Handgrip Strength: A Comparison of Values Obtained From the NHANES and NIH Toolbox Studies

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Importance: Handgrip dynamometry is probably the most commonly used method to characterize overall human muscle strength.

Objective: To compare and summarize grip strength measurements obtained from two population-based studies.

Design: Secondary data analysis.

Setting and Participants: Data from (1) the 2011–2014 National Health and Nutrition Examination Survey (NHANES) with 13,918 participants and (2) the 2011 normative phase of the National Institutes of Health (NIH) Toolbox project with 3,594 participants.

Outcomes and Measures: The NHANES values used were the mean and best of three trials; the NIH Toolbox value used was the one maximum trial after a practice trial.

Results: General linear model analysis revealed that values obtained from the NIH Toolbox differed from NHANES best values but not from NHANES mean values. The analysis also indicated, regardless of the values used, that grip strength differed significantly between dominant and nondominant sides, males and females, and age groups. We provide updated reference values for handgrip strength.

Conclusions and Relevance: On the basis of these analyses, we summarize grip strength measures obtained from the NHANES and NIH Toolbox for side, gender, and age group strata. Reference values are essential to assist in the interpretation of testing results and clinical decision making.

Muscle strength, defined as the force or torque brought by muscle to bear on the environment, is essential for maintaining and changing the position of body segments and the body as a whole. Muscle strength, therefore, plays an important role in everyday function (Bohannon, 2015; Vaapio et al., 2011). It also serves as an indicator of present health status and a predictor of future health status (Bohannon, 2015).

There are numerous options for measuring muscle strength, but handgrip dynamometry is probably used most often to characterize overall human muscle strength (Bohannon, 2008). Measurements of grip strength obtained by dynamometry are easily procured and have been shown to be reliable (Bohannon, 2017), valid (Turner & Ebrahim, 1992), and responsive (Kim et al., 2014). In addition, normative reference values have been published that can be used to interpret grip strength measurements obtained from individuals and groups of interest.

Optimally, reference values used for interpreting status should have been obtained from a population representative sample (Ritchie & Palomaki, 2004) within the past 15 or 20 yr (Strauss et al., 2006). Numerous peer-reviewed studies provide such values. Specifically, reference values for grip strength that fulfill these criteria have been reported for residents of several countries, among them Great Britain (Dodds et al., 2014), Australia (Massy-Westropp et al., 2011), Canada (Wong, 2016), Korea (Shim et al., 2013), Germany (Günther et al., 2008), and Japan (Seino et al., 2014). The importance of these reference values notwithstanding, caution must be exercised in applying them to residents of other countries (Dodds et al., 2016; Massy-Westropp et al., 2011).

Our impetus in undertaking the current study was the limited availability of current reference values over the age span for grip strength of U.S. residents. We were aware of Perna et al.'s (2016) recent publication addressing such values, but it focused on the combined strength of both hands. We examined the literature and identified two large-scale, population-based studies that provide sufficiently current data to generate such reference values for U.S. residents: the National Health and Nutrition Examination Survey (NHANES) and the National Institutes of Health (NIH) Toolbox.

The NHANES (Centers for Disease Control and Prevention [CDC], 2011; Perna et al., 2016) is a survey research program conducted by the National Center for Health Statistics (NCHS), housed within the CDC, to assess the health and nutritional status of U.S. adults and children and to track changes over time. Although the NHANES data collection has been ongoing for decades, handgrip dynamometer assessment was not included in the data collection until 2011. The handgrip component was added to provide nationally representative data on muscle strength; prevalence estimates of children with poor muscle strength; and data to study the association between muscle strength and other health conditions and risk factors, such as obesity, physical activity, and dietary patterns.

The NIH Toolbox (Beaumont et al., 2013; Gershon et al., 2013; Reuben et al., 2013) was a research study that aimed to develop a multidimensional set of brief royalty-free measures that researchers can use to assess cognitive, sensory, motor, and emotional function in people ages 3–85 yr. This entire set of measures can be administered to study participants in 2 hr or less, across diverse study designs and settings. Motor domain experts identified handgrip dynamometry as a proxy for upper extremity muscle strength. Toolbox measures have been normed and validated in a broad sample of the U.S. population in a cross-sectional data collection in 2011 (Beaumont et al., 2013).

