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Grip Strength and Health-Related Quality of Life in U.S. Adult Males

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Background: A need exists for a population-based evaluation of muscular strength in terms of its association with health-related quality of life (HRQOL) in males. Therefore, the purpose of this study was to examine the relationship between grip strength and HRQOL in a representative sample of U.S. men.
Methods: This study used data from adult males 20+ years of age participating in the 2013-2014 National Health and Nutrition Examination Survey. Grip strength (kg) was measured in both hands using a handgrip dynamometer. HRQOL was assessed by a single question asking participants to rate their general health. Additionally, measures of moderate-to-vigorous physical activity (PA), body mass index, waist circumference, TV time, sedentary time, and smoking were assessed. Multiple linear regression modeling for complex samples was used to examine the effect of HRQOL on grip strength while controlling for confounding variables.
Results: Overall, males with good HRQOL (*Mean* = 47.5 kg, *SE* = 0.31) had significantly greater grip strength than males with poor HRQOL (*Mean* = 44.5 kg, *SE* = 0.51, $p < 0.001$). In fully adjusted models, males with good HRQOL had greater grip strength (*slope* = 2.5 kg, *SE* = 0.57, $p = 0.001$) than their poor HRQOL counterparts. Additionally, HRQOL was a significant predictor of grip strength in male adults who did not meet PA guidelines but not in those who did meet PA guidelines.
Conclusion: Results from this study indicate that muscular strength and HRQOL are related in U.S. men. Furthermore, the muscular strength and HRQOL relationship appears to remain in adult males who do not meet PA guidelines.

Key Words: Muscular strength, Health-related quality of life, Population health, Epidemiology

INTRODUCTION

Muscular strength is a specific component of health-related fitness and is defined as the ability to develop maximal muscle force [1]. Muscular fitness is related to many health problems that affect men. Specifically, muscular fitness has been identified as a predictor of cardiovascular disease [2], cancer [3], diabetes [4,5], depression [6], cognitive decline [7], and unintentional injury [8]. Furthermore, muscular strength is associated with mortality from cardiovascular disease, cancer, and all-causes in men [9,10]. In elderly males, the maintenance of muscular strength may also protect against declines in physical function [11] and activities of daily living [12,13].

Despite the known associations between muscular fitness and health outcomes, less is known about the relationship between muscular strength and perceived health in adult males. Health-related quality of life (HRQOL) is one such

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measure of perceived health and can be defined as a construct that considers the relationship between an individual's health status and their quality of life [14]. A recent study has examined the relationship between muscle strength HRQOL using the WHOQOL-BREF questionnaire and found both a significant and positive association in men [15]. This study, however, used a small sample of males and was based in Austria. A larger population-based study examined the same relationship using the Short-Form-36 (SF-36) assessment and also found a significant and positive relationship in males [16]. This study, though, was based in the UK. Therefore, a need exists for a population-based evaluation of muscular strength as it relates to HRQOL is U.S. adult males. More specifically, the primary purpose of this study was to examine the relationship between grip strength and HRQOL in a representative sample of U.S. men. A secondary purpose of this study was to examine the moderating effects of both physical activity (PA) and obesity on the grip strength and HRQOL relationship in the same population.

MATERIALS AND METHODS

1. Study design

Data for this research came from the 2013-2014 National Health and Nutrition Examination Survey (NHANES) [17]. NHANES is a series of studies designed to assess health behavior, health status, and nutrition of noninstitutionalized civilian residents of the U.S. Specifically, NHANES collects data on individuals using personal interviews, standardized physical examinations, and laboratory tests. The current study used data only from personal interviews (demographic data and questionnaire data) and physical examinations (body measures data and muscle strength data). The sample in the current study consisted of N = 2,389 male participants who were 20+ years of age and had complete grip strength and HRQOL data.

2. Variables utilized

The dependent variable in this study was grip strength. The main independent variable was HRQOL. Moderating variables were obesity status and PA status. Other variables used in this study were body mass index (BMI), waist circumference (WC), moderate-to-vigorous PA (MVPA), TV time, sedentary time, smoking status, age, race, marital/partner status, income, and education.

