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Association between hand grip strength and health-related quality of life among in Korean cancer survivors: a cross-sectional study

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ABSTRACT

Objectives: To assess the association between hand grip strength (HGS) and health-related quality of life among Korean cancer survivors

Design: Population-based cross-sectional study

Setting: South Korea (Korea National Health and Nutrition Examination Surveys VI-VII)

Participants: Cancer survivors with available data on HGS and health-related quality of life (HRQoL) in the sixth and seventh Korea National Health and Nutrition Examination Surveys (2014-2017)

Primary outcome measures: Prevalence of impaired HRQoL by HGS (normal and weak)

Secondary outcome measures: Estimated risk of impaired quality of life by HGS by calculating odds ratios (ORs) and adjusting for covariates in a multinomial logistic regression analysis.

Results: Among 1,037 cancer survivors (60.7% women, mean age = 62.2 years), 19.2% of them had weak HGS according to gender-specific cut-off values (lowest quintile; <29.7 kg in men and <19.7 kg in women). The prevalent cancer site was the stomach, followed by the thyroid, breast, colorectum, and cervix. Individuals with weak HGS showed statistically significantly increased impairment in all five dimensions of the EQ-5D compared with those in patients with normal HGS. In a multinomial logistic regression analysis, the risk of impaired HRQoL was significantly reduced in all dimensions of the EuroQol-5 dimension (EQ-5D), except for anxiety/depression, when HGS was increased. The OR for impaired HRQoL ranged from 0.86 to 0.97 per 1 kg increase in HGS in four dimensions (mobility, self-care, usual activity, and pain/discomfort).

Conclusions: Weak HGS was associated with impaired HRQoL in cancer survivors. Future longitudinal studies are needed to confirm the causality between HGS and HRQoL in cancer

survivors.

Keywords: Korea National Health and Nutrition Examination Survey, neoplasms, cancer survivors, hand strength, quality of life

STRENGTHS AND LIMITATIONS OF THIS STUDY

1. To our knowledge, this is the first study to evaluate the correlation between hand grip strength (HGS) and health-related quality of life (HRQoL) in cancer survivors.

2. This large, population-based study used nationally representative data from the Korea National Health and Nutrition Examination Survey (KNHANES).

3. Multiple logistic regression analyses were used to examine the associations between HGS and impaired HRQoL status after adjusting for various health behavioral factors.

4. The cross-sectional design of this study limits the ability to establish causal-interference relationships between HGS and HRQOL.

5. Because our data were confined to the Korean population, the results cannot be generalized to other ethnic populations.

INTRODUCTION

Cancer is a fatal and serious disease. However, with improving diagnostic and therapeutic techniques, the survival rate of cancer patients is increasing worldwide.[1] According to the Korea National Cancer Incidence Database, overall cancer mortality has decreased 2.7% annually since 2002, although the all-cancer incidence rate increased by 3.6% annually from 1999 to 2011, resulting in a long-term survival probability of 70.5% in the 2010s compared with the that in 1990s.[2]

Compared with individuals in the general population, cancer survivors have increased risks of chronic diseases such as cardiovascular disease, second primary malignancy, and osteoporosis.[3-5] Furthermore, deterioration of physical function and psychosocial problems is common.[6]

As these survival issues and the life expectancy of cancer survivors have increased, health-related quality of life (HRQoL) has become an important outcome measure for survivors. HRQoL is a subjective, multidimensional concept that encompasses physical, social, functional, psychological/emotional health factors related to an individual's health. Several studies have reported that the HRQoL of cancer survivors is significantly lower than that of the non-cancer population.[7-9] The poor quality of life of cancer survivors is probably due to cancer itself and/or side effects of cancer treatments. Thus, there is a need to better monitor the quality of life in cancer survivors.

Hand grip strength (HGS) is a simple, fast, and reliable method for evaluating maximum voluntary squeezing force.[10 11] The measurement of HGS is useful not only to evaluate the qualitative and functional aspects of muscle strength in clinical practice but also to predict nutritional and general health statuses.[12 13] Additionally, HGS is associated with multiple chronic diseases and multimorbidity after adjusting for confounding factors.[14] Recent data showed that HGS could be an independent predictor of the quality of life in various disease

settings ranging from arthritis to chronic liver disease and depression.[15-17] In contrast, data on the impact of HGS on HRQoL in cancer survivors are lacking.

Given the above, we evaluated for the first time the cross-sectional associations of HGS with HRQoL among cancer survivors, using nationally representative data from the Korea National Health and Nutrition Examination Survey (KNHANES).

MATERIALS AND METHODS

Study population

The KNHANES is a cross-sectional, nationally representative survey that has been conducted to assess the health and nutritional status of the general population of Korea since 1998. The KNHANES uses a stratified multistage probability sampling to accurately represent the general population of South Korea. The present study analyzed data from the KNHANES VI-2,3 (2014-2015) and VII-1,2 (2016-2017). As shown in Figure 1, a total of 1,037 participants who met the eligibility criteria were enrolled in this study.

Personal characteristics and clinical data

The demographic characteristics included age, sex, height, weight, body mass index (BMI), education (<10 years or ≥10 years), household income (low or high), residence (rural or urban), and marital status (living with someone or living alone). Health behaviors, including smoking status (never, former, or current), high-risk drinking, and physical activity, were also assessed. High-risk drinking was defined as the consumption of more than seven (men) or five (women) drinks on a single occasion at least twice a week. Adequate physical activity was defined as at least 30 minutes of moderate-intensity activity five days a week or at least 20 minutes of vigorous physical activity three days per week. The comorbidities included hypertension, diabetes mellitus, ischemic heart disease, stroke, and depression. We collected data on cancer

sites without data on current treatment and cancer-related symptoms.

Measurement of HGS

HGS was measured to the nearest 0.1 kg using a digital hand dynamometer (Digital Grip Strength Dynamometer, T.K.K 5401, Takei Scientific Instruments Co., Ltd., Tokyo, Japan). During the assessment, the participants were required to stand upright with their feet hip-width apart and to stretch their elbows completely. The participants were asked to apply the maximum grip strength three times for their left and right hands individually. The participants were instructed to hold the grip continuously with full force for more than 3 seconds. At least 30 seconds of rest was allowed between each measurement. Grip strength was defined as the maximally measured value among the six measurements in both hands. Weak HGS was defined as the lowest quintile in both men and women.

Assessment of HRQoL

We assessed HRQoL using the EuroQoL-5 Dimension (EQ-5D), which is a standardized instrument used to measure generic health status. It has been applied to a wide range of health conditions and treatments. The EQ-5D descriptive system comprises five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. The participants had three possible responses depending on the severity for each dimension: “no problems,” “moderate problems,” and “severe problems.” The EQ-5D instrument has been translated into Korean.

Statistical analyses

We divided the participants into two groups based on HGS (normal or weak).

The baseline characteristics are reported as means and standard deviation for all continuous variables and as frequencies and percentage for categorical variables. The differences in several

covariates between the normal and weak HGS groups were assessed using Student's t-test for continuous variables and chi-square tests for categorical variables. Multiple logistic regression analyses were used to examine the associations between HGS and impaired HRQoL. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 21.0 (IBM Corp., Armonk, NY, USA). A two-tailed P-value <0.05 was considered statistically significant.

Ethics statement

This study's protocol for performing an analysis of the 2014–2017 KNHANES data was reviewed and approved by the Institutional Review Board of the Korea Centers for Disease Control and Prevention. Informed consent was obtained from all participants when the 2014–2017 KNHANES were conducted.

