



Multivariate analysis of the sociodemographic predictors of grip strength in U.S. Adults

Peter D Hart¹

¹ Associate Professor, Health Promotion Program, Montana State University - Northern, Havre, MT 59501, United States

¹ Kinesmetrics Lab, Montana State University - Northern, Havre, MT, United States

Abstract

Background: Grip strength is a measure of muscular fitness and is related to many health problems in adults. The purpose of this study was to examine the independent relationship that sociodemographic predictors have on grip strength in U.S. adults.

Methods: Data for this research came from adults 20+ years of age participating in the 2013-2014 National Health and Nutrition Examination Survey (NHANES). Grip strength (kg) was measured three different times in each hand using a handgrip dynamometer and the largest reading across all trials served as the participant's score. Sociodemographic variables consisted of age, income, education, race/ethnicity, and marital/partner status. Sex-specific multiple linear regression models were employed to examine the independent relationship between predictors and grip strength.

Results: In bivariate analyses, significant ($p < .05$) differences in grip strength were noticed within all sociodemographic variables. Linear trends in grip strength were seen across age (indirect) and income (direct) for both sexes and across education (direct) in females. In multivariate models, all sociodemographic predictors (except education for males) were significantly related to grip strength in both males ($F=208.2$, $R^2=0.24$, $SE=8.1$ kg, $p < .001$) and females ($F=95.3$, $R^2=0.28$, $SE=5.2$ kg, $p < .001$).

Conclusion: Results from this study indicate that sociodemographic characteristics are related to grip strength in U.S. adults and account for approximately a quarter of its variance.

Keywords: grip strength, epidemiology, NHANES, population health

Introduction

Grip strength is a measure of muscular fitness and has a strong connection to many health outcomes^[1]. More specifically, muscular fitness is related to several different health problems including cardiovascular disease, cancer, diabetes, metabolic syndrome, depression, falls, cognitive function, activities of daily living, and obesity^[2-10]. Despite these known associations with muscular fitness, little is known about the social and demographic influence on grip strength. One study has recently reported cross-sectional findings on the relationship between race, income, age and grip strength in adults^[11]. Results from this study found significantly greater grip strength in African American adults as compared to their White counterparts as well as greater strength in high income adults as compared to their low-income counterparts. Although this study has value, its inferences are limited to adults 30 to 64 years of age residing in the Baltimore (Maryland) community and limited by its narrow scope of demographic variables. Therefore, the purpose of this study was to examine the multivariate relationship between several sociodemographic predictors and grip strength in U.S. adults.

Methods

Study design

Data for this research came from adults 20+ years of age participating in the 2013-2014 National Health and Nutrition Examination Survey (NHANES)^[12]. NHANES collects data on health behavior, health status, and nutrition of non-institutionalized civilian residents of the U.S. The current

study used data only from questionnaires and physical examinations. The sample in the current study consisted of adults with complete grip strength and sociodemographic data.

Assessment of Grip Strength

Grip strength (kg) was measured in both hands using a handgrip dynamometer administered by a trained examiner^[13]. Participants were allowed a submaximal practice trial to get an understanding for the test and make grip size adjustments. Participants then squeezed the dynamometer as hard as possible with a randomly selected hand while in the standing position. The test was then followed by a test on the other hand with a total of three trials on each hand. The largest dynamometer reading across all trials served as the grip strength score in this study.

Sociodemographic variables

A total of six sociodemographic variables were used in this study: sex, age, race/ethnicity, income, education, and marital/partner status. Sex was used to stratify the analyses. Participant age was used as a continuous variable as well as in groups: 20-24 yr, 25-34 yr, 35-44 yr, 45-54 yr, 55-64 yr, and 65+ yr. Participant race/ethnicity was categorized into four discrete groups: White, Black, Hispanic, and Other. Participant household income was categorized into five discrete and ordinal-level groups: \$0-\$19,999, \$20,000-\$44,999, \$45,000-\$64,999, \$65,000-\$74,999, \$75,000+. Participant education was categorized into four discrete and ordinal-level groups: no high school diploma, high school

diploma, some college, and 4-year college degree. Finally, participant marital/partner status was categorized into two discrete groups: living with a spouse/partner, not living with spouse/partner.

Statistical analyses

Descriptive statistics were computed on grip strength values across each sociodemographic variable. Tests of linear trend in grip strength were conducted across ordinal sociodemographic variables and analysis of variance (ANOVA) tests conducted across nominal sociodemographic variables. Follow-up mean comparisons with Tukey-Kramer adjustments were made across all groups when the omnibus test was significant and applicable. Multiple linear regression analysis of grip strength regressed on the set of sociodemographic predictors was conducted for each sex group. All analyses were performed using the survey procedures of SAS version 9.4 [14-16]. All *p*-values were reported as 2-sided and statistical significance was defined as *p*-values < 0.05.

