Analysis of the Relationship between Grip Strength and Activity Limitation Due to Physical Diseases -The Eight National Health and Nutrition Examination Survey Ⅷ-1(2019)-

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Purpose The purpose of this study was to investigate the relationship between limitations in activity due to physical disease and grip strength. ***Methods*** This is secondary data that analyzed raw data from Korea National Health and Nutrition Examination Survey. The subjects ranged in age from their 30s to their 80s, and the reasons for activity limitations included fractures and joint injuries, arthritis and rheumatism, stroke, back problems, and knee and leg pain. ***Results*** There were 430 people (6.6%) with activity limitations due to physical diseases, including 168 men (5.9%) and 262 women (7.3%), and 4776 people (93.4%) had no activity limitations. Among the reasons for activity limitations, back and neck problems were the highest at 35.3%, and stroke was the lowest at 4.8%. There was no difference in grip strength depending on whether activity was restricted due to fractures, joint injuries, or back and neck problems. When arthritis was the reason for activity limitations, the grip strength of the right hand decreased 21.70 times and the grip strength of the left hand decreased 20.39 times compared to cases with no activity restrictions. In cases where back and neck problems were the reason for activity limitations, only left hand grip strength decreased by 2.25 times compared to cases where there were no activity limitations. no activity limitations. ***Conclusion*** In cases where physical disease was the reason for activity limitation, the correlation between the type of disease and grip strength was highest in arthritis.

Key words Activity limitation, Arthritis, Biomarker, Grip strength, Physical diseases

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Ⅰ. Introduction

An appropriate level of strength and muscle mass is essential to maintain proper physical function, and a decrease in strength is associated with various disorders.[1)] Decrease in muscle and strength is related to decreased physical activity due to a sedentary lifestyle, diabetes, chronic inflammatory diseases, and nutritional disorders depending on diet.[1)] Risk factors related to metabolic syndrome, such as high blood pressure, diabetes, and obesity, may affect muscle loss and resulting decrease in strength.[2)]

Low grip strength is related to executive function, processing speed and decline in activities of daily living,[3)] and cardiovascular and respiratory diseases not only increase mortality but also cause limitations in daily life.[4)] Measurement of grip strength is one of the most relevant biomarkers for measuring muscle strength in healthy or diseased people.[5)] Different biological mechanisms behind declining grip strength have been proposed and some risk factors have been suggested including age, gender, body size, low physical activity, smoking and morbidity.[1)] It has been said that grip strength is also related to depression and suicidal thoughts, and that functional limitations and activity limitations due to decreased muscle strength lead to stress and depression, which can lead to suicidal thoughts[6)]. This decline in muscle strength is closely related to age[2)] and can lead to several negative outcomes, such as hospitalization and death[7)], limited activities of daily living[8)], injuries from falls[9)], and mortality.[4)] Therefore, it is necessary to pay a lot of attention to improving and maintaining muscle strength.

Meanwhile, the loss of muscle strength will be further aggravated as the disease limits activities in the community or daily activities. According to a study

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that observed elderly people over 80 years of age for 3 years, the hospitalization rate and mortality rate were high in the group with reduced grip strength and performance[10]. Physically active people have higher levels of grip strength compared to inactive people.[5]

Hand Grip Strength is an index that evaluates the static strength of the muscles that make up the forearm and is the strength to grip an object with the palm.[11] Grip strength was the only assessment technique recommended for the measurement of muscle strength, and was the simplest method for assessment of muscle function in clinical practice[2]. Grip strength was the only assessment technique recommended for the measurement of muscle strength, and was the simplest method for assessment of muscle function in clinical practice[12]. Measuring muscle strength through grip strength is evaluated as a useful method that is non-invasive, simple, and convenient for measurement.[10]

Research on grip strength has been conducted in various fields, including grip strength as a bio mark[13], the relationship between grip strength and mental health[5], grip strength and body mass[14], and grip strength and balance.[15] However these studies mainly focused on the elderly, and no research was conducted on the relationship between activity limitations due to disease factors and grip strength.

Therefore, the purpose of this study was to find out how restrictions on activity due to physical diseases that affect muscle strength affect grip strength. Through this, we aim to provide evidence on the importance of activities in the community for future muscle strength improvement interventions.