RESULTS

Among 1,037 cancer survivors (60.7% women, mean age=62.2 years), the prevalent cancer site was the stomach, followed by the thyroid, breast, colorectum, and cervix. Overall, cancer survivors most commonly reported problems in pain/discomfort domain, followed by mobility and anxiety/depression. The sex-specific HGS cut-off values (lowest quintile) were 29.7 kg in men and 19.7 kg in women. The weak HGS group comprised 199 participants (19.2%) (18.6% of men and 19.6% of women). Table 1 shows the characteristics of the normal and weak HGS groups. There were significant differences in several anthropometric measurements (height, weight), socio-demographic characteristics (education, household income, residential area, marital status, physical activity), and comorbidities (hypertension, diabetes, stroke). Participants with weak HGS showed significantly more impaired status for all dimensions of the EQ-5D compared with those in participants with normal HGS.

Table 1. Characteristics of 1,037 cancer survivors according to hand-grip strength

	Total (N=1,037)	Normal HGS (n=822)	Weak HGS* (n=199)	P-value
Age (y)	62.2±12.4	60.3±12.1	70.1±10.3	<0.001
Sex				0.711
Men	408 (39.3)	332 (39.6)	76 (38.2)	
Women	629 (60.7)	506 (60.4)	123 (61.8)	
Height (cm)	160.4±8.2	161.3±7.8	156.3±8.6	<0.001
Weight (kg)	60.7±10.1	61.6±10.0	56.7±9.3	<0.001
BMI (kg/m^2)	23.6±3.2	23.6±3.3	23.2±3.2	0.071
Hand grip strength (kg)				
Men	36.3±7.7	38.7±6.2	25.9±3.7	<0.001
Women	23.7±4.8	25.3±3.6	16.8±2.6	<0.001
Education				<0.001
<10 years	498 (48.0)	365 (43.8)	133 (66.8)	
≥10 years	535 (51.6)	469 (56.2)	66 (33.2)	
Income				<0.001
1st, 2nd quartile (low)	565 (54.5)	419 (50.0)	146 (73.4)	

3rd, 4th quartile (high)	471 (45.4)	419 (50.0)	52 (26.1)	
Residence				0.005
Urban	722 (69.6)	600 (71.6)	122 (61.3)	
Rural	315 (30.4)	238 (28.4)	77 (38.7)	
Marital status				<0.001
Live alone	148 (14.3)	98 (11.7)	50 (25.1)	
Live with someone	889 (85.7)	740 (88.3)	149 (74.9)	
Former/current smoking	374 (36.1)	308 (37.2)	66 (33.5)	0.339
Problem drinking†	371 (35.8)	309 (42.1)	62 (35.8)	0.132
Inadequate physical activity‡	610 (58.8)	464 (55.6)	146 (74.1)	<0.001
Comorbidity				
Hypertension	383 (36.9)	289 (34.5)	94 (47.2)	0.001
Diabetes	161 (15.5)	118 (14.1)	43 (21.6)	0.008
Ischemic heart diseases	51 (4.9)	42 (5.0)	9 (4.5)	0.774
Stroke	32 (3.1)	17 (2.0)	15 (7.5)	<0.001
Depression	58 (5.6)	45 (5.4)	13 (6.5)	0.521
Cancer site§				0.052
Stomach	194 (18.7)	149 (17.8)	45 (22.6)	
Colorectum	134 (12.9)	103 (12.3)	31 (15.6)	

Liver	31 (3.0)	24 (2.9)	7 (3.5)	
Breast‖	134 (21.3)	111 (22.9)	23 (18.7)	
Cervix‖	117 (18.6)	95 (18.8)	22 (17.9)	
Lung	37 (3.6)	31 (3.7)	6 (3.0)	
Thyroid	217 (20.9)	195 (23.3)	22 (11.1)	
Prostate‖	42 (10.3)	32 (9.6)	10 (13.2)	
Other	184 (17.7)	145 (17.3)	39 (19.6)	
EQ-5D (moderate/severe problem)				
Mobility	230 (22.2)	142 (16.9)	88 (44.2)	<0.001
Self-care	42 (4.1)	20 (2.4)	22 (11.1)	<0.001
Usual activities	135 (13.0)	78 (9.3)	57 (28.6)	<0.001
Pain/discomfort	291 (28.1)	205 (24.5)	86 (43.2)	<0.001
Anxiety/depression	127 (12.2)	91 (10.9)	36 (18.1)	0.005

Data are given as mean±standard deviation or number (%). P-value were analyzed by t-test or chi-square test.

*Defined as less than 29.7/19.7 kg (for men/women); †Defined as consuming more than 7/5 (for men/women) drinks on a single occasion at least twice a week; ‡Defined as less than 150 minutes per week; § Allows for patient to have more than one type of cancer; ‖Percentage is limited to women for breast/cervical cancer and to men for prostate cancer.

Abbreviations: HGS: hand grip strength; BMI: body mass index; EQ-5D: EuroQol-5 dimension

The patterns of impairment of EQ-5D differed depending on age group, as shown in Figure 2. In the 61–70-years age group, the prevalence of pain/discomfort was very high, and there was a significant difference in the percentage of those having problems between the normal and weak HGS groups in terms of self-care, usual activity, and pain/discomfort. Overall, participants aged 20–60 years were less likely to have any problems in the EQ-5D compared with those aged 61–70 years. However, the overall patterns of impairment in the EQ-5D (shown as a Radar chart plot) showed similar shapes between 20–60 and 61–70-year age groups. The 71–80-year age group showed a unique pattern in the EQ-5D compared with those of the other age groups. Problems in the mobility domain were more frequent, and there were significant differences in the percentages of participants having problems in the anxiety/depression dimension as well as mobility, self-care, and usual activity between normal and weak HGS group, while there was no difference in the pain/discomfort dimension.

When the participants were divided into three groups according to the degree of problems according to the EQ-5D (no problem/moderate problem/severe problem), the mean HGS tended to decrease as the severity of the impairment increased in all the dimensions except for anxiety/depression for men and in all the dimensions for women (Figure 3)

Logistic regression analysis was performed to confirm the association between HGS and HRQoL represented by the five dimensions of the EQ-5D according to sex. All three models were used for logistic regression analysis. The first model was adjusted for just age, and the fully adjusted model included all covariables, showing a significant correlation in simple correlation. Finally, selective adjustment was performed by backward elimination with the significance set at $p<0.05$. The results of the logistic analysis are shown in Table 2. In the selectively adjusted model, the odds ratio (OR) for impairment of HRQoL decreased significantly (range, 0.90–0.94) per 1-kg increase in HGS in terms of mobility, self-care, usual

activity, and pain/discomfort but not for anxiety/depression in men. In women, there was a similar association between HGS and HRQoL in all dimensions except for anxiety/depression after selective adjustment.

Table 2. Logistic regression analysis of the associations between hand grip strength (per 1-kg increase) and impaired status of health-related quality of life* (five dimensions of the EQ-5D)

	Adjusted for age		Fully adjusted†		Selectively adjusted‡	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P-value
Men						
Mobility	0.93 (0.89-0.97)	0.001	0.94 (0.90-0.98)	0.008	0.94 (0.90-0.99)	0.011
Self-care	0.89 (0.82-0.95)	0.001	0.89 (0.81-0.97)	0.010	0.90 (0.84-0.98)	0.011
Usual activity	0.92 (0.88-0.97)	0.001	0.92 (0.87-0.97)	0.004	0.93 (0.88-0.97)	0.002
Pain/ discomfort	0.94 (0.91-0.98)	0.002	0.95 (0.90-0.99)	0.013	0.94 (0.91-0.98)	0.002
Anxiety/ depression	0.95 (0.90-1.00)	0.034	0.97 (0.92-1.00)	0.341	0.96 (0.92-1.01)	0.118
Women						
Mobility	0.93 (0.89-0.98)	0.009	0.93 (0.88-0.99)	0.021	0.93 (0.88-0.99)	0.018

Self-care	0.95 (0.86-1.05)	0.288	0.92 (0.81-1.03)	0.155	0.86 (0.77-0.95)	0.003
Usual activity	0.91 (0.86-0.97)	0.003	0.92 (0.85-0.98)	0.017	0.91 (0.84-0.97)	0.006
Pain/ discomfort	0.94 (0.90-0.98)	0.003	0.93 (0.89-0.98)	0.004	0.93 (0.88-0.97)	0.002
Anxiety/ depression	0.95 (0.90-1.01)	0.077	0.97 (0.91-1.03)	0.313	0.97 (0.92-1.02)	0.234

*Impaired status of health-related quality of life: some or extreme problem in EQ-5D domains.