The primary purpose of this project, therefore, was to compare and summarize grip strength measurements obtained from two population-based studies: the NHANES and the NIH Toolbox. We hypothesized that grip strength measurements from the two studies would differ significantly, as would measurements obtained from males and females, dominant and nondominant sides, and different age groups.

Method

The NHANES providing data for our study was approved by the NCHS research ethics review board; the NIH Toolbox study was approved by the Northwestern University institutional review board. Further approval was not sought for our study because the data used were free of personal identifiers.

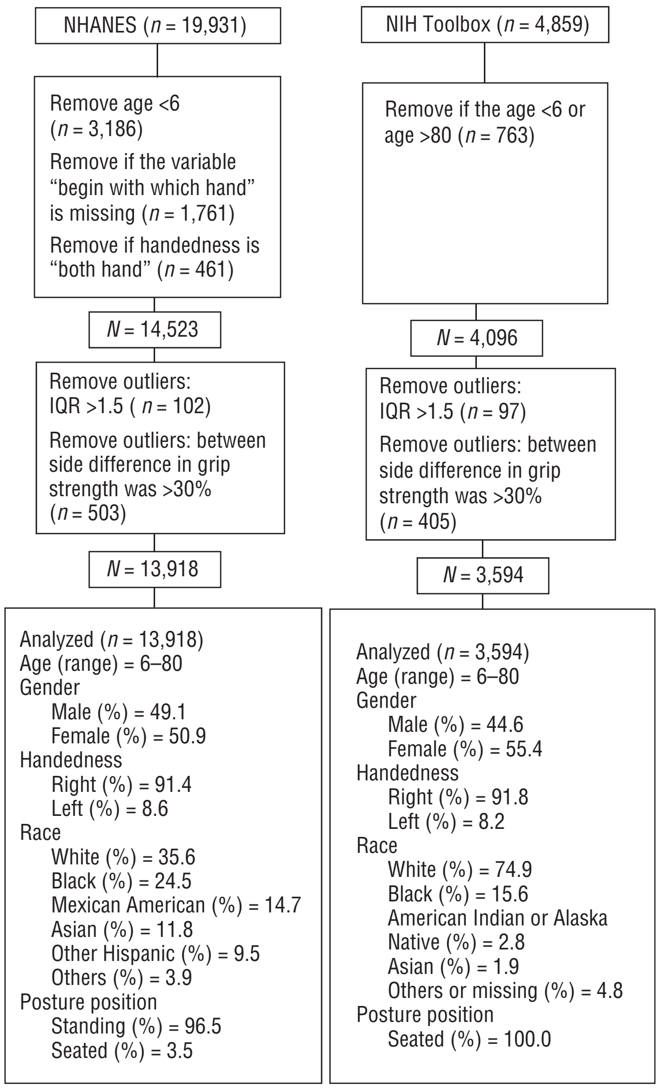
NHANES Data

We used NHANES data from 2011 to 2014. The data were acquired from a stratified multistage probability sample of civilian noninstitutionalized U.S. residents.

Participants.

Of the initial 19,931 data records, 3,186 participants were removed because they were younger than age 6 yr (no handgrip data), and 2,222 participants were removed because of missing values (e.g., begin with which hand, handedness). In addition, 605 participants were excluded as outliers because their grip strength values were greater than 1.5 interquartile range (IQR) of the same sex and age group or because their between-sides difference in grip strength was ≥ 30%. Thus, data from 13,918 remaining participants (ages between 6 and 80) were included in the final analysis with a comparable representation of males (49.1%) and females (50.9%). By self-report, 91.4% of the sample was right-hand dominant. Although the largest percentage of the sample was White (35.6%), other races were represented. Figure 1 presents the flowchart of the data management process.

Figure 1. Data cleaning and merging flowchart.



Note. IQR = interquartile range; NHANES = National Health and Nutrition Examination Survey; NIH = National Institutes of Health.

Procedures.

A detailed description of testing procedures can be found in the NHANES *Muscle Strength Procedures Manual* (CDC, 2011). In brief, the muscle strength/grip test involved the measurement of isometric grip strength with a calibrated Takei Digital handgrip dynamometer (Takei Scientific Instruments, Niigata City, Japan). Participants were randomly assigned to start the test with their dominant or nondominant hand. The grip test was performed in the standing position unless the participant was physically limited. A practice trial was performed with the hand opposite the hand tested first, unless the participant had only one hand eligible for the test.