3. Assessment of Grip Strength and HRQOL

Grip strength (kg) was measured repeatedly in both hands using a handgrip dynamometer that was administered by a trained examiner [18]. After a submaximal practice trial and grip adjustment, participants squeezed the dynamometer as hard as possible with a randomly selected hand while in the standing position (when possible). The test was then completed with the other hand for a total of three trials on each hand. The largest dynamometer reading across all trials served as the grip strength score in this study. HRQOL was assessed by a single question asking participants to rate their general health [19]. In this study, males rating their health as "good", "very good", or "excellent" were considered to have good HRQOL whereas those rating it "fair" or "poor" were considered to have poor HRQOL.

4. Assessment of PA variables

Sedentary time was assessed from a question asking participants how much time they usually spend sitting in a typical day [20]. For this study, sedentary time was converted to quartiles, where the first quartile contained the least sedentary individuals and the last quartile contained the most sedentary. TV time was assessed from a survey question asking participants how many hours per day they sat and watched TV or videos during the past 30 days [20]. For this study, two discrete TV time groups were formed: (1) < 5 hours and (2) 5+ hours. Two PA variables were used in this study. A continuous PA variable was computed from constructed variables of minutes of moderate physical activity (MPA) per week and minutes of vigorous physical activity (VPA) per week [20]. VPA was assessed from the responses to two questions. The first question asked respondents how many days they participated in vigorous intensity sports, fitness, or recreational activities. The second question asked respondents how much time they spend doing vigorous-intensity activity on a typical day. Multiplying days with minutes yielded VPA measured per week. The same two questions were asked regarding moderate-intensity activities to assess MPA per week. These two physical activity variables were then used to compute minutes of MVPA per week. A second PA status variable was computed from MVPA which consisted of two discrete PA groups: (1) < 150 minutes of MVPA and (2) 150+ minutes of MVPA.

5. Assessment of body composition variables

Using BMI (kg/m^2), participants were categorized into one of four discrete groups: 1) underweight (BMI: < 18.5), normal weight (BMI: 18.5 to 24.9), overweight (BMI: 25.0 to 29.9), and obese (BMI: 30+). Using WC, participants were categorized into two discrete groups: 1) obese (WC: > 102 cm) and non-obese (WC: ≤ 102 cm). The categorization of WC was used as the obese status variable. Measurements for both BMI (height and weight) and WC were collected by trained NHANES health professionals during a medical examination [21].

6. Other variables

A smoking status variable was constructed from a question asking participants if they now smoke cigarettes [22]. Those responding "yes, every day" or "yes, some days" were considered current smokers and those responding "no, not

Table 1. Descriptive values of grip strength by HRQOL across demographic characteristics, U.S. adult males 20+ years of age 2013-2014

Characteristic	Good HRQOL			Poor HRQOL			p
	Mean	*SE*	*t*	*Mean*	*SE*	*t*	
Overall	47.54	0.31		44.48	0.51		< 0.001
Age group (yr)							
20-24	49.42	0.58	a	46.52	2.27	a	0.229
25-34	50.73	0.45	b	49.93	1.22	b,c	0.577
35-44	50.53	0.61	c	49.03	1.06	d	0.157
45-54	49.01	0.53	d	45.39	0.93	b	0.016
55-64	45.07	0.47	a,b,c,d	42.98	0.87	c,d	0.016
65+	40.07	0.65	a,b,c,d	36.73	0.97	a,c,d	0.002
p for trend			< 0.001			< 0.001	
Race/Ethnicity							
White	47.76	0.35		44.13	0.70		< 0.001
Black	49.36	0.63	a,b	47.26	1.10		0.131
Hispanic	46.41	0.51	a	44.27	0.57		0.002
Other	45.04	1.00	b	43.35	1.63		0.361
p for overall diff			< 0.001			0.107	
Income (US $)							
0-19,999	44.91	0.76	a,b,c	42.58	1.44		0.155
20,000-44,999	46.28	0.35	d	42.89	1.15	a	0.011
45,000-64,999	47.82	0.60	a	46.51	0.95	a	0.277
65,000-74,999	50.43	1.62	b	47.39	2.63		0.418
75,000+	48.31	0.44	c,d	46.21	1.18		0.063
p for trend			< 0.001			0.038	
Education							
No high school diploma	46.58	0.58	a	43.50	0.96		0.012
High school diploma	46.97	0.39	b	44.83	0.78		0.012
Some college	49.26	0.48	a,b,c	45.17	0.88		< 0.001
4-year college degree	46.80	0.52	c	44.21	1.36		0.100
p for trend			0.669			0.402	
Living with spouse/partner							
Yes	46.72	0.45		43.90	1.03		0.049
No	47.92	0.43		44.85	0.61		0.000
p for overall diff			0.091			0.468	