†Adjusted for age, body mass index, education, household income, residential area, marital status, smoking, alcohol drinking, and physical activity, comorbidities (hypertension, diabetes, ischemic heart disease, stroke, and depression).

‡Backward elimination method was used with significance set at $p < 0.05$.

DISCUSSION

The major findings of this study are that weak HGS is significantly associated with having a poor HRQoL in cancer survivors among a representative population sample, according to the EQ-5D. Particularly, in multivariate analysis, the risk of impaired HRQoL was significantly reduced when HGS was increased in all dimensions of the EQ-5D except for anxiety/depression. The OR for impaired HRQoL ranged from 0.86 to 0.97 per 1-kg increase on HGS in four dimensions (mobility, self-care, usual activity, and pain/discomfort).

In the present study, the mean HGS value of cancer survivors by age was not different from that previously reported for the Korean general population.[18 19] The reasons might be that patients with poor physical condition were excluded by chance due to the nature of the

KNHANES or that most cancer survivors have well-managed physical function. However, these results were similar to those of a previous small-sized study. Morishita et al. reported no difference in muscle strength between cancer survivors and healthy subjects. More importantly, they suggested that cancer survivors showed a meaningful correlation between muscle strength and HRQoL, whereas there was no association in healthy subjects.[20] These results provided a basis for the need to monitor and rehabilitate muscle strength in cancer survivors.

The pain/discomfort dimension showed the highest proportion of participants with problem, accounting for 28.1% of the participating cancer survivors; this was followed by mobility (22.2%), usual activity (13.0%), anxiety/depression (12.2%) and self-care (4.1%) dimensions. These results were consistent with previous findings.[9 21] Additionally, it was well known that cancer survivors had a lower quality of life, which represented the impairment of not only physical function but also mental health, compared with those in non-cancer populations. [9 22 23] Because HGS is a direct measure of muscle strength, it is an important predictor of muscle mass and overall muscle strength and also reflects part of the physical function.[12 13] The HGS showed a strong correlation with the pain/discomfort dimension as well as the dimensions presumed to be directly related to physical function in cancer survivors such as mobility, self-care, and usual activity. There is evidence indicating that pain is related to muscle strength. Some studies showed that experimental pain reduced muscle strength directly[24] and others suggested that variables such as psychosocial factors might affect both muscle strength and pain.[25]

The cancer survivors with weak HGS had significantly more anxiety/depression problems compared with those with normal HGS. However, after adjusting for covariates, the anxiety/depression dimension showed the weakest association with HGS in comparison with other dimensions. Other studies have shown similar results suggesting that HGS was positively correlated with global, physical, and environmental domains but not with the psychological domain in quality of life.[26] However, opposite results have also been reported. Lene et al.

observed that HGS was correlated with not only mobility and physical function but also the mental component of HRQoL.[27] Recently, many studies have assessed the relationship between HGS and depression in the general population or elderly.[17 28] Most have shown a positive correlation; in particular, a longitudinal study with a six-year follow-up period reported that weak HGS increased the risk of depression.[28] In recent years, cytokines such as brain-derived neurotrophic factor (BDNF) and several interleukins (IL-6, IL-7, IL-15) have been reported to be secreted by skeletal muscle and act on the brain, ultimately affecting cognitive function. [29 30] One study suggested that low BDNF levels were associated with cognitive impairment and that high IL-6 levels were strongly associated with depression in cancer patients.[31] HGS was also strongly correlated with the anxiety/depression domain only for elderly over 70 years of age in the age-based analysis in the present study. Taking the above into consideration, the time factor may need to be considered to confirm the association between HGS and anxiety/depression domain. Therefore, longitudinal studies are necessary.

This study has significant strength as a large-scale study using a nationally representative sample. To the best of our knowledge, this is the first study to evaluate the correlation between HGS and HRQoL in cancer survivors. Previous studies have investigated the relationships in the general population or in other disease settings[15 26 27] or have assessed other endpoints such as cognitive dysfunction.[32] As the number of cancer survivors has rapidly increased and monitoring and managing the quality of life of cancer survivors has become important, the results of this study are noteworthy. The results of this study suggest the possibility of weak HGS as a tool to predict poor HRQoL in cancer survivors. In addition, the measurement of HGS is easy, fast, inexpensive, reproducible, and reliable enough to be used in clinical practice to monitor patient quality of life.

A major limitation of this study was its cross-sectional designs, which makes it difficult to assess causality between HGS and quality of life. It is possible that poor physical function

represented by weak HGS may have been the direct cause of poor quality of life. Conversely, cancer survivors with better HRQoL may be more independent, so that the physical function is well maintained. Of course, both may behave in a bidirectional way. Second, there may be a selection bias, even if this survey was well-designed to include a sample representing the Korean population. Subjects who died early or cancer survivors living in nursing homes or long-term care facilities may not have been included in this study. In addition, there was a possibility of underreporting because it was a self-reporting system about the history of cancer. Third, we did not collect detailed medical information related to cancer such as cancer stage, types of cancer treatments, and family history of cancer. Fourth, since our data were confined to the Korean population, the results cannot be generalized to other ethnic populations. Finally, there was a disadvantage that the cut-off value of the HGS used in this study was arbitrarily determined. We classified the normal HGS group and the weak HGS group as the lowest quintiles (29.7 kg for men and 19.7 kg for women). These values were similar to the cut-off values for low muscle strength of 30 kg for men and 20 kg for women for diagnosing sarcopenia defined by European Working Group on Sarcopenia in Older People (EWGSOP).[33] Although the recently updated guideline recommended the low cut-off value for low muscle strength of 27 kg for men and 16 kg for women by the European Working Group on Sarcopenia in Older People 2 (EWGSOP2)[34], we could not analyze data according to these values since the number of cases under 27 kg for men and 16 kg for women was extremely small.

Conclusion

Our results from a large population-based sample show that HGS is significantly associated with HRQoL in cancer survivors. HGS can be used as a predictor of quality of life in cancer survivors as it is easy, inexpensive, and reliable. The anxiety/depression dimension had a relatively weak correlation with HGS compared with those of mobility, self-care, usual activity,

and pain/discomfort. Future prospective studies on the management of weak HGS in cancer survivors will increase understanding of the causal relationships and determine the clinical implications.

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Competing interests statement

There are no known conflicts of interest associated with this publication.

Data sharing statement:

Data will be available if requested.

AUTHOR CONTRIBUTIONS

YJC: conceived the study question and contributed to the study design, supervision of data collection, data analysis and interpretation, and writing of the manuscript.

JKP: contributed to the study design and undertook data collection, analysis, and interpretation and writing of the manuscript.

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FIGURE LEGENDS

Figure 1. Flow diagram of participant selection (KNHANES VI-VII, Korea National Health and Nutrition Examination Survey VI-VII).