Before the test, a test administrator adjusted the grip size of the dynamometer until the second joint of the participant's index finger was at a 90° angle on the handle. Participants were asked to squeeze the dynamometer as hard as possible with each hand with the elbow fully extended at the side. The head was straight, the wrist was neutral, and the feet were hip width apart and even. There were three testing trials for each hand. Best values, expressed in kilograms, were determined for each hand. For this study, the mean values, averaged from three trials, were also calculated for comparison purposes. Under these two conditions, data were labeled *best* and *mean* values, respectively.

NIH Toolbox

We used NIH Toolbox data from the muscle strength/grip test component of the Motor Domain, obtained from August to November 2011.

Participants.

The norming sample included people with the following characteristics: community-dwelling and noninstitutionalized; ages 3–85 yr; capable of following test instructions (in English or Spanish); and able to give informed consent or, in the case of children, give assent with accompanying informed consent by proxy (i.e., parent or guardian). Data were collected at 10 sites (Atlanta, Chicago [Oak Brook], Cincinnati, Columbus, Dallas, Los Angeles, Minneapolis, Philadelphia, Phoenix, St. Louis) from primarily urban- and suburban-dwelling participants, and sampling was stratified by age, gender, and primary language (English or Spanish). Age was stratified into 21 age bands, within which target quotas were set relative to the U.S. population distribution of race, ethnicity, and level of education (parents' education for children). Detailed norming plans for the NIH Toolbox have been described (Beaumont et al., 2013).

Of the initial 4,859 data records, 763 were removed because the age of the participant was younger than 6 yr or older than 80 yr. Moreover, 502 were excluded as outliers because their grip strength values were greater than 1.5 IQR from the mean for other participants of the same sex and age group or because their between side difference in grip strength was ≥ 30% (Figure 1). Thus, data from 3,594 remaining participants (ages between 6 and 80) were included in the final analysis with somewhat fewer males (44.6%) than females (55.4%). By self-report, 91.8% of the sample was right-hand dominant. Although the majority of the sample was White (74.9%), other races were represented. All participants either consented to the study or assented and participants' parents or guardians provided written consent after being informed about the study's purpose and procedures.

Procedures.

Detailed descriptions of the protocol are provided in the *NIH Toolbox Administration Manual* (NIH, 2012). Briefly, a calibrated digital Jamar® dynamometer (Patterson Medical Ltd., Warrenville, IL) with its handle in its second position was used. Participants squeezed the dynamometer while seated with their arms by their sides, elbows flexed 90°, and forearms in a neutral position. A single submaximal practice trial was completed with each hand, followed after at least 30 s by a single maximal trial of 3 to 4 s from each hand. Participants were encouraged by the examiner who chanted "harder, harder, harder." Data were recorded in pounds but later converted to kilograms.

Statistical Analysis

All analyses were performed using IBM SPSS Statistics (Version 23; IBM Corp., Armonk, NY). To compare handgrip measures, age was stratified into 18 age bands: each year of age from 6 through 17, 18–29, 30–39, 40–49, 50–59, 60–69, and 70–80 yr old, consistent with the NIH sampling plan. Two (study: NHANES vs. NIH Toolbox) × 2 (gender: male vs. female) × 2 (side: dominant vs. nondominant) × 18 (age group) general linear model (GLM) analyses were conducted: (1) NHANES best values versus NIH handgrip forces and (2) NHANES mean values versus NIH handgrip forces. For independent variables found to have a significant main or interactive effect on grip strength, pairwise post hoc comparisons between NHANES and NIH forces were conducted using GLM. Separate comparisons were completed for the dominant and nondominant sides. Descriptive statistics were tabulated. On the basis of the numerous hypothesis tests conducted and a desire to reduce the risk of Type 1 error, a significant level of $p < .005$ was adopted as an indicator of statistical significance.