Grip strength values are in kilograms (kg). p-values in bold are significant at the 0.05 level. t column represents tests of within group differences with Tukey-Kramer adjustment where groups with same letter represent a significant difference.
HRQOL: Health-related quality of life, SE: standard error.

at all" were considered non-current smokers. Demographic variables used in this study were age (20-24 yr, 25-34 yr, 35-44 yr, 45-54 yr, 55-64 yr, 65+ yr), race/ethnicity (White, Black, Hispanic, Other), household income ($0-$19.999, $20,000-$44,999, $45,000-$64,999, $65,000-$74,999, $75,000+), education (no high school diploma, high school diploma, some college, 4-year college degree), and marital/partner status (living with a spouse/partner, not living with spouse/partner).

7. Statistical analyses

Descriptive statistics (means and standard errors) were computed and tests of mean differences were conducted on grip strength values across HRQOL groups. Tests of linear trend were conducted within each HRQOL group across ordinal variables and analysis of variance (ANOVA) tests were conducted across nominal variables. Additionally, within group mean comparisons with Tukey-Kramer adjustments were made across all variables groups when the omnibus test was significant and group levels were greater than 2. Multiple linear regression analysis of grip strength regressed on HRQOL was conducted at three different levels. First, grip strength was regressed on HRQOL while controlling for age (Model I). Second, grip strength was regressed

Table 2. Descriptive values of grip strength by HRQOL across health characteristics, U.S. adult males 20+ years of age 2013-2014

Characteristic	Good HRQOL			Poor HRQOL			p
	Mean	*SE*	*t*	*Mean*	*SE*	*t*	
BMI group							
Underweight	39.07	0.77	a,b	40.02	1.51	a	0.203
Normal weight	46.07	0.61	a,c	41.12	1.18	b	0.004
Overweight	47.41	0.46	b,d	44.72	0.83		0.002
Obese	49.19	0.34	a,b,c,d	46.45	0.94	a,b	0.004
p for trend			< 0.001			0.007	
WC group							
Obese	47.90	0.30		46.01	0.60		0.005
Not obese	47.36	0.46		43.36	0.80		0.001
p for diff			0.324			0.027	
Met PA Guidelines							
No	46.82	0.41		43.97	0.62		< 0.001
Yes	48.42	0.38		46.38	0.89		0.031
p for diff			0.007			0.051	
TV time (per day)							
< 5 hours	47.87	0.32		45.26	0.62		0.001
5+ hours	45.05	0.76		42.05	1.32		0.054
p for diff			0.003			0.054	
Sedentary time (quartiles)							
Q1 (least sedentary)	48.87	0.50	a,b,c	45.59	0.79		0.011
Q2	47.10	0.48	a	46.03	1.06		0.337
Q3	46.92	0.69	b	43.13	1.14		0.006
Q4 (most sedentary)	47.44	0.47	c	42.59	1.26		0.001
p for trend			0.043			0.059	
Current smoker							
No	46.47	0.60		42.44	1.00		0.003
Yes	48.36	0.61		45.07	0.86		0.003
p for diff			0.066			0.099	

Q1 – Q4 are the 1st thru 4th quartiles. Grip strength values are in kilograms (kg). p-values in bold are significant at the 0.05 level. t column represents tests of within group differences with Tukey-Kramer adjustment where groups with same letter represent a significant difference.
HRQOL: health-related quality of life, BMI: body mass index, WC: waist circumference, PA: physical activity, TV: television, SE: standard error.

on HRQOL while controlling for age, race/ethnicity, marital/partner status, income, and education (Model II). Lastly, grip strength was regressed on HRQOL while controlling for age, race/ethnicity, marital/partner status, income, education, MVPA, sedentary time, BMI, and smoking status (Model III). Additionally, two other sets of regression models were run to examine moderator effects. One set of regression models were run across both PA groups (meeting and not meeting PA guidelines). The other set of regression models were run across both obesity status groups (obese and non-obese). All analyses were performed using the survey procedures of SAS version 9.4 [23-25]. All p-values were reported as 2-sided and statistical significance was defined as p-values < 0.05.