Figure 2. Radar chart plot of the percentages of participants with impaired of health-related quality of life according to age group. An asterisk indicates a significantly (p-value <0.05) larger percentage of impairment in health-related quality of life (some or extreme problems in EQ-5D dimensions) in the weak hand strength group compared with that in the normal group. MO: mobility; SC: self-care, UA: usual activity; PD: pain/discomfort; AD: anxiety/depression; HGS: hand grip strength.

Figure 3. Comparisons of hand grip strengths according to three levels of health-related quality of life for each dimension. The trend of hand grip strength according to the severity of dimension was assessed using Jonckheere-Terpstra tests. EQ-5D: EuroQol-5 dimension

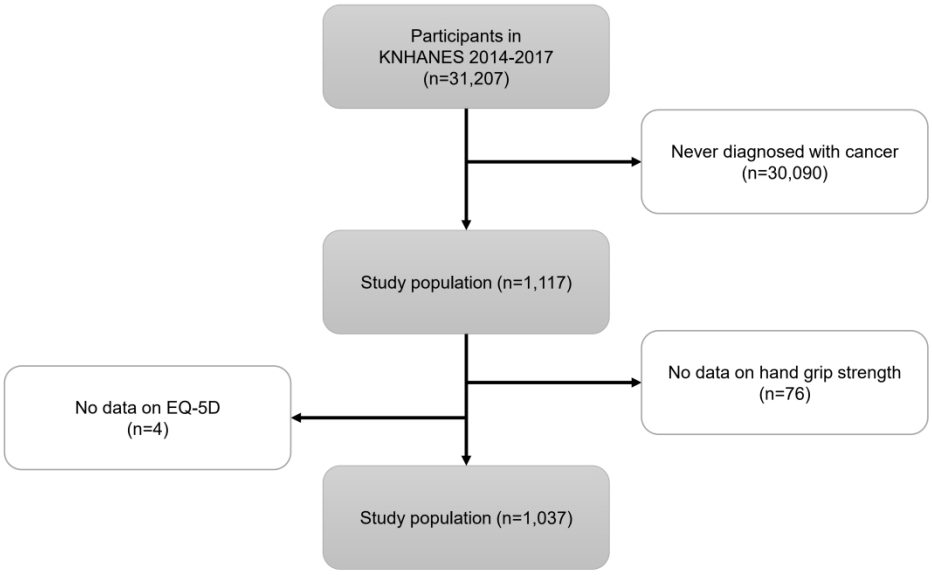

Figure 1. Flow diagram of participant selection (KNHANES VI-VII, Korea National Health and Nutrition Examination Survey VI-VII).

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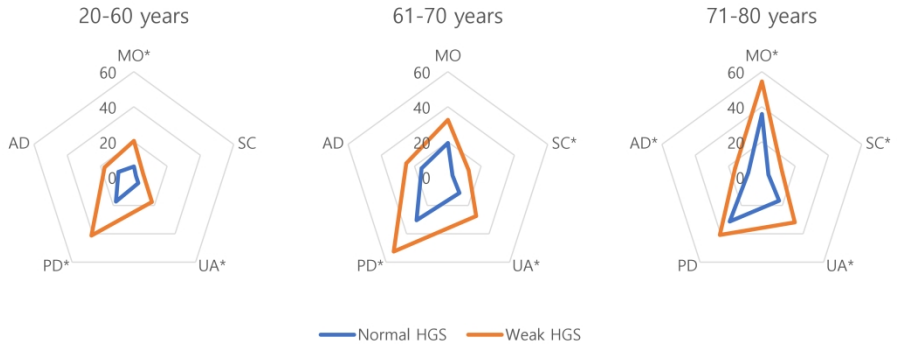

Figure 2. Radar chart plot of the percentages of participants with impaired of health-related quality of life according to age group. An asterisk indicates a significantly (p-value <0.05) larger percentage of impairment in health-related quality of life (some or extreme problems in EQ-5D dimensions) in the weak hand strength group compared with that in the normal group. MO: mobility; SC: self-care, UA: usual activity; PD: pain/discomfort; AD: anxiety/depression; HGS: hand grip strength.

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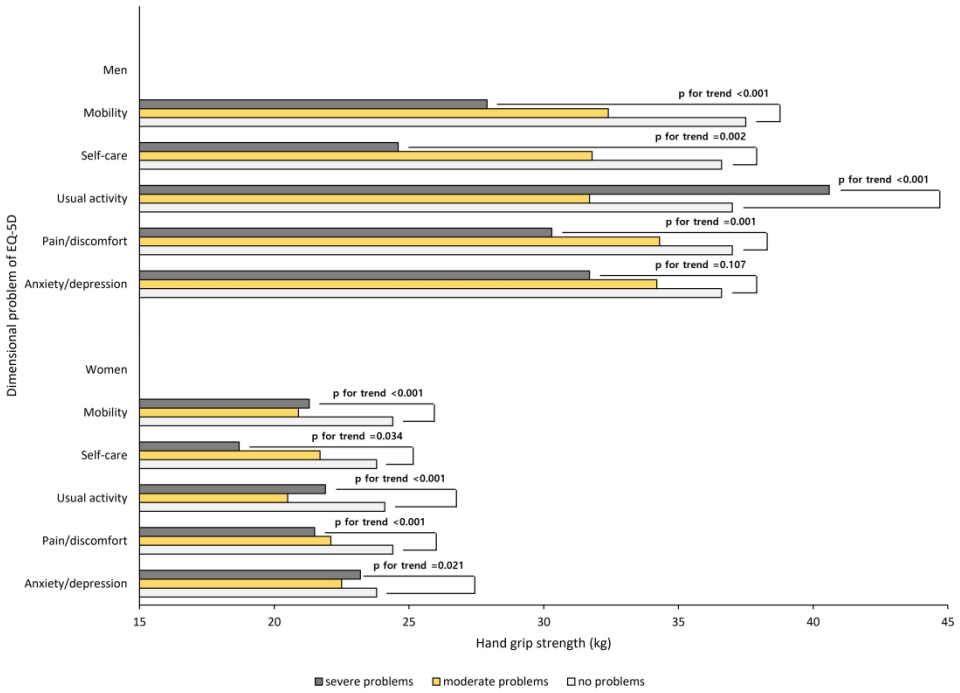

Figure 3. Comparisons of hand grip strengths according to three levels of health-related quality of life for each dimension. The trend of hand grip strength according to the severity of dimension was assessed using Jonckheere-Terpstra tests. EQ-5D: EuroQol-5 dimension

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Reporting checklist for cross sectional study.

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		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	3
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	#3	State specific objectives, including any prespecified hypotheses	7
Study design	#4	Present key elements of study design early in the paper	7
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	7

	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	7-8
Bias	#9	Describe any efforts to address potential sources of bias	8-9
Study size	#10	Explain how the study size was arrived at	7
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	8-9
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	8-9
	#12b	Describe any methods used to examine subgroups and interactions	8-9
	#12c	Explain how missing data were addressed	8-9
	#12d	If applicable, describe analytical methods taking account of sampling strategy	8-9
	#12e	Describe any sensitivity analyses	8-9
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	9
	#13b	Give reasons for non-participation at each stage	7
	#13c	Consider use of a flow diagram	7
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9

	#14b	Indicate number of participants with missing data for each variable of interest	7
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	9-12
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13-15
	#16b	Report category boundaries when continuous variables were categorized	13-14
	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	14-15
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	13-14
Key results	#18	Summarise key results with reference to study objectives	15
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	17-18
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	16-17
Generalisability	#21	Discuss the generalisability (external validity) of the study results	17-18
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

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Association between hand grip strength and impaired health-related quality of life in Korean cancer survivors: a cross-sectional study

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Association between hand grip strength and impaired health-related quality of life in Korean cancer survivors: a cross-sectional study