Results

The GLM comparing NHANES best values to NIH handgrip values demonstrated that, overall, grip strength values were higher for the NHANES group than the NIH Toolbox group ($F = 98.6$, $p < .001$), for males than for females ($F = 3{,}967.6$, $p < .001$), for the dominant side than the nondominant side ($F = 9{,}497.9$, $p < .001$), and for some age groups than others ($F = 1{,}406.9$, $p < .001$). Pairwise comparisons showed significant differences in grip strength ($p < .005$) between the NHANES and NIH Toolbox studies in five age groups of the dominant side of males, six age groups of the dominant sides of females, four age groups of the nondominant side of males, and four age groups of the nondominant side of females.

The GLM comparing NHANES mean values to NIH handgrip values demonstrated that, overall, grip strength values were not higher for the NHANES group than the NIH Toolbox group ($F = 2.6$, $p = .105$). In contrast, grip strength values were higher for males than for females ($F = 3{,}984.0$, $p < .001$), for the dominant sider than the nondominant side ($F = 1{,}869.5$, $p < .001$), and for some age groups than others ($F = 1{,}522.5$, $p < .001$). Pairwise comparisons showed significant differences in grip strength ($p < .005$) between the NHANES and NIH Toolbox studies in one age group of the dominant side of males, two age groups of the dominant side of females, one age group of the nondominant side of males, and three age groups of the nondominant side of females.

Tables 1 and 2 provide summary grip strength statistics for each study stratified by side, gender, and age. These statistics have potential as a reference for interpreting individual handgrip performance.

Table 1. Summary of Handgrip Strength Measurements (kg) Obtained From the Dominant Hand of Male and Female Participants

Gender (age, yr)	*M* (*SD*), *n*			*F* (*p*)	
	NHANES Mean	NHANES Best	NIH Tool Box	NHANES Mean vs. Toolbox	NHANES Best vs. Toolbox
Male (6)	10.0 (2.2), 211	10.7 (2.3), 213	9.6 (2.8), 95	1.6 (.206)	13.5 (.000)
Male (7)	11.8 (2.5), 213	12.6 (2.6), 213	11.2 (3.4), 113	2.6 (.106)	17.1 (.000)
Male (8)	13.2 (2.9), 202	14.1 (2.9), 202	13.4 (3.5), 98	0.2 (.636)	3.7 (.055)
Male (9)	15.3 (3.0), 196	16.4 (3.0), 196	16.5 (3.8), 101	8.0 (.005)	0.0 (.878)
Male (10)	17.5 (3.5), 193	18.6 (3.6), 193	17.9 (3.6), 102	1.2 (.277)	2.6 (.106)
Male (11)	20.2 (4.4), 176	21.4 (4.7), 176	20.5 (4.1), 97	0.2 (.697)	2.6 (.105)