Results

Table 1 contains bivariate descriptive statistics on grip strength values by sex across sociodemographic groups. Overall, males and females showed comparable

sociodemographic differences in grip strength. Specifically, grip strength decreased linearly (*ps*<.001) with increasing age in both sexes. Similarly, grip strength increased linearly (*ps*<.05) with increasing income in both sexes. In the race/ethnicity analyses, Black females had significantly (*ps*_{adjusted}<.05) greater strength as compared to all other race/ethnicity groups. Whereas Black males had significantly (*ps*_{adjusted}<.05) greater strength as compared to Hispanic and Other race/ethnicity groups only. Finally, grip strength increased linearly (*p*<.001) with increasing education in females only.

Table 2 displays results from the multiple linear regression analysis of grip strength regressed on the set of sociodemographic predictors. The set of sociodemographic variables significantly predicted grip strength in both males (*F*=208.2, *R*²=0.24, *SE*=8.1 kg, *p*<.001) and females (*F*=95.3, *R*²=0.28, *SE*=5.2 kg, *p*<.001). However, income was not a significant independent predictor of grip strength in the male model. Finally, models were re-fit including all possible sociodemographic interactions. In the male model, the education-by-race/ethnicity interaction was significant. However, including this term in the model made no improvement to model fit. In the female model, the marital/partner-by-age interaction was significant. Again, including this term in the final model made no improvement in fit and therefore was left out.

Table 1: Descriptive values of grip strength by sociodemographic characteristics among U.S. adults 20+ years of age, 2013-2014.

Characteristic	Males (N=2,522)			Females (N=2,689)		
	Mean	SE	p	Mean	SE	p
Overall	46.96	0.31	<.001	29.46	0.15	<.001
Age group (yr)			<.001			<.001
20-24	49.03	0.59	a	31.56	0.50	a
25-34	50.55	0.44	b	32.10	0.25	b
35-44	50.21	0.57	c	31.92	0.21	c
45-54	48.28	0.41	b	30.93	0.22	b
55-64	44.78	0.46	a,b,c	27.88	0.32	a,b,c
65+	39.14	0.64	a,b,c	23.69	0.31	a,b,c
<i>p</i> for trend			<.001			<.001
Race/Ethnicity			<.001			<.001
White	47.18	0.39		29.14	0.18	a
Black	48.96	0.53	a,b	32.37	0.37	a,b
Hispanic	45.79	0.44	a	29.21	0.21	b
Other	44.62	0.86	b	28.17	0.33	b
Income (US \$)			<.001			<.001
0-19,999	44.12	0.67	a,b,c	28.01	0.42	a,b
20,000-44,999	45.42	0.44	d,e	29.07	0.25	
45,000-64,999	47.41	0.51	a,d	30.63	0.38	a
65,000-74,999	49.84	1.26	b,e	30.45	0.75	
75,000+	48.17	0.46	c	29.86	0.24	b
<i>p</i> for trend			<.001			.003
Education			<.001			.002
No high school diploma	45.54	0.47	a	27.82	0.45	a,b
High school diploma	46.59	0.39	b	29.10	0.28	
Some college	48.46	0.48	a,b,c	30.16	0.21	a
4-year college degree	46.53	0.48	c	29.68	0.17	b
<i>p</i> for trend			.063			<.001
Living with spouse/partner			.022			.029
Yes	46.12	0.35	a	29.82	0.14	a
No	47.38	0.41	a	28.97	0.31	a
<i>p</i> for overall diff						

Note: Grip strength values are in kilograms (kg). *p* column represents tests of within group differences by linear regression with Tukey-Kramer adjustment where groups with same letter represent a significant difference between groups.

Table 2: Multiple linear regression analysis of sociodemographic predictors of grip strength among U.S. adults 20+ years of age, 2013-2014.

Characteristic	Males (N=2,276)				Females (N=2,462)			
	Estimate	SE	t	p	Estimate	SE	t	p
Intercept	54.69	1.30	42.06	<.001	34.52	0.70	49.07	<.001
Age	-0.26	0.01	-22.08	<.001	-0.17	0.01	-18.80	<.001
Income	0.73	0.20	3.60	.003	0.18	0.07	2.71	.016
Education	-0.11	0.25	-0.46	.652	0.29	0.11	2.56	.022
Race/Ethnicity								
White	-1.78	0.83	-2.13	.049	-2.89	0.36	-7.97	<.001
Black	ref	-	-	-	ref	-	-	-
Hispanic	-4.68	0.82	-5.71	<.001	-3.96	0.48	-8.25	<.001
Other	-5.62	0.83	-6.73	<.001	-5.09	0.52	-9.87	<.001
Living with spouse/partner								
Yes	Ref	-	-	-	ref	-	-	-
No	-3.12	0.45	-6.94	<.001	-0.87	0.27	-3.24	.006
Model Fit								
F	208.2				95.3			
p	<.001				<.001			
SEE	8.1				5.2			
R ²	0.24				0.28			

Note: Model estimates are in kilograms (kg). Age is continuous in years. Income is ordinal in income categories. Education is ordinal in education categories.