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ABSTRACT

Objectives: To assess the association between hand grip strength (HGS) and health-related quality of life (HRQoL) among Korean cancer survivors

Design: Population-based cross-sectional study

Setting: A nationally representative population survey data (face-to-face interviews and health examinations were performed in mobile examination centers)

Participants: A total of 1,037 cancer survivors (person with cancer of any type who is still living) with available data on HGS and HRQoL in the sixth and seventh Korea National Health and Nutrition Examination Surveys (KNHANES 2014-2017)

Primary outcome measures: Prevalence of impaired HRQoL by HGS

Results: Among 1,037 cancer survivors (60.7% women, mean age = 62.2 years), 19.2% of them had weak HGS according to gender-specific cut-off values (lowest quintile; <29.7 kg in men and <19.7 kg in women). In study population, the most common cancer site was the stomach, followed by the thyroid, breast, colorectal, and cervix. Individuals with weak HGS showed statistically significantly increased impairment in all five dimensions of the EuroQol-5 dimension compared with those in patients with normal HGS. In a multinomial logistic regression analysis, impaired HRQoL (some or extreme problem in EQ-5D) was significantly reduced in each dimension of the EQ-5D, except for anxiety/depression, when HGS was increased. The OR for impaired HRQoL ranged from 0.86 to 0.97 per 1 kg increase in HGS in four dimensions (mobility, self-care, usual activity, and pain/discomfort).

Conclusions: Weak HGS was associated with impaired HRQoL in cancer survivors. Future longitudinal studies are needed to confirm the causality between HGS and HRQoL in cancer survivors.

Keywords: Korea National Health and Nutrition Examination Survey, neoplasms, cancer survivors, hand strength, quality of life

STRENGTHS AND LIMITATIONS OF THIS STUDY

1. This study identified that weak hand grip strength (HGS) is associated with impaired health related quality of life (HRQoL) in cancer survivors.

2. The data used in this study were derived from nationally representative and well-designed systematic surveys.

3. The cross-sectional design of this study limits the ability to establish causal-interference relationships between HGS and HRQOL.

4. Because our data were confined to the Korean population, the results cannot be generalized to other ethnic populations.

INTRODUCTION

Cancer is a fatal and serious disease. However, with improving diagnostic and therapeutic techniques, the survival rate of cancer patients is increasing worldwide.[1] According to the Korea National Cancer Incidence Database, overall cancer mortality has decreased 2.7% annually since 2002, although the all-cancer incidence rate increased by 3.6% annually from 1999 to 2011, resulting in a long-term survival probability of 70.5% in the 2010s compared with the that in 1990s.[2]

Cancer survivor is defined as person who have been diagnosed with cancer of any type, including before, during and after treatment.[3] Compared with individuals in the general population, cancer survivors have increased risks of chronic diseases such as cardiovascular disease, second primary malignancy, and osteoporosis.[4-6] Furthermore, deterioration of physical function and psychosocial problems is common.[7]

As these survival issues and the life expectancy of cancer survivors have increased, health-related quality of life (HRQoL) has become an important outcome measure for survivors. HRQoL is a subjective, multidimensional concept that encompasses physical, social, functional, psychological/emotional health factors related to an individual's health. Several studies have reported that the HRQoL of cancer survivors is significantly lower than that of the non-cancer population.[8-10] The poor quality of life of cancer survivors is probably due to cancer itself and/or side effects of cancer treatments. Thus, there is a need to better monitor the quality of life in cancer survivors.

Hand grip strength (HGS) is a simple, fast, and reliable method for evaluating maximum voluntary squeezing force.[11 12] The measurement of HGS is useful not only to evaluate the qualitative and functional aspects of muscle strength in clinical practice but also to predict nutritional and general health statuses.[13 14] Additionally, HGS is associated with multiple chronic diseases and multimorbidity after adjusting for confounding factors.[15] Recent data

showed that HGS could be an independent predictor of the quality of life in various disease settings ranging from arthritis to chronic liver disease and depression.[16-18] In contrast, data on the impact of HGS on HRQoL in cancer survivors are lacking.

Given the above, we evaluated the cross-sectional associations of HGS with HRQoL among cancer survivors, using nationally representative data from the Korea National Health and Nutrition Examination Survey (KNHANES).

MATERIALS AND METHODS

Study population

The KNHANES is a cross-sectional, nationally representative survey that has been conducted to assess the health and nutritional status of the general population of Korea since 1998. The KNHANES uses a stratified multistage probability sampling to accurately represent the general population of South Korea. The present study analyzed data from the KNHANES VI-2,3 (2014-2015) and VII-1,2 (2016-2017). Adults who have been diagnosed with any type of cancer by a physician were included in this study as cancer survivor. As shown in Figure 1, a total of 1,037 participants who met the eligibility criteria were enrolled in this study.

Personal characteristics and clinical data

The demographic characteristics included age, sex, height, weight, body mass index (BMI), education (<10 years or ≥10 years), household income (low or high), residence (rural or urban), and marital status (living with someone or living alone). Health behaviors, including smoking status (never, former, or current), high-risk drinking, and physical activity, were also assessed. High-risk drinking was defined as the consumption of more than seven (men) or five (women) drinks on a single occasion at least twice a week. Adequate physical activity was defined as at least 30 minutes of moderate-intensity activity five days a week or at least 20 minutes of

vigorous physical activity three days per week. The comorbidities included hypertension, diabetes mellitus, ischemic heart disease, stroke, and depression. We collected data on cancer sites without data on current treatment and cancer-related symptoms.

Measurement of HGS

HGS was measured to the nearest 0.1 kg using a digital hand dynamometer (Digital Grip Strength Dynamometer, T.K.K 5401, Takei Scientific Instruments Co., Ltd., Tokyo, Japan). During the assessment, the participants were required to stand upright with their feet hip-width apart and to stretch their elbows completely. The participants were asked to apply the maximum grip strength three times for their left and right hands individually. The participants were instructed to hold the grip continuously with full force for more than 3 seconds. At least 30 seconds of rest was allowed between each measurement. Grip strength was defined as the maximally measured value among the six measurements in both hands. Weak HGS was defined as the lowest quintile in both men and women.

Assessment of HRQoL

We assessed HRQoL using the EuroQoL-5 Dimension (EQ-5D), which is a standardized instrument used to measure generic health status. It has been applied to a wide range of health conditions and treatments. The EQ-5D descriptive system comprises five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. The participants had three possible responses depending on the severity for each dimension: “no problems,” “moderate problems,” and “severe problems.” The EQ-5D instrument has been translated into Korean.

Statistical analyses

We divided the participants into two groups based on HGS (normal or weak).

The baseline characteristics are reported as means and standard deviation for all continuous variables and as frequencies and percentage for categorical variables. The differences in several covariates between the normal and weak HGS groups were assessed using Student's t-test for continuous variables and chi-square tests for categorical variables. Multiple logistic regression analyses were used to examine the associations between HGS and impaired HRQoL. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 21.0 (IBM Corp., Armonk, NY, USA). A two-tailed P-value <0.05 was considered statistically significant.

Ethics statement

This study's protocol for performing an analysis of the 2014–2017 KNHANES data was reviewed and approved by the Institutional Review Board of the Korea Centers for Disease Control and Prevention. Informed consent was obtained from all participants when the 2014–2017 KNHANES were conducted.

Patient and public involvement

We used publicly available and de-identified KNHANES data collected by the Korea Centers for Disease Control and Prevention (KCDC) for this study. No patients were involved in the design of this study.

