Percentile Determination of Hand Grip Strength Measured Using Jamar Dynamometer and Modified Sphygmomanometer Among Healthy Adults

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Abstract

Background: An accurate, quantifiable assessment of hand grip strength (HGS) can predict overall strength and health with a good predictor for identifying populations at higher risk for any medical conditions like rheumatoid arthritis, neuromuscular diseases and stroke that helps clinicians establish realistic treatment goals and provides treatment outcome data. The purpose of the study is to determine the percentile scores of HGS of healthy adult individuals of various age groups using Jamar dynamometer and modified sphygmomanometer.

Methods: This descriptive study measures HGS using Jamar dynamometer and modified sphygmomanometer obtained from one hundred twenty healthy participants 20 years old and above. Comparative analyses of the 2 apparatuses were conducted using One-Way ANOVA. The reference intervals at different percentiles were calculated using the Clinical and Laboratory Standard Institute (CLSI) guidelines.

Results: Grip strength (GS) using Jamar dynamometer (JD) and modified sphygmomanometer (MS) among younger (20-29 years old) participants, the 50th percentile (Q2) JD score was 28.29 kg with an equivalent MS score of 161.38 mmHg, were significantly higher compared to those across older age groups especially among the ≥70 years old with a JD Q2 score of 16.74 kg and MS Q2 score of 101.33 mmHg. These findings suggest that HGS decreases with increasing age.

Conclusion: Scores obtained from this study can serve as preliminary baseline values or guide for interpreting GS measurements.

Keywords: Grip strength; Dynamometer; Sphygmomanometer

Introduction

Hand grip strength (HGS) is an underutilized component of the assessment of patients with diverse disorders, including rheumatoid arthritis, carpal tunnel syndrome, lateral epicondylitis, stroke, and neuromuscular diseases.[1] An accurate, quantifiable assessment of HGS helps the clinician establish realistic treatment goals, provides treatment outcome data, and is frequently utilized during determination of hand disability ratings.[2]

Grip strength (GS) has also been used as a screening and diagnostic tool in the evaluation of sarcopenia and frailty. It is an indicator of overall muscle strength and power. It can be quantified by measuring the amount of static force that the hand can squeeze around a dynamometer. A study by Benton et al, described that a decreased HGS is associated with greater risk of frailty, and loss of physical function and mobility because this tool is a surrogate measure of whole-body strength and can be used clinically to assess for age-related deterioration in function and health status associated with frailty.[3] Frailty is also associated with sarcopenia, for which it has been recommended for diagnostic purposes.[1,3,4] A study by R. Bohannon, grip strength (GS) in midlife can predict physical disability in senior years and help evaluate a patient's overall health.[5]

The American Society of Hand Therapists has recommended that the Jamar hand grip dynamometer be considered the standard instrument for measuring GS, many other devices continue to be used for this purpose. Among such devices are modified sphygmomanometers (MSs), which are used most frequently to evaluate patients with rheumatoid arthritis[1] to better understand the previous or existing grip

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Table I. Demographic and Clinical Characteristics of the Participants according to Age Groups (N = 120)