Discussion

The purpose of this study was to examine the multivariate relationship between several sociodemographic predictors and grip strength in U.S. adults. The evidence supports the use of sociodemographic characteristics as predictors of grip strength in U.S. adults. Furthermore, the studied sociodemographic characteristics accounted for approximately one quarter of the variance in grip strength in both sexes. Therefore, this study presents evidence that exceeds the previously mentioned study [11] in that it supports the association between a large set of sociodemographic predictors in relation to grip strength in a representative sample of non-institutionalized U.S. adults.

One strength concerning this study was its use of an objective measure of muscular strength. The use of a handgrip dynamometer adds strong validity to the study's dependent variable. One limitation concerning this study was the cross-sectional nature of the NHANES design. Therefore, results from this study should not be considered cause-and-effect and should only be considered as correlational.

Conclusions

Results from this study indicate that common sociodemographic variables are related to grip strength in U.S. adults. Specifically, age, income, education (not in males), race/ethnicity, and marital/partner status are independent predictors of grip strength in both sexes and account for a large percentage of its variance.

Acknowledgements

No financial assistance was used to assist with this project.

References

- Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, Nieman DC, Swain DP. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Medicine and science in sports and exercise*. 2011; 43(7):1334-59.
- Kim Y, Wijndaele K, Lee DC, Sharp SJ, Wareham N, Brage S. Independent and joint associations of grip strength and adiposity with all-cause and cardiovascular disease mortality in 403,199 adults: the UK Biobank study. *The American journal of clinical nutrition*. 2017; 106(3):773-82.
- Celis-Morales CA, Welsh P, Lyall DM, Steell L, Petermann F, Anderson J, *et al*. Associations of grip strength with cardiovascular, respiratory, and cancer outcomes and all-cause mortality: prospective cohort study of half a million UK Biobank participants. *BMJ*. 2018; 361:k1651.
- Li JJ, Wittert GA, Vincent A, Atlantis E, Shi Z, Appleton SL, *et al*. Muscle grip strength predicts incident type 2 diabetes: population-based cohort study. *Metabolism*. 2016; 65(6):883-892.
- Wijndaele K, Duvigneaud N, Matton L, Duquet W, Thomis M, Beunen G, *et al*. Muscular strength, aerobic fitness, and metabolic syndrome risk in Flemish adults. *Medicine and science in sports and exercise*. 2007; 39(2):233.
- McDowell CP, Gordon BR, Herring MP. Sex-related differences in the association between grip strength and depression: Results from the Irish Longitudinal Study on Ageing. *Experimental gerontology*. 2018; 104:147-52.
- Tsuyuguchi R, Kurose S, Seto T, Takao N, Tagashira S, Tsutsumi H, Otsuki S, Kimura Y. Toe grip strength in middle-aged individuals as a risk factor for falls. *The Journal of sports medicine and physical fitness*. 2018; 58(9):1325-30.
- Yang L, Koyanagi A, Smith L, Hu L, Colditz GA, Toriola AT, *et al*. Hand grip strength and cognitive function among elderly cancer survivors. *PloS one*. 2018; 13(6):e0197909.
- Matsui Y, Fujita R, Harada A, Sakurai T, Nemoto T, Noda N, Toba K. Association of grip strength and related indices with independence of activities of daily living in older adults, investigated by a newly-developed grip

- strength measuring device. *Geriatrics & gerontology international*. 2014; 14:77-86.
10. Zoico E, Di Francesco V, Guralnik JM, Mazzali G, Bortolani A, Guariento S, *et al*. Physical disability and muscular strength in relation to obesity and different body composition indexes in a sample of healthy elderly women. *International journal of obesity*. 2004; 28(2):234.
 11. Thorpe RJ, Simonsick E, Zonderman A, Evans M. Association between race, household income and grip strength in middle-and older-aged adults. *Ethnicity & disease*. 2016; 26(4):493.
 12. Centers for Disease Control and Prevention. National Center for Health Statistics. National Health and Nutrition Examination Survey: Plan and Operations, 1999-2010: <https://www.cdc.gov/nchs/nhanes/analyticguidelines.aspx>
 13. Centers for Disease Control and Prevention National Center for Health Statistics. NHANES 2013-2014 Muscle Strength Procedures Manual, 2013.
 14. Cody RP, Smith JK. *Applied Statistics & SAS Programming*. Prentice Hall, 2006.
 15. Allison PD. *Multiple regression: A primer*. Pine Forge Press, 1999.
 16. Lewis TH. *Complex survey data analysis with SAS*. Chapman and Hall/CRC, 2016.