II. Materials and Methods

1. Subjects

This study is a secondary data analysis of raw data from the 8th Korea National Health and Nutrition Examination Survey (KNHANES) 1st year (2019).[16] The raw data used in this study were approved by the Institutional Review Board (IRB) of the Korea Disease Control and Prevention Agency and were downloaded from the KNHANES website according to appropriate procedures. Because this study was a secondary data analysis, informed consent from participants was not required. The total number of people who participated in the KNHANES was 8,110. Among them, the relationship between activity limitations and grip strength of 5,865 adults (2,591 men and 3,274 women) over 30 years of age was analyzed.

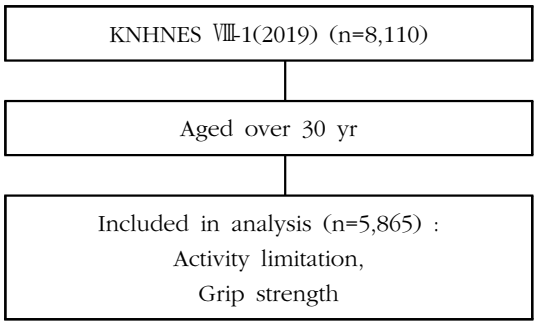

Figure 1. Study flow chart

2. Method and instrumental

The Korea National Health and Nutrition Examination Survey (KNHANES) data consists of a screening survey[16], a health survey, and a nutritional survey, and is Korea's national level data on the people's health level, health-related awareness and behavior, and food and nutritional intake. This data is representative and reliable and is used as basic data for establishing various health policies and programs.

In the National Health and Nutrition Examination Survey, the maximum grip strength of the right and left hands was measured three times each using a Japanese digital grip strength meter (Takai TKK-5401, Takei Scientific Instruments Co., Ltd., Tokyo, Japan) to measure grip strength. In this study, the average value of grip strength measured three times was created and used for analysis.

3. Related variables

Sociodemographic characteristics included age, gender, education level, and marital status. Age was classified into 10-year increments, and education level was classified as elementary school graduation or less, middle school graduation, high school graduation, and college graduation or higher. Marital status was divided

into two groups: those who answered that they were married and those who answered that they were single. A total of five physical diseases that limit activity were selected: fractures and joint injuries, arthritis and rheumatism, stroke, back problems, and knee and leg pain (excluding arthritis). Activity restrictions were categorized into no or yes

4. Data analysis

Since the Korea National Health and Nutrition Examination Survey data used a complex sample design method, complex sample analysis was performed according to the guidelines for using the Korea National Health and Nutrition Examination Survey raw data.

Complex sample frequency analysis and descriptive statistics were conducted to determine the general characteristics of the study subjects, and the extent of activity limitations according to the subjects' disease was compared using the chi-square test. Linear regression analysis was used to analyze the relationship between study subjects' activity limitations and grip strength. All missing values were included in the analysis to prevent statistical bias. The statistical program SPSS 26.0 was used, and the significance level of the statistical test was set at $p < 0.05$.

Ⅲ. Results

1. Sociodemographic characteristics of survey subjects

The ages of the survey subjects were found out. 985 people (17.0%) in their 30s, 1,182 people (20.4%) in their 40s, 1,245 people (21.5%) in their 50s, 1,186 people (20.5%) in their 60s, 1,186 people (20.5%) in their 70s, 349 people (6.0%) in their 80s or older. Regarding marital status, 5,144 people (91.4%) were married, 398 people (8.6%) were single, and 1 person did not respond. The level of education was as follows: 1,087 people (15.4%) had elementary school or lower, 554 people (9.3%) had graduated from middle school, 1,585 people (32.2%) had graduated from high school, and 1,973 people (43.1%) had graduated from college or higher (Table 1).

2. Reasons for activity limitations and physical diseases

In cases where the reason for activity limitation was physical diseases, the frequency of physical diseases was investigated(Table 2).