Characteristics	Age Groups						Test Statistic	*p*-value (Two-Tailed)
	20–29 Years Old (n = 20)	30–39 Years Old (n = 20)	40–49 Years Old (n = 20)	50–59 Years Old (n = 20)	60–69 Years Old (n = 20)	≥70 Years Old (n = 20)		
Age (Years; $\bar{x}$, SD)	24.70 (1.53)	33.75 (2.73)	44.95 (2.33)	53.85 (3.23)	64.60 (2.56)	75.70 (5.69)	115.70†	0.001
Sex (*f*, %)							7.61	0.179
Male	10 (50.00%)	9 (45.00%)	8 (40.00%)	9 (45.00%)	4 (20.00%)	4 (20.00%)		
Female	10 (50.00%)	11 (55.00%)	12 (60.00%)	11 (55.00%)	16 (80.00%)	16 (80.00%)		
Marital Status (*f*, %)							76.19†	0.001
Single	18 (90.00%)	17 (85.00%)	3 (15.00%)	5 (25.00%)	1 (5.00%)	5 (25.00%)		
Married	2 (10.00%)	3 (15.00%)	17 (85.00%)	15 (75.00%)	18 (90.00%)	10 (50.00%)		
Widow	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (5.00%)	5 (25.00%)		
Educational Attainment (*f*, %)							84.60†	0.001
Primary Level Education	2 (10.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (5.00%)		
Secondary Level Education	1 (5.00%)	1 (5.00%)	3 (15.00%)	2 (10.00%)	2 (10.00%)	0 (0.00%)		
Vocational Degree	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (5.00%)	1 (5.00%)		
Tertiary Level Education	1 (5.00%)	6 (30.00%)	13 (65.00%)	18 (90.00%)	17 (85.00%)	16 (80.00		
Medical Degree	16 (80.00%)	13 (65.00%)	3 (15.00%)	0 (0.00%)	0 (0.00%)	1 (5.00%)		
Masters or Doctorate Degree	0 (0.00%)	0 (0.00%)	1 (5.00%)	0 (0.00%)	0 (0.00%)	1 (5.00%)		
Employment Status (*f*, %)							72.00†	0.001
Unemployed	14 (70.00%)	0 (0.00%)	1 (5.00%)	3 (15.00%)	7 (35.00%)	6 (30.00%)		
Employed	6 (30.00%)	20 (100.00%)	19 (96.00%)	17 (85.00%)	6 (30.00%)	7 (35.00%)		
Retired	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	7 (35.00%)	7 (35.00%)		
Weight (Kilogram; $\bar{x}$, SD)	68.47 (16.04)	67.74 (12.76)	70.27 (11.62)	70.71 (15.28)	63.03 (10.54)	56.76 (13.53)	15.16†	0.010
Height (Centimeters; $\bar{x}$, SD)	164.35 (7.65)	160.91 (12.16)	165.12 (9.51)	165.83 (7.84)	157.28 (8.68)	155.09 (9.57)	20.58†	0.001
Body Mass Index (kg/m^2; $\bar{x}$, SD)	25.36 (5.98)	26.11 (4.67)	25.71 (3.25)	25.91 (6.13)	25.45 (3.59)	23.61 (4.99)	3.47	0.629
Age-related Conditions (*f*, %)								
None	18 (90.00%)	19 (95.00%)	16 (80.00%)	9 (45.00%)	2 (10.00%)	4 (20.00%)	55.25†	0.001
Hypertension	0 (0.00%)	0 (0.00%)	3 (15.00%)	7 (35.00%)	12 (60.00%)	15 (75.00%)	46.62†	0.001
Diabetes Mellitus	1 (5.00%)	0 (0.00%)	2 (10.00%)	4 (20.00%)	9 (45.00%)	5 (25.00%)	18.53†	0.002
Hyperthyroidism	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (5.00%)	0 (0.00%)	1 (5.00%)	4.07	1.000
Hypothyroidism	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (5.00%)	2 (10.00%)	0 (0.00%)	7.18	0.430
Osteoporosis	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (15.00%)	1 (5.00%)	11.38	0.087
Asthma	0 (0.00%)	1 (5.00%)	0 (0.00%)	0 (0.00%)	1 (5.00%)	0 (0.00%)	4.07	1.000
Dyslipidemia	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (5.00%)	2 (10.00%)	2 (10.00%)	6.05	0.421
Systemic Lupus Erythematosus	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (5.00%)	0 (0.00%)	0 (0.00%)	5.04	1.000
Thyroid Nodule Immune	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (15.00%)	0 (0.00%)	15.38†	0.024
Thrombocytopenic Purpura	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (5.00%)	0 (0.00%)	0 (0.00%)	5.04	1.000
Fatty Liver Disease	1 (5.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	5.04	1.000
Polycystic Ovarian Syndrome	1 (5.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	5.04	1.000
Smoking Status (*f*, %)								
Current Smoker	1 (5.00%)	1 (5.00%)	0 (0.00%)	2 (10.00%)	1 (5.00%)	0 (0.00%)	3.55	0.899
Previous Smoker	1 (5.00%)	1 (5.00%)	1 (5.00%)	0 (0.00%)	0 (0.00%)	2 (10.00%)	3.55	0.899
Non-Smoker	18 (90.00	18 (90.00	19 (5.00%)	18 (90.00%)	19 (95.00%)	18 (90.00%)	0.87	1.000
Alcohol Intake (*f*, %)							5.04	1.000
Non-Alcohol Drinker	20 (100.00%)	20 (100.00%)	19 (95.00%)	20 (100.00%)	20 (100.00%)	20 (100.00%)		
Alcohol Drinker	0 (0.00%)	0 (0.00%)	1 (5.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)		
Exercise Status (*f*, %)							4.40	0.532
Without Exercise	12 (60.00%)	15 (75.00%)	14 (70.00%)	12 (60.00%)	15 (75.00%)	10 (50.00%)		
With Exercise	8 (40.00	5 (25.00%)	6 (30.00%)	8 (40.00%)	5 (15.00%)	10 (50.00%)		