Male (12)	22.9 (4.9), 152	24.1 (5.1), 152	23.6 (5.3), 91	1.0 (.307)	0.5 (.501)
Male (13)	28.2 (6.2), 157	29.7 (6.4), 157	28.2 (6.8), 105	0.0 (.973)	3.4 (.066)
Male (14)	32.1 (6.2), 151	34.0 (6.5), 151	33.5 (7.5), 102	2.6 (.110)	0.3 (.611)
Male (15)	36.8 (6.8), 143	38.8 (7.2), 143	36.7 (7.8), 96	0.0 (.870)	4.9 (.028)
Male (16)	39.3 (7.1), 166	41.4 (7.4), 166	39.1 (7.8), 89	0.0 (.849)	5.6 (.019)
Male (17)	40.9 (7.1), 133	43.2 (7.3), 133	44.3 (9.8), 104	9.6 (.002)	1.1 (.291)
Male (18–29)	44.5 (8.1), 1,129	47.2 (8.6), 1,129	46.3 (8.2), 68	2.9 (.088)	0.7 (.397)
Male (30–39)	47.2 (8.6), 801	49.9 (9.0), 801	43.6 (10.7), 56	9.2 (.003)	25.3 (.000)
Male (40–49)	45.5 (7.6), 756	47.8 (7.9), 757	43.2 (9.3), 75	6.1 (.014)	22.6 (.000)
Male (50–59)	42.1 (7.6), 721	44.0 (7.8), 724	42.7 (10.2), 77	0.4 (.538)	1.9 (.164)
Male (60–69)	38.9 (8.1), 695	40.8 (8.3), 696	37.3 (9.9), 57	2.0 (.160)	8.7 (.003)
Male (70–80)	33.2 (7.5), 637	34.6 (7.8), 637	33.0 (9.6), 77	0.0 (.833)	2.8 (.092)
Female (6)	9.6 (2.1), 193	10.4 (2.2), 194	8.8 (2.8), 99	6.4 (.012)	26.1 (.000)
Female (7)	10.8 (2.2), 187	11.6 (2.4), 187	11.8 (3.4), 107	9.2 (.003)	0.3 (.607)
Female (8)	12.8 (2.9), 177	13.7 (2.9), 177	12.8 (3.3), 91	0.0 (.950)	4.6 (.032)
Female (9)	14.6 (3.1), 190	15.5 (3.2), 190	14.9 (3.3), 99	0.8 (.385)	2.0 (.154)
Female (10)	17.0 (3.3), 171	18.0 (3.4), 171	17.4 (4.0), 106	0.9 (.331)	1.9 (.171)
Female (11)	19.7 (4.1), 219	20.8 (4.4), 219	19.9 (3.9), 95	0.3 (.612)	3.0 (.084)
Female (12)	22.8 (4.8), 154	24.0 (4.9), 154	23.4 (4.5), 108	1.1 (.303)	1.1 (.305)
Female (13)	24.5 (5.3), 150	25.8 (5.3), 150	25.2 (5.4), 94	1.1 (.299)	0.6 (.454)
Female (14)	26.2 (4.7), 156	27.6 (4.9), 156	26.6 (6.1), 113	0.2 (.618)	2.3 (.132)
Female (15)	27.4 (4.5), 146	28.8 (4.8), 146	28.2 (5.0), 100	1.8 (.177)	1.0 (.323)
Female (16)	27.4 (4.7), 177	28.8 (4.8), 177	28.5 (5.3), 99	3.6 (.058)	0.1 (.739)
Female (17)	27.7 (5.6), 129	29.2 (5.7), 129	28.6 (5.6), 104	1.7 (.198)	0.5 (.478)
Female (18–29)	29.1 (5.2), 1132	30.7 (5.4), 1,134	29.0 (7.3), 166	0.1 (.780)	13.5 (.000)
Female (30–39)	30.0 (5.4), 830	31.6 (5.7), 831	29.1 (6.1), 204	4.6 (.033)	31.8 (.000)
Female (40–49)	29.4 (5.5), 836	31.0 (5.7), 838	29.4 (6.5), 143	0.0 (.957)	9.1 (.003)
Female (50–59)	27.5 (5.4), 780	28.9 (5.6), 782	27.1 (6.4), 98	0.5 (.473)	8.8 (.003)
Female (60–69)	25.3 (5.1), 738	26.6 (5.2), 740	23.0 (6.5), 88	14.6 (.000)	35.3 (.000)
Female (70–80)	21.0 (5.2), 700	22.0 (5.3), 704	20.7 (5.2), 77	0.2 (.682)	4.4 (.036)