RESULTS

Among 1,037 cancer survivors (60.7% women, mean age=62.2 years), the prevalent cancer site was the stomach, followed by the thyroid, breast, colorectum, and cervix. Overall, cancer survivors most commonly reported problems in pain/discomfort domain, followed by mobility and anxiety/depression. The sex-specific HGS cut-off values (lowest quintile) were 29.7 kg in men and 19.7 kg in women. The weak HGS group comprised 199 participants (19.2%) (18.6%

of men and 19.6% of women). Table 1 shows the characteristics of the normal and weak HGS groups. There were significant differences in several anthropometric measurements (height, weight), socio-demographic characteristics (education, household income, residential area, marital status, physical activity), and comorbidities (hypertension, diabetes, stroke). Participants with weak HGS showed significantly more impaired status for all dimensions of the EQ-5D compared with those in participants with normal HGS.

Table 1. Characteristics of 1,037 cancer survivors according to hand-grip strength

	Total (N=1,037)	Normal HGS (n=822)	Weak HGS* (n=199)	P-value
Age (y)	62.2±12.4	60.3±12.1	70.1±10.3	<0.001
Sex, n (%)				0.711
Men	408 (39.3)	332 (39.6)	76 (38.2)	
Women	629 (60.7)	506 (60.4)	123 (61.8)	
Height (cm)	160.4±8.2	161.3±7.8	156.3±8.6	<0.001
Weight (kg)	60.7±10.1	61.6±10.0	56.7±9.3	<0.001
BMI (kg/m^2)	23.6±3.2	23.6±3.3	23.2±3.2	0.071
Hand grip strength (kg)				
Men	36.3±7.7	38.7±6.2	25.9±3.7	<0.001

Women	23.7±4.8	25.3±3.6	16.8±2.6	<0.001
Education, n (%)				<0.001
<10 years	498 (48.0)	365 (43.8)	133 (66.8)	
≥10 years	535 (51.6)	469 (56.2)	66 (33.2)	
Income, n (%)				<0.001
1st, 2nd quartile (low)	565 (54.5)	419 (50.0)	146 (73.4)	
3rd, 4th quartile (high)	471 (45.4)	419 (50.0)	52 (26.1)	
Residence, n (%)				0.005
Urban	722 (69.6)	600 (71.6)	122 (61.3)	
Rural	315 (30.4)	238 (28.4)	77 (38.7)	
Marital status, n (%)				<0.001
Live alone	148 (14.3)	98 (11.7)	50 (25.1)	
Live with someone	889 (85.7)	740 (88.3)	149 (74.9)	
Former/current smoking, n (%)	374 (36.1)	308 (37.2)	66 (33.5)	0.339
Problem drinking†, n (%)	371 (35.8)	309 (42.1)	62 (35.8)	0.132
Inadequate physical activity‡, n (%)	610 (58.8)	464 (55.6)	146 (74.1)	<0.001
Comorbidity, n (%)				
Hypertension	383 (36.9)	289 (34.5)	94 (47.2)	0.001

Diabetes	161 (15.5)	118 (14.1)	43 (21.6)	0.008
Ischemic heart diseases	51 (4.9)	42 (5.0)	9 (4.5)	0.774
Stroke	32 (3.1)	17 (2.0)	15 (7.5)	<0.001
Depression	58 (5.6)	45 (5.4)	13 (6.5)	0.521
Cancer site§, n (%)				0.052
Stomach	194 (18.7)	149 (17.8)	45 (22.6)	
Colorectum	134 (12.9)	103 (12.3)	31 (15.6)	
Liver	31 (3.0)	24 (2.9)	7 (3.5)	
Breast‖	134 (21.3)	111 (22.9)	23 (18.7)	
Cervix‖	117 (18.6)	95 (18.8)	22 (17.9)	
Lung	37 (3.6)	31 (3.7)	6 (3.0)	
Thyroid	217 (20.9)	195 (23.3)	22 (11.1)	
Prostate‖	42 (10.3)	32 (9.6)	10 (13.2)	
Other	184 (17.7)	145 (17.3)	39 (19.6)	
EQ-5D (moderate/severe problem), n (%)				
Mobility	230 (22.2)	142 (16.9)	88 (44.2)	<0.001
Self-care	42 (4.1)	20 (2.4)	22 (11.1)	<0.001
Usual activities	135 (13.0)	78 (9.3)	57 (28.6)	<0.001

Pain/discomfort	291 (28.1)	205 (24.5)	86 (43.2)	<0.001
Anxiety/depression	127 (12.2)	91 (10.9)	36 (18.1)	0.005

Data are given as mean±standard deviation or number (%). P-value were analyzed by t-test or chi-square test.

*Defined as less than 29.7/19.7 kg (for men/women); †Defined as consuming more than 7/5 (for men/women) drinks on a single occasion at least twice a week; ‡Defined as less than 150 minutes per week; § Allows for patient to have more than one type of cancer; ‖Percentage is limited to women for breast/cervical cancer and to men for prostate cancer.

Abbreviations: HGS: hand grip strength; BMI: body mass index; EQ-5D: EuroQol-5 dimension

The patterns of impairment of EQ-5D differed depending on age group, as shown in Figure 2. In the 61–70-years age group, the prevalence of pain/discomfort was very high, and there was a significant difference in the percentage of those having problems between the normal and weak HGS groups in terms of self-care, usual activity, and pain/discomfort. Overall, participants aged 20–60 years were less likely to have any problems in the EQ-5D compared with those aged 61–70 years. However, the overall patterns of impairment in the EQ-5D (shown as a Radar chart plot) showed similar shapes between 20–60 and 61–70-year age groups. The 71–80-year age group showed a unique pattern in the EQ-5D compared with those of the other age groups. Problems in the mobility domain were more frequent, and there were significant differences in the percentages of participants having problems in the anxiety/depression dimension as well as mobility, self-care, and usual activity between normal and weak HGS group, while there was no difference in the pain/discomfort dimension. Compared with the general population who never had been diagnosed with cancer, the difference in the frequency of impaired HRQoL according to weak HGS was remarkable in cancer survivors.

When the participants were divided into three groups according to the degree of problems according to the EQ-5D (no problem/moderate problem/severe problem), the mean HGS tended to decrease as the severity of the impairment increased in all the dimensions except for anxiety/depression for men and in all the dimensions for women (Figure 3)

Logistic regression analysis was performed to confirm the association between HGS and HRQoL represented by the five dimensions of the EQ-5D according to sex. All three models were used for logistic regression analysis. The first model was adjusted for just age, and the fully adjusted model included all covariables, showing a significant correlation in simple correlation. Finally, selective adjustment was performed by backward elimination with the significance set at $p<0.05$. The results of the logistic analysis are shown in Table 2. In the selectively adjusted model, the odds ratio (OR) for impairment of HRQoL decreased significantly (range, 0.90–0.94) per 1-kg increase in HGS in terms of mobility, self-care, usual activity, and pain/discomfort but not for anxiety/depression in men. In women, there was a similar association between HGS and HRQoL in each dimension except for anxiety/depression after selective adjustment.