*Significant at 0.05.
†Significant at 0.01.

strength capacity to estimate the deviation from "normal" in order to allow better management of a patient's treatment program.[5]

Differences in methods described in studies of GS measuring devices make cross-study comparisons difficult. Flood-Joy and Mathiowetz reported differences in GS measurements obtained with Jamar dynamometers with different grip configurations.[6] Modified sphygmomanometers used in previous studies have been pre-inflated to different baselines: 20 mmHg, 25 mmHg, or 30 mmHg.[7-10] Although studies using MSs to test subjects with strength deficits have reported favorable reliability,[10] studies in which subjects had near-normal strength may have been hampered by the low ceiling of the MSs scale. Frequently, individuals with near-

Table II. Between-Group Comparisons of Jamar Dynamometer and Aneroid Sphygmomanometer Scores According to Age Group Among the Participants (N = 120)

Characteristics	Age Groups						*F*-Value	*p*-value (Two-Tailed)
	20–29 Years Old (n = 20)	30–39 Years Old (n = 20)	40–49 Years Old (n = 20)	50–59 Years Old (n = 20)	60–69 Years Old (n = 20)	≥70 Years Old (n = 20)		
Jamar Dynamometer Score (Kilograms; $\bar{x}$, SD)	28.73 (5.69)	26.58 (7.44)	27.72 (7.71)	26.02 (6.95)	18.28 (5.36)	14.55 (6.09)	15.46†	0.001
Aneroid Sphygmomanometer Score (mmHg; $\bar{x}$, SD)	163.30 (37.14)	149.23 (35.59)	142.08 (38.63)	148.00 (46.12)	104.47 (31.70)	96.45 (26.67)	10.93†	0.001

*Significant at 0.05.
†Significant at 0.01.

Table III. Reference Intervals (2.5th, 5th, 10th, 50th, 90th, 95th, and 97.5th Percentiles) of Jamar Dynamometer and Aneroid Sphygmomanometer Scores among the Participants according to Age Groups (N = 120)

Age Groups	Percentile Scores													
	Jamar Dynamometer							Aneroid Sphygmomanometer						
	2.50th	5th	10th	50th	90th	95th	97.5th	2.50th	5th	10th	50th	90th	95th	97.50th
20–29 Years Old	16.53	18.43	20.61	28.29	35.98	38.16	40.05	85.69	97.86	111.89	161.38	210.87	224.90	237.07
30–39 Years Old	14.82	16.98	19.46	28.21	36.97	39.45	41.60	71.91	85.18	100.49	154.47	208.46	223.76	237.04
40–49 Years Old	12.86	15.12	17.72	26.89	36.07	38.67	40.93	61.17	74.65	90.19	145.03	199.86	215.40	228.89
50–59 Years Old	10.52	12.72	15.26	24.21	33.16	35.70	37.90	52.76	65.56	80.31	132.34	184.37	199.12	211.92
60–69 Years Old	9.16	11.28	13.71	22.31	30.91	33.35	35.46	45.99	57.20	70.12	115.70	161.29	174.21	185.42
≥70 Years Old	5.64	7.43	9.48	16.74	23.99	26.05	27.83	41.83	51.40	62.43	101.33	140.23	151.26	160.82

normal strength exceed the maximum 300 mmHg of the typical modified sphygmomanometer scale.[11] Descriptions of methods of instrument calibration and the frequency of recalibration have been infrequent and varied as well.[1]

Materials and Methods

Study Design. A descriptive study on hand grip strength was conducted among healthy adults seen in rheumatology outpatient clinic of University of Santo Tomas Hospital (USTH) between May 2022 and September 2022. Ethical approval was sought from the USTH Research Ethics Committee prior to the initiation of the study.

Participants. One hundred twenty participants 20 years old and above with no hand orthopedic problem or disability, and with or without age-related conditions with no influence on predicted 5-year mortality were eligible for inclusion. Exclusion criteria were those taking steroids, NSAIDs and anti-convulsant. Participants were included after a written informed consent has been secured.