RESULTS

Table 1 contains descriptive grip strength values by HRQOL across demographic groups. Overall, males with good HRQOL (*Mean* = 47.5 kg, *SE* = 0.31) had significantly greater grip strength than males with poor HRQOL (*Mean* = 44.5 kg, *SE* = 0.51, $p < 0.001$). Grip strength appeared to decline linearly with increasing age in both HRQOL groups (*ps* for trend < 0.001). Additionally, strength was significantly lower (*ps* < 0.05) in the last three age groups (45+ yr) for those with poor HRQOL, as compared to those with good HRQOL. Grip strength differed across race/ethnicity group, only for participants with good HRQOL, where Black men had significantly (adj *ps* $<$ 0.05) greater strength than both Hispanic men and those of other race/ethnic groups. Furthermore, strength was significantly lower ($p < 0.05$) in White males with poor HRQOL, as compared to those with good HRQOL. Finally, grip strength increased linearly with increasing income in both HRQOL groups (*ps* for trend < 0.001).

Table 2 contains descriptive grip strength values by HRQOL across health characteristic groups. Grip strength appeared to increase linearly with increasing BMI group in both HRQOL groups (*ps* for trend < 0.001). Additionally, males with poor HRQOL had significantly (*ps* < 0.05) lower strength across all BMI groups except underweight. Also noteworthy, grip strength decreased linearly with increasing sedentary time in males with good HRQOL only (p for trend < 0.001). Furthermore, the most sedentary males (last

Table 3. Multiple linear regression analysis of grip strength regressed on HRQOL, U.S. adult males 20+ years of age 2013-2014

Characteristic	Model I			Model II			Model III		
	Estimate	*SE*	p	*Estimate*	*SE*	p	*Estimate*	*SE*	p
Overall									
Poor HRQOL	reference			reference			reference		
Good HRQOL	2.40	0.51	< 0.001	1.50	0.51	0.010	2.45	0.57	0.001
Did meet PA guidelines									
Poor HRQOL	reference			reference			reference		
Good HRQOL	1.91	1.07	0.096	1.26	1.02	0.238	1.08	1.15	0.365
Did not meet PA guidelines									
Poor HRQOL	reference			reference			reference		
Good HRQOL	2.37	0.62	0.002	1.38	0.74	0.080	2.61	0.68	0.002
Obese									
Poor HRQOL	reference			reference			reference		
Good HRQOL	2.15	0.52	0.001	1.44	0.55	0.020	1.48	0.77	0.076
Non-obese									
Poor HRQOL	reference			reference			reference		
Good HRQOL	3.06	0.89	0.004	2.02	0.97	0.054	3.02	1.26	0.030

p-values in bold are significant at the 0.05 level. Model estimates are in kilograms (kg). Model I is age adjusted. Model II is age, race, marital/partner status, income, and education adjusted. Model III is adjusted as model II but additionally MVPA, sedentary time, BMI, and smoking status adjusted, when appropriate. Obese status was defined as a WC > 102 cm. Meeting PA guidelines was defined as self-reporting 150+ minutes of moderate-to-vigorous-intensity recreational PA per week.
HRQOL: Health-related quality of life, SE: standard error.

2 quartiles) with poor HRQOL had significantly (*ps* < 0.05) lower strength than their counterparts with good HRQOL.

Table 3 displays results from the multiple linear regression analysis of grip strength regressed on HRQOL. In the overall age adjusted model, males with good HRQOL had greater grip strength (*slope* = 2.40 kg, *SE* = 0.51, $p < 0.001$) than their poor HRQOL counterparts. This relationship persisted in the overall fully adjusted model (*slope* = 2.5 kg, *SE* = 0.57, p = 0.001). Additionally, in fully adjusted PA status models, HRQOL was a significant predictor of grip strength in men who did not meet PA guidelines (*slope* = 2.6 kg, *SE* = 0.68, p = 0.002). The relationship was not significant in the model with those who did meet the PA guidelines. Similarly, in fully adjusted obese status models, HRQOL was a significant predictor of grip strength in men who were non-obese (*slope* = 3.02 kg, *SE* = 1.26, p = 0.030) and not in those who were obese.