When asked about activity limitations, 2,077 (94.1%) of men and 2,699 (92.7%) of women answered that they had no activity limitations, for a total

Table 1. General characteristics of subjects

Variables		Men	Women	Total
Age groups	30	456(18.0%)	529(16.3)	985(17.0%)
	40	524(20.6%)	658(20.2)	1182(20.4%)
	50	526(20.7%)	719(22.1)	1245(21.5%)
	60	527(20.7%)	659(20.3)	1186(20.5%)
	70	367(14.4)	479(14.7)	846(14.6)
	≥80	140(5.5)	209(6.4)	349(6.0)
	Total	2540(43.8)	3253(56.2)	5793(100)
Marital status	Married	2160(88,0)	2984(94.8)	5144(91.4%)
	Not married	244(12.0)	154(5.2)	398(8.6%)
	No response	0(0.0%)	1(0.0%)	1(0.0%)
	Total	2404(49.1)	3139(50.9)	5543(100%)
Educational level	≤Elementary school	321(9.1%)	766(21.4%)	1087(15.4%)
	Middle school	250(9.6%)	304(9.0)	554(9.3%)
	High school	701(32.4%)	884(32.1%)	1585(32.2%)
	≥College	969(48.9)	1004(37.5%)	1973(43.1%)
	Total	2241(48.9%)	2958(51.1%)	5199(100%)

Table 2. Activity limitations and physical diseases

Variables			Men	Women	Total
Activity limitation	No		2077(94.1%)	2699(92.7%)	4776(93.4%)
	Yes		168(5.9%)	262(7.3%)	430(6.6%)
	Total		2245(100%)	2961(100%)	5206(100%)
	Fractures, joint injuries	No	154(91.1%)	248(93.4%)	402(92.4%)
		Yes	14(8.9%)	14(6.6%)	28(7.8%)
	Arthritis. rheumatism	No	149(92.7%)	194(75.8%)	343(83.1%)
		Yes	19(7.3%)	68(24.2%)	87(16.9%)
	Stroke	No	158(92.0%)	255(97.6%)	413(95.2%)
		Yes	10(8.0%)	7(2.4%)	17(4.8%)
	Back•neck problems	No	120(71.5%)	160(59.4%)	280(64.7%)
		Yes	48(28.5%)	102(40.6%)	150(35.3%)
	Knee, leg pain	No	145(86.7%)	216(86.5%)	361(86.6%)
		Yes	23(14.3%)	46(13.5%)	69(13.4%)

of 4,776 (93.4%). There were 168 (5.9%) men and 262 (7.3%) women who answered that they had activity limitations, for a total of 430 (6.6%).

There were 28 patients (7.8%) with activity limitations and 402 (92.4%) without activity limitations due to fractures and joint injuries. There were 87 people (16.9%) who had activity limitations and 343 people (83.1%) without activity restrictions. There were 17 patients (4.8%) with activity limitations and 413 patients (95.2%) without activity limitations. There were 150 people (35.3%) who had activity limitations and 280 people (64.7%) without activity restrictions. There were 69 patients (13.4%) who had activity limitations and 361 patients (86.6%) who had no activity limitations due to knee and leg pain (excluding arthritis),

Among the reasons for activity limitations, back and neck problems were the highest rate (35.3%), and stroke was the lowest rate (4.8%).

3. Reasons for activity limitation and degree of grip strength

A multiple samples t-test was conducted to determine the reasons for activity limitations and the level of grip strength according to the presence or absence of activity limitations (Table 3).

The grip strength of the right hand due to fractures and joint injuries was 24.50kg without activity limitations and 26.62kg with activity limitations, and the grip strength of the left hand was 23.85kg without activity limitations and 25.59kg with activity limitations. It was. There was no statistically significant difference in grip strength between fractures and joint injuries with or without activity limitations. In cases where there were no activity limitations due to arthritis, the grip strength of the right hand was 25.24kg, and in cases where there were activity limitations, it was 21.70kg. The difference in right hand grip strength according to the presence or absence of activity restrictions was statistically significant ($p < 0.01$). In cases with no activity limitations due to arthritis, the left hand grip strength was 24.67kg, and in cases with activity limitations, it was 20.39kg. The difference in left hand grip strength according to the presence or absence of activity limitations due to arthritis was statistically significant ($p < 0.001$)

The grip strength of the right hand when there were no activity restrictions due to back and neck reasons was 25.28kg, and the grip strength of the left hand when there were activity restrictions was 23.57kg. The difference in grip strength according to the presence or absence of activity restrictions was not statistically significant.