The sample size computation for one correlation analysis was conducted using PASS 2008 version 08.0.15. From the study of Chandrasekaran et al., a null correlation coefficient (r_0) of 0.90 was utilized.[12] The study of Martins et al. estimated that the correlation between the Jamar dynamometer and sphygmomanometer was 0.66 (r_1). With an r_0 of 0.90, an r_1 of 0.66, a minimum power of 80%, and a significance level of 5% (two-tailed), the computed sample size for a single age group was 20 respondents. However, cognizant of the study methodology and objectives involving six (6) age groups or strata (20-29, 30-39, 40-49, 50-59, 60-69 and ≥70 years old), the sample size was inflated to ensure a 1:1 allocation ratio for each stratum. With 6 strata and 20 respondents in each stratum, a total of 120 respondents was necessary.[13] Hence, the final sample size was a total of 120 respondents, with 20 respondents in each age group.

Apparatus and Measurement

Dynamometer Measurement. For all measurements, the grip width on the Jamar was standardized to the second position (5.0cm) regardless of age, body mass, or hand dimensions.[3] Consistent with the recommendations for handgrip by the American Society of Hand Therapy and previous research, the HGS was measured three times with a 5-minute interval to prevent fatigue. Result was obtained from the mean value after three measurements.[2,3,14,15]

Sphygmomanometer Measurement. The sphygmomanometer cuff was inflated to 20 mmHg as this is universally accepted method which demonstrated good correlation with the measurements[1], participants were asked to squeeze the inflated cuff three times with a 5-minute interval to prevent fatigue. Result was obtained from the mean value after three measurements.[16,17]

Statistical Analysis. Statistical analyses were performed using STATA Statistical Software, Version 13, College Station, TX: StataCorp LP and MedCalc® Statistical Software version 20.116 (MedCalc Software Ltd, Ostend, Belgium). A *p*-value of 0.05 was considered statistically significant. Descriptive statistics included frequency and

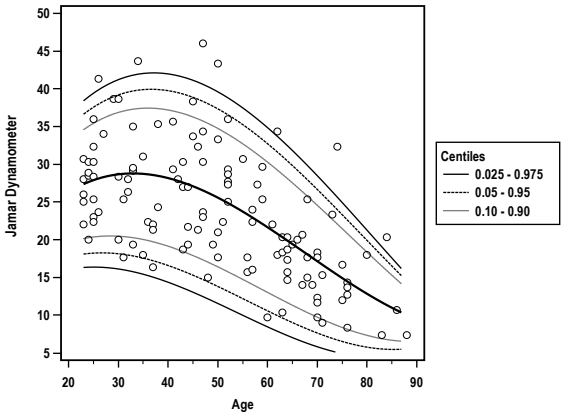

Figure 1. Continuous Reference Intervals for Jamar Dynamometer Scores According to Age at 2.5th, 5th, 10th, 50th, 90th, 95th, and 97.5th Percentiles

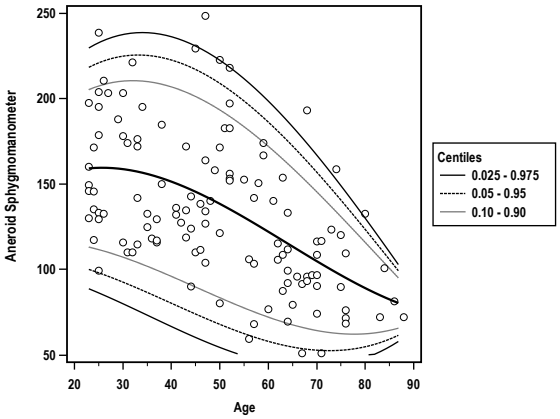

Figure 2. Continuous Reference Intervals for Aneroid Sphygmomanometer Scores According to Age at 2.5th, 5th, 10th, 50th, 90th, 95th, and 97.5th Percentiles

percentage for nominal data and mean and standard deviation for continuous-level variables. The normality of the data was evaluated using Kolmogorov–Smirnov tests.[18] Comparative analyses of the Jamar dynamometer and aneroid sphygmomanometer scores according to age group was conducted using One-Way ANOVA, if normally-distributed, and Kruskall-Wallis H Test, if not normally-distributed.[18] The reference intervals at different percentiles (2.5th, 5th, 10th, 50th, 90th, 95th, and 97.50th) were calculated using the Clinical and Laboratory Standard Institute (CLSI) guidelines (C28-A2 and C28-A3).[19,20] Finally, the Jamar dynamometer and aneroid sphygmomanometer score-for-age reference intervals were graphed in a reference curve.[19,20]

Results

Demographic and Clinical Characteristics of the Participants. *Table I* illustrates the demographic and clinical characteristics of the participants according to age group. Results showed that the distributions of educational attainment, employment status, and occupation among the participants according to age group were significant different ($p<0.05$). The proportion of participants who were single was significantly higher among those who were 20 – 39 years old, and the proportions of participants who were employed were significantly higher among those who were >30 years old. More than half of the participants did not have any age-related conditions (56.67%). Among those who had age-related conditions, the most common were hypertension (30.83%) and diabetes mellitus (17.50%) seen among ≥ 60 years old.