DISCUSSION

The primary purpose of this study was to examine the relationship between grip strength and HRQOL in a representative sample of U.S. men. Results showed clearly that HRQOL is a significant predictor of grip strength, a measure of muscular strength, in U.S. men. These finding imply that men who perceive their general health as good to excellent, have greater muscular strength than their counterparts who perceive their general health as fair to poor. Therefore, HRQOL and its potential effect on muscular strength can be viewed similarly among men 20+ years of age in the U.S. as previously mentioned in other countries [15,16].

A secondary purpose of this study was to examine the moderating effects of both PA status and obesity on the grip strength and HRQOL relationship. This portion of the study showed noteworthy findings. Specifically, both PA status and obesity status moderated the HRQOL and grip strength relationship. HRQOL was a significant predictor of grip strength among men who did not meet PA guidelines and failed to predict strength among those who did meet guidelines. These findings may be explained by the benefits received from participating in regular PA. That is, regular activity itself is known to independently affect muscular strength, regardless of an individual's perceived health [26-28]. In the same way, HRQOL was a significant predictor of grip strength among men who were not obese and failed to predict strength among those who were obese. The explanations behind these findings are less clear. However, measurements of WC were used to create the obesity status variable in this study. Furthermore, the descriptive analysis of obese men indicated that those with good HRQOL had a similar grip strength as those with poor HRQOL, albeit significant, a difference of < 1.9 kg. In other words, obese men had very similar muscular strength, regardless of HRQOL. In the fully adjusted obese model, the regression estimate was 1.5 kg, indicating that adjustments in the model reduced the independent effect of HRQOL, making it non-significant. Therefore, factors such MVPA, sedentary time, and smoking could have explained grip strength variance more in obese men than non-obese. Another possible explanation for the failure of HRQOL to predict grip strength in obese men is the obesity paradox [29]. Grip strength measurements in this study were in absolute units (kg). Therefore, it is possible that obese men had similar strength to non-obese men merely because of their greater body mass and hence greater muscle mass [30]. Future studies should consider analyzing relative measures of grip strength (i.e., kg/body mass or kg/BMI) to better understand this null finding [31].

This study does have strengths worth mentioning. One strength of this study was its use of an objective measure of muscular strength. The use of grip strength, by hand-held dynamometer, is a valid and reliable means of assessing muscular strength and functional ability in adults [32-34]. Another strength of this study was its use of a population-based survey. NHANES data represent the total noninstitutionalized civilian U.S. population residing in the 50 states and District of Columbia [35]. Therefore, results from this study can validly be generalized to all noninstitutionalized adult males 20+ years of age residing in the U.S.

Results from this study, however, should not be interpreted without considering its limitations. The most serious limitation in this study is the cross-sectional nature of NHANES data. An obvious shortcoming to cross-sectional data is its inability to provide evidence for cause-and-effect relationships. That is, results from this study do not support the notion that improvements in HRQOL mediate the improvements in muscular strength. A well-controlled randomized trial should be conducted to address such cause-and-effect associations. Instead, results from this study should be considered as correlational. That is, point-in-time levels of HRQOL were found to be related to the same point-in-time levels of muscular strength.

Another limitation of this study was the self-report assessment of HRQOL and PA measures. That is, data from self-reported questionnaires have certain biases over more objective means of measurement. However, HRQOL is a measure of perceived health and the item used in this study has shown to have adequate psychometric properties [36,37]. Similarly, the items used to assess the PA measures in this study came from the Global Physical Activity Questionnaire (GPAQ), which also has shown to have adequate validity and reliability evidence supporting its use in this population [38,39].

CONCLUSION

Results from this study indicate that muscular strength and HRQOL are related in U.S. adult males. The muscular strength and HRQOL relationship appears to remain in men who do not meet PA guidelines and disappears in men who do meet the guidelines. Additionally, the muscular strength and HRQOL relationship appears to exist in non-obese and not obese men. Health promotion efforts directed toward improving HRQOL may also find benefits of improved muscular strength in men.

CONFLICTS OF INTERESTS

No financial assistance was used to assist with this project.

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