care		Usual Activities		Pain/Discomfort		Anxiety/Depression	
	N	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)**	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)**	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)**	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)**	**Unadjusted OR(95% CI)**	**Adjusted OR (95% CI)**
With inactive physical activity	237	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
With active physical activity	101	**0.55 (0.32–0.96)**	0.58 (0.32–1.03)	**0.37 (0.15–0.95)**	**0.38 (0.15–0.98)**	**0.44 (0.22–0.87)**	**0.45 (0.22–0.92)**	0.74 (0.43–1.28)	0.74 (0.43–1.29)	1.19 (0.58–2.46)	1.24 (0.59–2.61)

Notes: Inactive physical activity was determined using physical activity level recommended by the World Health Organization (≥ 600 METs-min/week). The aOR and 95% CI were analyzed using multivariable logistic regression. Multivariable model was adjusted for age, sex, categorized BMI, smoking status, income, education, respiratory symptoms, FEV_1%predicted, and comorbidities (a history of pulmonary tuberculosis, asthma, hypertension, and diabetes mellitus). The text in **bold** indicates the factors that were statistically associated with hand grip strength.

Abbreviations: HRQoL, health-related quality of life; FEV_1, forced expiratory volume in 1s; HGS, hand grip strength; MET, metabolic equivalent of task; OR, odds ratio; CI, confidence interval; BMI, body mass index.

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Table 5 Impact of Physical Activity on Mental Health and Healthcare Utilization in individuals with Airflow Limitation and Low HGS

		Perceived stress		Admission	
	N	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
With inactive physical activity	237	Ref.	Ref.	Ref.	Ref.
With active physical activity	101	0.96 (0.49–1.88)	0.89 (0.45–1.75)	0.50 (0.22–1.14)	0.57 (0.26–1.25)

Notes: Inactive physical activity was determined using physical activity level recommended by the World Health Organization (≥ 600 METs-min/week). The aOR and 95% CI were analyzed using multivariable logistic regression. Multivariable model was adjusted for age, sex, categorized BMI, smoking status, income, education, respiratory symptoms, FEV_1%predicted, and comorbidities (a history of pulmonary tuberculosis, asthma, hypertension, and diabetes mellitus).
Abbreviations: FEV_1, forced expiratory volume in 1s; HGS, hand grip strength; MET, metabolic equivalent of task; OR, odds ratio; CI, confidence interval.

individuals with AFL and reduced HGS, participation in regular physical activity was significantly linked to improved HRQoL, particularly in self-care and usual activity domains, compared to those who remained physically inactive.

HGS is a valuable tool for assessing muscle strength due to its simplicity, cost-effectiveness, and well-established role in predicting negative patient outcomes.[24,25] Given these notable merits of HGS, the KNHANES incorporates HGS, reporting an average of 39.5 ± 9.3 kg for men and 24.4 ± 5.3 kg for women.[26] Meanwhile, the overall prevalence of sarcopenia was reported to be 13.1% in the elderly Korean population.[27] Although only individuals with AFL were included in this study, the prevalence of low HGS was comparable at 12.6%. Consistent with this result, another study using KNHANES data did not report significant differences in HGS between individuals with and without AFL.[28] A potential explanation for this could be our recruitment method, which focused on individuals with AFL from the general population. Both our study and a previous study observed an average FEV_1 value of approximately 80%predicted, indicating that most participants might have had mild disease. However, the inclusion of individuals under 65 years of age in our study allowed us to infer that low HGS may be more prevalent in this specific population with AFL.

Our study showed that low HGS was associated with a decrease in HRQoL in individuals with AFL. Previous studies have already demonstrated negative correlations between HGS and HRQoL in individuals at risk of AFL, including asthma and COPD.[15,29,30] Our subgroup analysis found that individuals with reduced lung function and low HGS had a decrease in HRQoL across more items than those with preserved lung function. In further analyses stratified by physical activity level, low HGS was significantly associated with decreased HRQoL in individuals with inactive physical activity. These results suggest that the combination of reduced lung function or inactive physical activity, with low HGS not only decreases quality of life, but may also have a compounded negative effect on it, which can be explained by the vicious circle of dyspnea inactivity.[31,32]

Moreover, low HGS was associated with increased perceived stress in individuals with AFL, which was more evident in those with reduced lung function.[33,34] Mental disorders and exacerbation–the major leading cause of hospitalization–are common features of chronic respiratory diseases, including asthma, COPD, interstitial lung diseases, and bronchiectasis.[35–37] Our findings highlight the additional detrimental impact of sarcopenia on clinical outcomes in individuals with chronic respiratory diseases and reduced lung function. Notably, we also found that active engagement in physical activity was associated with better HRQoL, especially in the domains of self-care and usual activities, among individuals with AFL and low HGS, suggesting that maintaining regular physical activity may support better HRQoL in this population. These findings could extend to populations with AFL due to various respiratory diseases such as asthma and TB destroyed lung.[38,39] Conversely, our data showed no significant differences across most HRQoL domains—including mobility, usual activities, pain/discomfort, anxiety/depression, perceived stress, and hospitalization—between individuals with normal and low HGS when FEV_1 was ≥ 80% predicted or when physical activity levels were high. This lack of perceived impairment of HRQoL may partially explain why individuals with AFL but better lung function may delay or be less likely to initiate pulmonary rehabilitation.

Our study has several limitations. First, the absence of post-bronchodilator spirometry results indicates that individuals with AFL may represent heterogeneous disease entities rather than classical COPD.[40] However, recent proposals have advocated for broadening the definition of COPD to encompass a range of underlying causes, aiming to support earlier detection. In this context, most individuals with AFL could be classified as having COPD under a unified umbrella

term.[41] Nevertheless, the possibility of subject misclassification should be considered. Second, lung function was assessed only once, which may have introduced measurement errors. Third, the use of survey data based on self-administered questionnaires may have introduced recall bias. Fourth, this study was conducted in a single nation and ethnic group, which necessitates caution when generalizing the findings to other populations.

In conclusion, low HGS was associated with reduced quality of life and worsened mental health in individuals with AFL. These associations were more evident in individuals with reduced lung function and low levels of physical activity. Moreover, participation in regular physical activity was significantly associated with better HRQoL, particularly in the domains of self-care and usual activities in individuals with AFL and reduced HGS. Our findings highlight the critical role of muscle strength in maintaining HRQoL, especially in individuals with impaired lung function and sedentary lifestyles, and suggest that engaging in regular physical activity including muscle-strengthening exercises may offer meaningful improvements of HRQoL.

Abbreviations

COPD, Chronic Obstructive Pulmonary Disease; KNHANES, Korea National Health and Nutrition Examination Survey; AFL, Airflow Limitation; HGS, Handgrip Strength; HRQoL, Health-Related Quality of Life; aOR, Adjusted Odds Ratio; FEV_1, Forced Expiratory Volume in 1 second; FVC, Forced Vital Capacity; BMI, Body Mass Index; GPAQ, Global Physical Activity Questionnaire; MET, Metabolic Equivalent of Task; GOLD, Global Initiative for Chronic Obstructive Lung Disease; WHO, World Health Organization.

Ethics Approval Declaration

The KNHANES 2014–2019 was conducted following the Declaration of Helsinki. The Institutional Review Board (IRB) of the Korea Disease Control and Prevention Agency (KDCA) approved the study (IRB: 2013-12EXP-03-5C, 2018-01-03-P-A, and 2018-01-03-C-A). Also, this study protocol was approved by the Institutional Review Board of Korea University Anam Hospital (No. 2024AN0383). Written informed consent was obtained from all participants, and anonymized data were provided.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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