Table 2. Logistic regression analysis of the associations between hand grip strength (per 1-kg increase) and impaired status of health-related quality of life* (five dimensions of the EQ-5D)

	Adjusted for age		Fully adjusted†		Selectively adjusted‡	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P-value
Men						
Mobility	0.93 (0.89-0.97)	0.001	0.93 (0.88-0.98)	0.003	0.94 (0.90-0.99)	0.011

Self-care	0.89 (0.82-0.95)	0.001	0.89 (0.80-0.97)	0.009	0.90 (0.84-0.98)	0.011
Usual activity	0.92 (0.88-0.97)	0.001	0.93 (0.88-0.99)	0.015	0.93 (0.88-0.97)	0.002
Pain/ discomfort	0.94 (0.91-0.98)	0.002	0.94 (0.90-0.99)	0.017	0.94 (0.91-0.98)	0.002
Anxiety/ depression	0.95 (0.90-1.00)	0.034	0.98 (0.92-1.04)	0.429	0.96 (0.92-1.01)	0.118
Women						
Mobility	0.93 (0.89-0.98)	0.009	0.94 (0.89-1.01)	0.074	0.93 (0.88-0.99)	0.018
Self-care	0.95 (0.86-1.05)	0.288	0.93 (0.82-1.06)	0.257	0.86 (0.77-0.95)	0.003
Usual activity	0.91 (0.86-0.97)	0.003	0.93 (0.86-1.00)	0.045	0.91 (0.84-0.97)	0.006
Pain/ discomfort	0.94 (0.90-0.98)	0.003	0.94 (0.89-0.98)	0.010	0.93 (0.88-0.97)	0.002
Anxiety/ depression	0.95 (0.90-1.01)	0.077	0.97 (0.90-1.03)	0.315	0.97 (0.92-1.02)	0.234

*Impaired status of health-related quality of life: some or extreme problem in EQ-5D domains.

†Adjusted for age, height, weight, education, household income, residential area, marital status, smoking, alcohol drinking, and physical activity, comorbidities (hypertension, diabetes, ischemic heart disease, stroke, and depression).

‡Backward elimination method was used with significance set at $p < 0.05$.

DISCUSSION

The major findings of this study are that weak HGS is significantly associated with having a poor HRQoL in cancer survivors among a representative population sample, according to the EQ-5D. Particularly, in multivariate analysis, the risk of impaired HRQoL was significantly reduced when HGS was increased in all dimensions of the EQ-5D except for anxiety/depression. The OR for impaired HRQoL ranged from 0.86 to 0.97 per 1-kg increase on HGS in four dimensions (mobility, self-care, usual activity, and pain/discomfort).

In the present study, the mean HGS value of cancer survivors by age was not different from that previously reported for the Korean general population.[19 20] The reasons might be that patients with poor physical condition were excluded by chance due to the nature of the KNHANES or that most cancer survivors have well-managed physical function. However, these results were similar to those of a previous small-sized study. Morishita et al. reported no difference in muscle strength between cancer survivors and healthy subjects. More importantly, they suggested that cancer survivors showed a meaningful correlation between muscle strength and HRQoL, whereas there was no association in healthy subjects.[21] The results of present study were also in good agreement with this results. These results that the weak HGS is more closely related to the impaired HRQoL in cancer survivors than the general population will be a basis for the need to monitor and rehabilitate muscle strength in cancer survivors.

The pain/discomfort dimension showed the highest proportion of participants with problem, accounting for 28.1% of the participating cancer survivors; this was followed by mobility (22.2%), usual activity (13.0%), anxiety/depression (12.2%) and self-care (4.1%) dimensions. These results were consistent with previous findings.[10 22] Additionally, it was well known that cancer survivors had a lower quality of life, which represented the impairment of not only physical function but also mental health, compared with those in non-cancer populations. [10 23]

[24]

Because HGS is a direct measure of muscle strength, it is an important predictor of muscle mass and overall muscle strength and also reflects part of the physical function.[13 14] The HGS showed a strong correlation with the pain/discomfort dimension as well as the dimensions presumed to be directly related to physical function in cancer survivors such as mobility, self-care, and usual activity. There is evidence indicating that pain is related to muscle strength. Some studies showed that experimental pain reduced muscle strength directly[25] and others suggested that variables such as psychosocial factors might affect both muscle strength and pain.[26]

The cancer survivors with weak HGS had significantly more anxiety/depression problems compared with those with normal HGS. However, after adjusting for covariates, the anxiety/depression dimension showed the weakest association with HGS in comparison with other dimensions. Other studies have shown similar results suggesting that HGS was positively correlated with global, physical, and environmental domains but not with the psychological domain in quality of life.[27] However, opposite results have also been reported. Lene et al. observed that HGS was correlated with not only mobility and physical function but also the mental component of HRQoL.[28] Recently, many studies have assessed the relationship between HGS and depression in the general population or elderly.[18 29] Most have shown a positive correlation; in particular, a longitudinal study with a six-year follow-up period reported that weak HGS increased the risk of depression.[29] In recent years, cytokines such as brain-derived neurotrophic factor (BDNF) and several interleukins (IL-6, IL-7, IL-15) have been reported to be secreted by skeletal muscle and act on the brain, ultimately affecting cognitive function. [30 31] One study suggested that low BDNF levels were associated with cognitive impairment and that high IL-6 levels were strongly associated with depression in cancer patients.[32] HGS was also strongly correlated with the anxiety/depression domain only for elderly over 70 years of age in the age-based analysis in the present study. Taking the above into consideration, the time

factor may need to be considered to confirm the association between HGS and anxiety/depression domain. Therefore, longitudinal studies are necessary.

This study has significant strength of using a nationally representative and well-designed systematic data. This study identified that weak HGS is associated with impaired HRQoL in cancer survivors. Previous studies have investigated the relationships in the general population or in other disease settings[16 27 28 33] or have assessed other endpoints such as cognitive dysfunction.[34] As the number of cancer survivors has rapidly increased and monitoring and managing the quality of life of cancer survivors has become important, the results of this study are noteworthy. The results of this study suggest the possibility of weak HGS as a tool to predict poor HRQoL in cancer survivors. In addition, the measurement of HGS is easy, fast, inexpensive, reproducible, and reliable enough to be used in clinical practice to monitor patient quality of life.

A major limitation of this study was its cross-sectional designs, which makes it difficult to assess causality between HGS and quality of life. It is possible that poor physical function represented by weak HGS may have been the direct cause of poor quality of life. Conversely, cancer survivors with better HRQoL may be more independent, so that the physical function is well maintained. Of course, both may behave in a bidirectional way. Second, there may be a selection bias, even if this survey was well-designed to include a sample representing the Korean population. Subjects who died early or cancer survivors living in nursing homes or long-term care facilities may not have been included in this study. In addition, there was a possibility of underreporting because it was a self-reporting system about the history of cancer. Third, we did not collect detailed medical information related to cancer such as cancer stage, types of cancer treatments, and family history of cancer. Fourth, since our data were confined to the Korean population, the results cannot be generalized to other ethnic populations. Finally, there was a disadvantage that the cut-off value of the HGS used in this study was arbitrarily

determined. We classified the normal HGS group and the weak HGS group as the lowest quintiles (29.7 kg for men and 19.7 kg for women). These values were similar to the cut-off values for low muscle strength of 30 kg for men and 20 kg for women for diagnosing sarcopenia defined by European Working Group on Sarcopenia in Older People (EWGSOP).[35] Although the recently updated guideline recommended the low cut-off value for low muscle strength of 27 kg for men and 16 kg for women by the European Working Group on Sarcopenia in Older People 2 (EWGSOP2)[36], we could not analyze data according to these values since the number of cases under 27 kg for men and 16 kg for women was extremely small.

Conclusion

Our results from a population-based sample show that weak HGS is significantly associated with impaired HRQoL in cancer survivors. HGS can be used as a predictor of quality of life in cancer survivors as it is easy, inexpensive, and reliable. The anxiety/depression dimension had a relatively weak correlation with HGS compared with those of mobility, self-care, usual activity, and pain/discomfort. Future prospective studies on the management of weak HGS in cancer survivors will increase understanding of the causal relationships and determine the clinical implications.

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AUTHOR DISCLOSURES

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Competing interests statement

There are no known conflicts of interest associated with this publication.

Data sharing statement:

The data are available in a public, open access repository. Currently, anyone can access the website.

AUTHOR CONTRIBUTIONS

YJC: conceived the study question and contributed to the study design, supervision of data collection, data analysis and interpretation, and writing of the manuscript.