Comparison of Jamar Dynamometer and Aneroid Sphygmomanometer Scores. The comparative analyses of the Jamar dynamometer and aneroid sphygmomanometer scores according to age group are presented in *Table II*. Results of the one-way Analysis of Variance tests indicated that the Jamar dynamometer scores (F=15.46, $p=0.001$) and aneroid sphygmomanometer scores (F=10.93, $p=0.001$) were significantly different across age groups. Post-hoc ANOVA analyses, using Bonferroni adjustment, indicated that the Jamar dynamometer scores of participants who were 20-29 years old, 30-39 years old, 40-49 years old and 50-59 years old were significantly higher compared to those who were 60-69 years old and ≥ 70 years old. Similar results were also noted in the post-hoc ANOVA pairwise comparisons, with the mean aneroid sphygmomanometer scores of those who were 20-59 years old being significantly higher compared to those who were ≥60 years old.

Reference Intervals and Curve of Jamar Dynamometer and Aneroid Sphygmomanometer Scores. *Table III* illustrates the reference intervals of the Jamar dynamometer and aneroid sphygmomanometer scores at different percentiles according to age groups, while *Figures 1* and *2* depict the reference curves. It is of note that the 50th percentile Jamar dynamometer scores ranged from 28.29 kilograms for those who were 20 – 29 years old to 16.74 kilograms for those who were ≥70 years old. Similarly, the 50th percentile aneroid sphygmomanometer score varied from 161.38 mmHg for those who were 20 – 29 years old to 101.33 mmHg for those who were ≥70 years old. There was a decline in the percentile scores of Jamar dynamometer and aneroid sphygmomanometer as the age of the participant increases.

Discussion

Measurement of GS is important in hand rehabilitation. It assesses the patient's initial limitations and provides a quick reassessment of the patient's progress throughout the treatment.[21] These data provide the first Philippine population estimates of GS, a marker of overall strength and future health risk, for people age 20 and above using dynamometer and sphygmomanometer. Likewise, these data may inform surveillance data interpretation and intervention programming aimed at improving physical education and physical activity.

The main objective of this study was to determine the percentile scores of HGS of healthy individuals in various age groups using Jamar dynamometer and Modified sphygmomanometer. The reference values of HGS established in this study were based on the mean of three maximum successive trials. Although the maximum value among these trials has commonly been used by many previous researchers,[16,22,23] the average value of three consecutive trials was recommended by the ASHT.[24]

The one-way Analysis of Variance result indicates that age significantly influence GS using Jamar dynamometer and Aneroid sphygmomanometer. From the results using both apparatuses, the grip strength of participants who were 20 – 29 years old were significantly higher compared to individuals in different age groups. These results are in accordance with the previous findings of Tsang et al, who reported that GS peaked between the ages of 21 and 30 years.[16]

From the reference intervals of the Jamar dynamometer and aneroid sphygmomanometer scores at different percentiles according to age groups, we found HGS to decline with advancing age. This is consistent with previous reports that HGS decreases with increasing age.[16,17,25] Likewise, this corroborates previous studies which reported that there is an inverse relationship between hand strength and age.[25-28] Age-related decline in grip strength can be attributed to decreasing physical activity, loss of muscle mass, alterations in muscle fibers, decreasing hormone levels, and chronic diseases that come with advancing age.[29-32]

Conclusion

The reference values derived in this study would be useful in assessing impairment in functional ability of the upper extremities in both healthy and patient populations. It can serve as preliminary baseline values or guide for interpreting GS measurements against which health care professionals can compare the measurement of their patients.

Limitation of the Study. The limitation of this study was that the participants were recruited from a single institution, which may affect generalizability of our results. In addition, measurements of hand grip strength both for Jamar dynamometer and sphygmomanometer is operator-dependent, thus the importance of conducting the measurements according to the recommendations for handgrip by the American Society of Hand Therapy.

Acknowledgement. The authors would like to thank Prof. John Rey B. Macindo for assisting in the data analysis of this research.

Disclosure Statement. The authors declare no competing interest.

Funding. No funding was received by the authors for this work.

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