Note. M = mean; NHANES = National Health and Nutrition Examination Survey; NIH = National Institutes of Health; *SD* = standard deviation.

Discussion

Much of the research proposing to characterize the grip strength of people in the United States across the age span is outdated and used small convenience samples. Both NHANES and NIH Toolbox projects have remedied these issues by recently examining large population-based samples of U.S. residents. Both of the projects have rigorous sampling plans, data collection procedures, and ongoing quality control practices. For the NHANES, NCHS staff and field supervisors regularly monitored examiners. Retraining sessions are conducted periodically with the examiners to reinforce the proper protocols and techniques. All data are reviewed systematically for logical or operational inconsistencies and examiner errors. For the NIH Toolbox, examiners were trained on standardized procedures before data collection, and an administration manual (NIH, 2012) was provided in both English and Spanish for all sites.

Table 2. Summary of Hand Grip Strength Measurements (kg) Obtained From the Nondominant Hand of Male and Female Participants

Gender (age, yr)	*M* (*SD*), *n*			*F* (*p*)	
	NHANES Mean	NHANES Best	NIH Tool Box	NHANES Mean vs. Toolbox	NHANES Best vs. Toolbox
Male (6)	9.7 (2.1), 210	10.4 (2.2), 213	9.5 (3.0), 95	0.2 (.623)	8.8 (.003)
Male (7)	11.3 (2.5), 213	12.1 (2.6), 213	11.0 (3.4), 113	0.8 (.358)	11.5 (.001)
Male (8)	12.8 (2.9), 202	13.7 (3.0), 202	13.2 (3.5), 98	0.8 (.361)	1.7 (.200)
Male (9)	14.6 (2.8), 196	15.6 (3.0), 196	15.7 (3.7), 101	6.9 (.009)	0.0 (.862)
Male (10)	16.5 (3.3), 193	17.6 (3.5), 193	17.0 (3.5), 102	1.4 (.234)	1.5 (.221)
Male (11)	19.5 (4.0), 176	20.7 (4.1), 176	19.3 (4.0), 97	0.1 (.700)	7.2 (.008)
Male (12)	21.7 (4.9), 152	22.8 (5.1), 152	22.5 (4.2), 91	1.8 (.183)	0.3 (.589)
Male (13)	26.7 (5.8), 157	28.1 (6.0), 157	26.6 (6.5), 105	0.0 (.867)	3.8 (.053)
Male (14)	30.5 (6.2), 151	32.0 (6.4), 151	31.0 (6.7), 102	0.5 (.501)	1.4 (.237)
Male (15)	34.7 (6.5), 143	36.7 (6.7), 143	35.0 (7.8), 96	0.1 (.761)	3.1 (.082)
Male (16)	36.9 (7.1), 166	39.2 (7.3), 166	36.6 (7.2), 89	0.1 (.741)	7.1 (.008)
Male (17)	38.0 (6.6), 133	40.2 (6.7), 133	41.5 (8.6), 104	12.6 (.000)	1.7 (.196)
Male (18–29)	42.3 (8.2), 1,129	44.7 (8.5), 1,129	43.9 (7.9), 68	2.3 (.127)	0.6 (.433)
Male (30–39)	44.8 (8.4), 800	47.4 (8.7), 801	42.5 (9.8), 56	4.0 (.045)	16.4 (.000)
Male (40–49)	43.5 (7.6), 754	45.7 (7.9), 757	41.7 (9.4), 75	3.4 (.064)	16.6 (.000)
Male (50–59)	40.2 (7.3), 723	42.2 (7.5), 724	41.0 (10.4), 77	0.8 (.365)	1.7 (.196)
Male (60–69)	37.0 (7.8), 693	38.8 (8.0), 696	36.2 (9.1), 57	0.5 (.465)	5.4 (.020)
Male (70–80)	31.5 (7.2), 635	32.9 (7.3), 637	32.0 (10.0), 77	0.3 (.592)	1.0 (.317)
Female (6)	9.2 (2.0), 193	10.0 (2.2), 194	8.5 (2.7), 99	5.2 (.024)	23.1 (.000)
Female (7)	10.5 (2.2), 187	11.2 (2.3), 187	11.4 (3.2), 107	8.3 (.004)	0.3 (.573)
Female (8)	12.3 (2.7), 177	13.1 (2.8), 177	12.0 (2.8), 91	0.4 (.529)	8.0 (.005)
Female (9)	13.8 (3.0), 190	14.6 (3.1), 190	14.1 (3.3), 99	1.0 (.327)	1.6 (.213)
Female (10)	15.9 (3.0), 171	16.9 (3.1), 171	16.4 (3.9), 106	1.2 (.274)	1.4 (.241)
Female (11)	18.4 (3.9), 219	19.5 (4.1), 219	19.2 (3.9), 95	2.5 (.116)	0.4 (.553)
Female (12)	21.2 (4.5), 154	22.5 (4.7), 154	22.1 (4.1), 108	2.3 (.131)	0.6 (.449)
Female (13)	22.7 (4.9), 150	24.0 (5.1), 150	24.2 (4.7), 94	5.8 (.017)	0.1 (.761)
Female (14)	24.1 (4.7), 156	25.4 (4.9), 156	24.7 (5.5), 113	0.9 (.338)	1.2 (.277)
Female (15)	24.9 (4.6), 146	26.3 (4.8), 146	26.2 (5.0), 100	3.9 (.049)	0.1 (.817)
Female (16)	25.2 (4.4), 177	26.6 (4.5), 177	27.0 (5.0), 99	8.9 (.003)	0.4 (.532)
Female (17)	26.0 (5.2), 128	27.4 (5.4), 129	27.1 (6.1), 104	2.1 (.152)	0.2 (.667)
Female (18–29)	27.1 (5.0), 1,132	28.6 (5.2), 1134	27.3 (6.8), 166	0.2 (.645)	8.2 (.004)
Female (30–39)	28.1 (5.1), 830	29.6 (5.4), 831	28.0 (6.0), 204	0.1 (.739)	14.9 (.000)
Female (40–49)	27.6 (5.2), 838	29.0 (5.4), 838	28.3 (6.7), 143	2.1 (.152)	2.3 (.127)
Female (50–59)	25.7 (5.1), 781	27.0 (5.2), 782	25.5 (6.5), 98	0.1 (.739)	7.1 (.008)
Female (60–69)	23.9 (4.8), 739	25.1 (4.9), 740	22.2 (6.5), 98	8.8 (.003)	25.6 (.000)
Female (70–80)	19.7 (5.0), 700	20.7 (5.1), 704	19.6 (5.1), 77	0.0 (.891)	3.6 (.060)