JKP: contributed to the study design and undertook data collection, analysis, and interpretation and writing of the manuscript.

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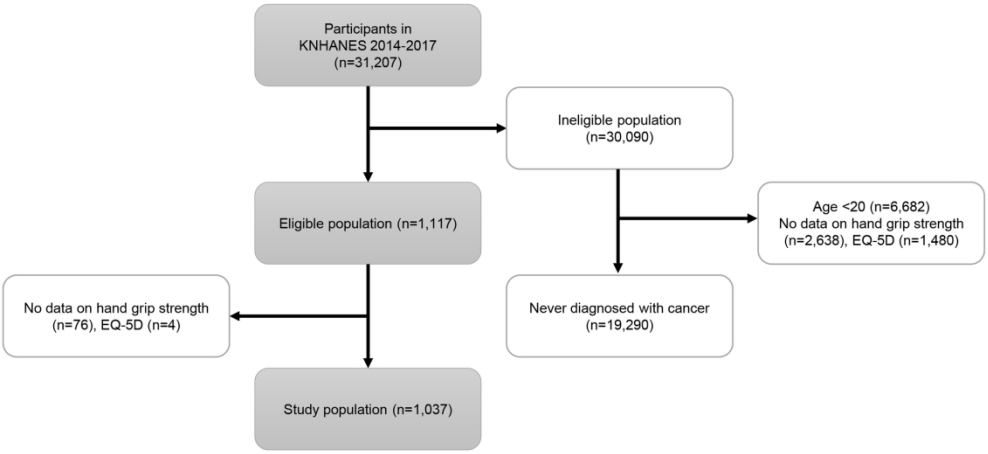
FIGURE LEGENDS

Figure 1. Flow diagram of participant selection (KNHANES VI-VII, Korea National Health and Nutrition Examination Survey VI-VII).

Figure 2. Radar chart plot of the percentages of participants with impaired of health-related quality of life according to age group in cancer survivors (compared with general population). An asterisk indicates a significantly (p-value <0.05) larger percentage of impairment in health-related quality of life (some or extreme problems in EQ-5D dimensions) in the weak hand strength group compared with that in the normal group. MO: mobility; SC: self-care, UA: usual activity; PD: pain/discomfort; AD: anxiety/depression; HGS: hand grip strength.

Figure 3. Comparisons of hand grip strengths according to three levels of health-related quality of life for each dimension. The trend of hand grip strength according to the severity of dimension was assessed using Jonckheere-Terpstra tests. EQ-5D: EuroQol-5 dimension



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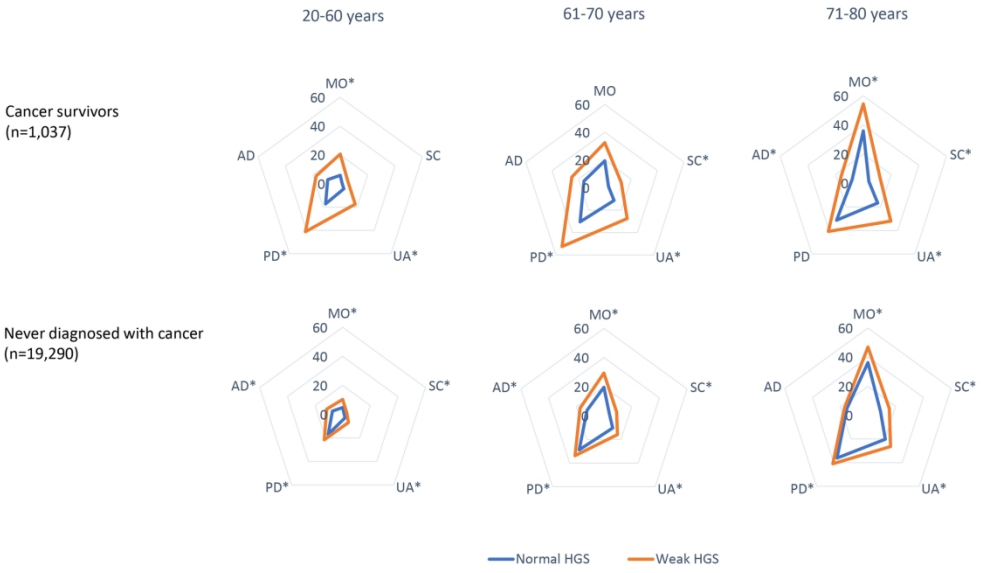

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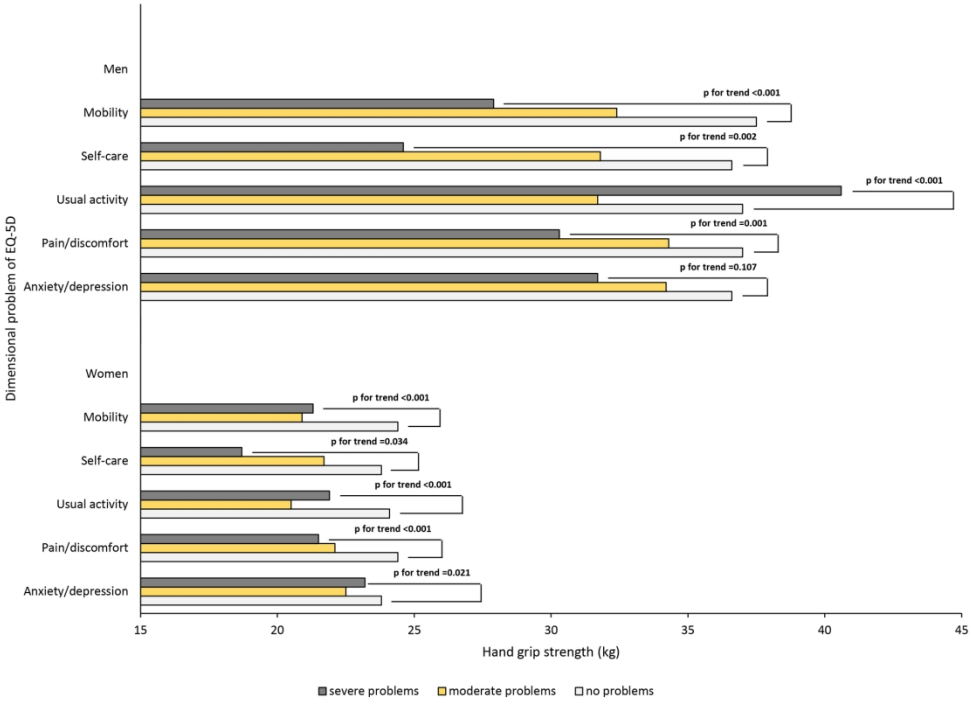

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Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

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Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

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		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	3

Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	#3	State specific objectives, including any prespecified hypotheses	7
Study design	#4	Present key elements of study design early in the paper	7
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	7
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	7-8
Bias	#9	Describe any efforts to address potential sources of bias	8-9
Study size	#10	Explain how the study size was arrived at	7

Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	8-9
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	8-9
	#12b	Describe any methods used to examine subgroups and interactions	8-9
	#12c	Explain how missing data were addressed	8-9
	#12d	If applicable, describe analytical methods taking account of sampling strategy	8-9
	#12e	Describe any sensitivity analyses	8-9
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	9
	#13b	Give reasons for non-participation at each stage	7
	#13c	Consider use of a flow diagram	7
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9

	#14b	Indicate number of participants with missing data for each variable of interest	7
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	9-12
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13-15
	#16b	Report category boundaries when continuous variables were categorized	13-14
	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	14-15
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	13-14
Key results	#18	Summarise key results with reference to study objectives	15
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	17-18
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	15-17

Generalisability	#21	Discuss the generalisability (external validity) of the study results	17-18
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20