The grip strength of the left hand without activity restrictions due to back and neck was 24.78kg, and the grip strength of the left hand without activity restrictions was 22.52kg, and the difference in left hand grip strength according to the presence or absence of activity restrictions was statistically significant ($p < 0.05$).

The grip strength of the right hand without activity restrictions due to knee and leg problems was 22.72kg, and the grip strength of the right hand with activity limitations was 24.30kg. The difference in grip strength of the right hand according to the presence or absence of activity restrictions was not statistically significant. The grip strength of the left hand without activity restrictions due to knee and leg problems was 24.11kg, and the grip strength of the left hand with activity limitations was 23.24kg. The difference in left hand grip strength according to the presence or absence of activity restrictions was not statistically significant.

The grip strength of the right hand without activity limitations due to stroke was 24.67kg, and the grip strength of the right hand with activity limitations was 24.60kg. The difference in grip strength of the right hand according to the presence or absence of activity limitations was not statistically significant. The grip strength of the left hand without activity limitations due to stroke was 23.72kg, and the grip strength of the left hand with activity limitations was 29.71kg, and the difference in left hand grip strength according to the presence or absence of activity limitations was statistically significant ($p < 0.05$).

4. Association between activity limitations and grip strength

Complex sample linear regression analysis was conducted to determine the relationship between grip strength and the presence or absence of activity restrictions for each reason(Table 4).

The grip strength of the right hand, which has lim-

Table 3. Activity limitation and degree of grip strength

			Mean	SE	CE	p
Fractures, joint injuries	Rt	No	24.50	.450	-2.125	.298
		Yes	26.62	1.973		
	Lt	No	23.85	.466	-1.736	.303
		Yes	25.59	1.606		
Arthritis. rheumatism	Rt	No	25.24	.483	3.535	.001
		Yes	21.70	.970		
	Lt	No	24.67	.487	4.277	.000
		Yes	20.39	.956		
Back•neck problems	Rt	No	25.28	.589	-707	.078
		Yes	23.57	.713		
	Lt	No	24.78	.589	-2.254	.028
		Yes	22.52	.768		
Knee, leg pain	Rt	No	24.72	.473	-.423	.742
		Yes	24.30	1.190		
	Lt	No	24.11	.473	-.866	.523
		Yes	23.24	1.265		
Stroke	Rt	No	24.67	.438	.067	.978
		Yes	24.60	2.437		
	Lt	No	23.72	.430	5.989	.019
		Yes	29.71	2.513		

SE: Standard error, CE: Contrast estimate

Table 4. Association between reasons for activity limitations and grip strength

					95% % Confidence interval			
		Division	Estimate	SE	Lower	upper	t	p
Fractures, joint injuries	Rt	Intercept	26.622	1.973	22.725	30.519	13.490	.000
		No	-2.125	2.037	-6.147	1.898	-1.043	.298
		Yes	.000	.	.	.	.	.
	Lt	Intercept	25.587	1.606	22.417	28.758	15.935	.000
		No	-1.736	1.680	-5.054	1.582	-1.033	.303
		Yes	.000	.	.	.	.	.
Arthritis. rheumatism	Rt	Intercept	21.700	.970	19.784	23.616	22.366	.000
		No	3.535	1.077	1.409	5.661	3.283	.001
		Yes	.000	.	.	.	.	.
	Lt	Intercept	20.390	.956	18.502	22.278	21.325	.000
		No	4.277	1.072	2.161	6.394	3.991	.000
		Yes	.000	.	.	.	.	.
Back · neck problems	Rt	Intercept	23.573	.713	22.165	24.980	33.071	.000
		No	1.707	.962	-.192	3.606	1.775	.078
		Yes	.000	.	.	.	.	.
	Lt	Intercept	22.524	.767	21.008	24.039	29.350	.000
		No	2.254	1.015	.251	4.257	2.222	.028
		Yes	.000[b]	.	.	.	.	.
Knee, leg pain	Rt	Intercept	24.298	1.190	21.948	26.648	20.420	.000
		No	.423	1.281	-2.107	2.953	.330	.742
		Yes	.000	.	.	.	.	.
	Lt	Intercept	23.242	1.265	20.745	25.739	18.376	.000
		No	.866	1.352	-1.804	3.536	.640	.523
		Yes	.000	.	.	.	.	.
Stroke	Rt	Intercept	24.599	2.437	19.786	29.412	10.092	.000
		No	.067	2.440	-4.751	4.884	.027	.978
		Yes	.000	.	.	.	.	.
	Lt	Intercept	29.708	2.513	24.746	34.671	11.820	.000
		No	-5.989	2.533	-10.990	-.988	-2.365	.019
		Yes	.000	.	.	.	.	.