Note. M = mean; NHANES = National Health and Nutrition Examination Survey; NIH = National Institutes of Health; *SD* = standard deviation.

These controls notwithstanding, there are important differences in how grip strength was measured in the two studies. These include, but are not limited to, differences in the hand dynamometer used (e.g., Takei vs. Jamar; Amaral et al., 2012), dynamometer handle position (Trampisch et al., 2012), upper limb position (e.g., shoulder, elbow; Desrosiers et al., 1995; Oxford, 2000; Su et al., 1994), and posture (e.g., sitting vs. standing; Balogun et al., 1991). All of these factors have the potential to influence grip strength measures. The NIH Toolbox study, unlike the NHANES study, used a protocol very similar to that recommended by the American Society of Hand Therapists (1992) and more recently proposed by Roberts et al. (2011).

Our finding that gender, side, and age group affect grip strength confirms the results of a legion of previous studies. The confirmation was necessary, however, to justify our stratification of grip strength values. The values provided in

Tables 1 and 2 can be used as rough normative references for grip strength measured using the same procedures. That noted, we do not recommend use of the NHANES values because they involve a protocol considerably different from those recommended by the American Society of Hand Therapists (1992) and by Roberts et al. (2011). Moreover, the NHANES protocol calls for adjustment of the handle position and three trials, both of which require additional time and are not necessary (Trampisch et al., 2012). The NIH Toolbox values presented can be interpreted in light of those presented in a 2006 meta-analysis (Bohannon et al., 2006). Such an interpretation, however, must take into account that NIH Toolbox data were summarized for dominant and nondominant sides and the meta-analysis summarized data for the left and right sides. In any case, the NIH Toolbox values tend to be lower than those in the meta-analysis, except perhaps for the oldest adults.

There were several limitations of the study. Because this study included secondary data sources, the researchers were not in control of the data collection procedures. In both studies, handgrip values were collected as part of a larger set of survey questions or measures, so fatigue may have had an effect. Some variables, such as handedness in both studies, relied on self-report. Missing data and extreme responses were encountered in both large-scale studies across multiple sites. When reading the results of this study, clinicians should be aware that different data collection protocols and devices were used in these two studies.

The value of handgrip strength as an indicator of overall strength and as a predictor of important outcomes notwithstanding (Bohannon, 2008, 2015; Vaapio et al., 2011), current nationally relevant reference values are needed if the grip strength of individuals and groups i to be interpreted. Herein, we provide information toward that end. Nevertheless, more specific reference values are required—specific to subpopulations and to performance within the spectrum of measured scores.

Implications for Occupational Therapy Practice

The results of this research indicate the need for further study to develop handgrip strength reference norms. Occupational therapy practitioners need such norms for interpreting the performance of hand function, evaluating treatment effects, and formulating treatment goals.

- Handgrip strength is an indicator of overall strength and is a predictor of important outcomes such as functional independence in daily activities.
- Handgrip strength reference values are essential to assist in the interpretation of testing results and clinical decision making.
- To make patient-centered treatment plans and interpret grip strength of individuals and groups correctly, occupational therapy practitioners need reference values stratified by age group and gender.

Conclusion

Some of the stratified grip strength values from the NHANES and NIH Toolbox studies differ. On the basis of this finding and the lack of conformity of the NHANES protocol with current recommendations, we cannot recommend the values for broad application as reference norms.

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