Grip Strength in Older Adults: Test-Retest Reliability and Cutoff for Subjective Weakness of Using the Hands in Heavy Tasks

Ching-Yi Wang, PhD, Li-Yuan Chen, MS


Objective: To examine the test-retest reliability of grip strength when using the mean value, the best value, and the first value of 2 grip strength measurements and to determine the cutoff value for separating those who were able or unable to perform a heavy task with their hands in a group of Taiwanese adults.

Design: Cross-sectional test-retest study.

Setting: Local community centers.

Participants: Community-dwelling older adults (N=469; age, ≥60y).

Interventions: Not applicable.

Main Outcome Measures: Self-reported measure of ability to perform heavy tasks with their hands and grip strength.

Results: The test-retest reliability of grip strength in older adults was good (intraclass correlation coefficient ≥.85) when using the mean value, the best value, or the first of 2 measurements. Optimum cutoff values were 28.5 and 18.5kg, and values with 75% sensitivity were 34 and 22kg for men and women, respectively.

Conclusions: The test-retest reliability of grip-strength measurement in a group of Taiwanese older adults was acceptable when the best value, the mean value, or the first of 2 measurements was used. The reported mean and cutoff values for grip strength also could serve as reference values for the public to monitor their grip strength performance and identify those at risk for early intervention.

Key Words: Aging; Hand strength; Rehabilitation; Reproducibility of results. © 2010 by the American Congress of Rehabilitation Medicine

TO MAINTAIN THE INDEPENDENCE of older adults as long as possible is a priority goal in the field of public health. To achieve this goal, indicators that can identify older adults at risk for developing dependence are imperative. Grip strength has been shown to predict multiple important health-related outcomes in older adults, such as frailty, disability, and mortality.1,5 Because of its predictive validity, simplicity, and portability, grip-strength measurement could be used as a vital sign to screen for further decline in middle-aged to older adults.2 A reliable measure and a clinically useful cutoff for grip strength are required to identify older adults at risk for advanced disability.

Frailty is a precursor of more advanced disability in older adults.9 Grip weakness is 1 of the major characteristics of frailty.6,7 Older adults have reported needing help or being unable to perform heavy tasks with their hands at an earlier age compared with walking 400 to 800m or climbing stairs.8,9 Because weakness of the hands in heavy tasks is an early sign of further disablement, it is reasonable to determine objective cutoff values with high sensitivity and specificity. Several studies have reported important reference values for grip strength while using different criteria, such as disability or mortality.3,10,11 However, no cutoff for using weakness of the hand as a criterion has been reported.

Variation in grip-strength normative values from the literature has been noticed because of differences in anthropometric factors, culture, and lifestyle habits, especially in older adults from Western and Eastern countries.12,13 Therefore, it is necessary to establish the reliability, normative values, and cutoff values in the population of interest. To objectively identify older adults with weak grasp, a cutoff value with optimum diagnostic accuracy is required, whereas for the purpose of identifying most of those with weak grip for early-intervention or health-promotion programs, a cutoff value with high sensitivity is suggested, given that the penalty for false-positive results is small.14 The specific goals of this study were to (1) compare the test-retest reliability of grip strength by using the mean value, the best value, and the first value of 2 measurements; (2) determine the discriminative ability of the grip-strength measure in differentiating older adults with and without difficulty using the hands in heavy tasks; and (3) identify the optimum cutoff values and those with 75% sensitivity for grip strength in a group of Taiwanese community-dwelling older adults.

List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tr>
<td>ANOVA</td>
<td>analysis of variance</td>
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<tr>
<td>AUC</td>
<td>area under the curve</td>
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<tr>
<td>BMI</td>
<td>body mass index</td>
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<tr>
<td>CI</td>
<td>confidence interval</td>
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<tr>
<td>ICC</td>
<td>intraclass correlation coefficient</td>
</tr>
<tr>
<td>ICC2,1</td>
<td>ICC using a single rating (either the best or the first of the 2 measures)</td>
</tr>
<tr>
<td>ICC2,2</td>
<td>ICC using the mean rating (mean of 2 measures)</td>
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<td>ROC</td>
<td>receiver operating characteristic</td>
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<td>SEM</td>
<td>standard error of the measurement</td>
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METHODS

Participants
Subjects were recruited from local communities through local advertisements and flyers. Older adults who participated in activities at community centers were approached by a research assistant asking for their consent to participate. Those who met the following criteria were included: (1) aged 60 years or older, (2) living in the community, and (3) able to understand the instructions and perform the physical tests. People with the following conditions were excluded: (1) lesions/diseases of the central or peripheral nervous system, dizziness, poor standing balance, shortness of breath, musculoskeletal disease, or pain that would hamper their ability to perform heavy housework or lifting 11-kg objects; and (2) those who had received their physicians’ advice to avoid laborious activities because of their medical conditions. One older woman was excluded from this study because she had deformity and pain in both hands from rheumatoid arthritis, was unable to perform heavy housework or lift 11-kg objects, and refused to undergo grip-strength measurement. A total of 469 subjects met the criteria and consented to participate in this study. Subjects read and signed the informed consent approved by the institutional review board before testing.