ited activity due to fractures and joint injuries, decreased by -2.92 times compared to the case with no activity limitations, and the grip strength of the left hand, which has activity limitations, decreased by -1.73 times compared to the case with no activity limitations. It decreased two-fold, and no statistical significance was found. The grip strength of the right hand, which has activity limitations due to arthritis, decreased 21.70 times compared to the case where there were no activity limitations, and the grip strength of the left hand, which had activity limitations, decreased 20.39 times compared to the grip strength of the left hand, which had no activity limitations. and was statistically significant ($p < 0.001$). In cases where activities were restricted due to back or neck reasons, the grip strength of the right hand decreased by 1.7 times compared to the grip strength of the right hand with no restrictions on activities, but statistical significance was not shown. In cases where activity was restricted, the grip strength of the left hand decreased by 2.25 times compared to the left hand grip strength without activity limitations, which was significant ($p< 0.05$). In cases where activity was restricted due to knee or leg problems, the grip strength of the right hand decreased by 0.4 times compared to the grip strength of the right hand with no activity limitations, and the grip strength of the left hand without activity limitations decreased by 0.8 times compared to cases with activity limitations. However, it was not statistically significant.

Compared to cases with activity limitations due to stroke, the grip strength of the right hand decreased

0.67 times in cases with no activity limitations, and compared to cases with activity limitations, the grip strength of the left hand with no activity limitations decreased -5.790 times, did not appear statistically significant.

Ⅳ. Discussion

This study used data from the National Health and Nutrition Examination Survey to investigate the relationship between grip strength and the presence or absence of activity limitations due to physical diseases in adults in their 30s or older. Through this, we sought to determine the impact of daily activities on muscle strength and provide evidence for the importance of activity in the community.

The use of grip strength as a biomarker of current health status is valuable for research showing associations between grip strength and the intensity of other muscle activities in both healthy individuals and adults with conditions[3]. There was a significant interaction between total physical activity and grip strength, with the higher risk of death associated with low physical activity being greatest among participants with the lowest grip strength and lowest among those with the highest grip strength.[4] Kim et al.[17] stated that low handgrip strength is a risk factor for low functional limitations and disabilities, and all-cause mortality. Although grip strength is not directly required for the performance of functional activities such as gait, it does distinguish between older adults on the basis of their mobility[4]. On average, grip strength tends to peak at the age of 30-40[18], and decreases with age in both women and men[19]. On average, men's grip strength level decreases faster with age compared to women, so the gender gap tends to narrow slightly with age[18].

In this study, 6.6% of patients had activity limitations due to physical diseases (fractures and joint injuries, arthritis and rheumatism, stroke, back and neck problems, knee and leg pain). The natural aging process can lead to bone density which can increase the likelihood of developing osteoporosis, especially in women[20]. According to a report by Jang[21] based on data from the Korean Medical Panel, in 2012, the proportion of people with limitations in daily life and social activities due to health problems or physical or mental disabilities was 15.4% for men aged 65 or older and 15.4% for women. It is 22.2% of the elderly, and the activity limitation rate increases with age. Kim[22] reported that the prevalence of activity limitations among the elderly population aged 65 or older in Korea in 2016 was 17.3% for men, 21.1% for women, and 19.6% overall. These reports showed a higher activity limitation rate than this study, which appears to be because this study targeted adults in their 30s or older and only physical diseases that cause activity limitations were selected. In this study, the rate of activity limitation was higher in women, at 5.9% in men and 7.3% in women. A report by Jang[21] also showed that as age increases, the rate of increase in activity limitation rate is greater in women than in men, which is similar to this study. Low handgrip strength is associated with low bone density and is therefore a predictor of fragility fractures[17].

In this study, 35.3% of cases had activity limitations due to back and neck problems. It was found to be somewhat high, with the activity limitation rate due to arthritis and rheumatism being 16.9%. It was said that in cases where activities are limited due to back and neck problems, the grip strength of the left hand decreases by 2.25 times. Kim [22] reported that the highest reasons for activity limitations in 65-year-olds were back and neck problems (19.8%) and arthritis and rheumatism (17.1%), so the ranking of the reasons for activity limitations was similar to this study. When activity was limited due to arthritis, the grip strength of the right hand was reduced by 21.7 times, and the grip strength of the left hand was reduced by 20.39 times. In a study by Kwon et al.[2], muscle strength can be well maintained in older men without osteoarthritis, but 42.7% of older women have arthritis, and the effect of arthritis on muscle strength differs depending on gender. In a study by Lee & Nam[23], patients with osteoarthritis who had activity limitations had more serious problems with exercise ability, self-management, daily activities, pain/discomfort, anxiety/depression, and subjective health status than those

without activity limitations. did. A study by Roh[24] showed that even in cases of arthritis, there is a decrease in overall muscle strength and a decrease in grip strength. In this study, the grip strength of the right and left hands due to arthritis was found to be lower in cases with activity limitations than in cases without activity limitations. Compared to cases with activity restrictions, right-hand grip strength decreased 21.70 times in cases with no activity restrictions, and left-hand grip strength decreased 20.39 times. Dodds et al.[25] found that the most active people aged 60 to 64 had an average grip strength of 1.73kg (95% CI: 0.61, 2.85) higher than those who were inactive. In addition, as leisure time physical activity increases throughout middle age, both men and women have stronger grip strength between the ages of 60 and 64, and this association appears after the age of 53, so leisure time physical activity throughout adulthood increases during the early years. It is said that it can prevent the decline of grip strength in old age.

In this study, the activity limitation rate due to knee and leg pain was 13.4%, and when activity was limited due to knee and leg problems, there was no statistical difference in the grip strength of the right and left hands. In this study, the number of fractures and joint injuries with activity limitations was 7.8%, and there was no difference in grip strength between the right and left hands depending on the presence or absence of activity limitations.

The activity limitation rate due to stroke was the lowest at 4.8% As of 2014, the prevalence of stroke is estimated to be 1.71% to 1.37% in adults aged 19 or older, and it is a disease with a high incidence, with a total of 692,259 people estimated to have been diagnosed with stroke[26]. A study by Jang[21] also showed different results from this study, saying that the activity limitation rate due to stroke was the highest at 416.9 per 1,000 people. These different results appear to be due to the fact that the National Health and Nutrition Survey was based on community residents and excluded residents of medical institutions or facilities for the elderly. In this study, when activity was limited due to stroke, the grip strength of the right hand decreased by 0.67 times and the grip strength of the left hand decreased by -5.790 times compared to cases with limited activity, but there was no significant difference. Stock et al.[27] reported that grip strength often decreases after a stroke, affecting the ability to maintain grip strength and rapidly increase strength over time. A typical symptom of stroke is motor impairment[28], but in this study, not only was the rate of activity limitation low, but there was no difference in grip strength when there was activity limitation. The reason for this appears to be that the paralyzed side and dominant hand caused by the stroke and the time of stroke occurrence were not taken into consideration. Additionally, it appears that stroke patients living in the community have relatively mild paralysis symptoms compared to those living in medical facilities.

A limitation of this study is that it did not distinguish between dominant and non-dominant hands. For left-handers, there is no significant difference, but for right-handers, the dominant hand is much stronger[29]. Therefore, in future research, it seems necessary to distinguish between the dominant hand and the non-dominant hand and compare and examine them.

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