Procedure
Subjects were asked if they were able, needed help, or were unable to perform (1) heavy housework and (2) lifting or carrying 11-kg objects. Based on self report, participants were considered in the able group if they answered that they were able to perform both items; otherwise, they were considered to be in the disabled group (need help or unable to perform at least 1 item). A Jamar dynamometer was used to measure grip strength of the dominant hand. The dominant hand was defined as the hand used in performing heavy tasks or using heavy tools. The dynamometer was set at the second handle position for all subjects. Subjects were seated with the arms by the trunk, the elbow flexed to 90° and in a neutral position, and the wrist in slight extension. Subjects were told to squeeze the dynamometer as hard as they could when they heard “ready, go.” Two consecutive grasps were measured with about 5 seconds of rest in between. A subgroup of 77 older adults who were willing (or able) to return 1 week later for a second grip-strength measurement were used to determine test-retest reliability.

To characterize the health status of older adults in the able and disabled groups, subjects were interviewed to obtain the following health-related information: BMI, number of comorbid conditions, depression status, mental status, and self-perceived health status. Body height and weight were measured, and BMI (in kilograms per meter squared) was calculated. The number of comorbid conditions was recorded when participants were asked to report if high blood pressure, heart disease, diabetes, and/or arthritis had been diagnosed. Subjects’ depression and mental status were assessed by using the Chinese version of the Geriatric Depression Scale and the Chinese version of the Mini-Mental Status Examination, respectively. Self-perceived health status was assessed by asking them to rate their health as healthier, the same, or worse compared with people at the same age. Gait speeds were determined from walking at their usual and fastest speeds for 15.24 m (50ft).

Data Analysis
Data were analyzed by using the SPSS statistical package. Numbers of participants in the sex and disability subgroups were reported. The group mean difference for continuous variables (age, BMI, Chinese version of the Mini-Mental Status Examination score, Chinese version of the Geriatric Depression Scale score, number of comorbid conditions) was examined by using t test with the significance level set at .01, separately for men and women. The group difference for discrete variables (self-perceived health status) was tested by using chi-square test with the significance level set at .01. Group mean differences for usual gait speed and fastest gait speed between able and disabled groups were examined by using t test with the significance level set at .01, separately for men and women.

The relative retest reliability of grip-strength measures was determined by using the ICC. Because measurement error of the “occasion” facet is the main interest in the test-retest reliability of the grip-strength measure, ICC model 2, a 2-way random-effects ANOVA model (subject by occasion) and the absolute agreement definition, was used. We calculated 95% CIs for the ICCs. ICC values vary from 0 (no relationship) to 1 (perfect relationship). Values for test-retest reliability (ICC) of a value greater than .80 indicated good reliability. Systematic error between the test and retest was checked by using ANOVA test with the significance level set at .01.

Absolute retest reliability was assessed by using the SEM. SEM also indicates the concept of response stability. The SEM represents the variability between measurements obtained from the 2 occasions and is calculated as the square root of the within-subject error variance (WMS) (SEM = √WMS). It estimates the SD of the measurement error and can be used to establish a CI of where the true score is located when measurement is repeated on the same people.

The diagnostic validity of grip-strength measurement was determined by using the AUC, and its 95% CI was determined from the ROC curve analysis. AUC values vary from 0.5 to 1.0. A value of 0.5 means a chance result; 0.5 to 0.7, low accuracy; 0.7 to 0.9, moderate accuracy; greater than 0.9, high accuracy; and 1.0, a perfect distinction. The mean value of the 2 grip-strength measurements was used for this analysis.

The optimum cutoff score and that with 75% sensitivity for grip strength to discriminate the able and disabled were determined by using ROC curves. The optimal cutoff score is the value with the highest diagnostic accuracy (the greatest sum of sensitivity and specificity). The cutoff value with 75% sensitivity could identify 75% of those with difficulty using the hands in heavy tasks.

RESULTS
Community-dwelling elderly adults (N=469) participated in this study. This study sample included 249 (53.1%) women and 220 (46.9%) men with a mean ± SD age of 73.1±6.7 years. There were 311 (66.3%) in the able group (able to perform both heavy tasks) and 158 (33.7%) in the disabled group (need help or unable to perform at least 1 heavy task).

Demographic statistics of participants are listed in table 1. The able group was younger, had fewer comorbid conditions, and walked faster in both the male and female groups. The able group of women also showed less depression compared with the disabled group. Significantly more able subjects perceived a healthier health status than did subjects who were disabled in the group of men. BMI was not significantly different between groups.

Results of test-retest reliability for grip strength are listed in table 2. Results of ANOVA indicated that the group mean values for test and retest grip strength were not significantly different.
**DISCUSSION**

The aims of this study were to examine and compare the test-retest reliability of grip-strength measures using the mean value, the best value, and the first of 2 measurements, as well as to identify cutoff values for separating older adults into able and disabled groups for performing heavy tasks with their hands in a group of Taiwanese community-dwelling older adults. Consistent with previous studies, our results support the test-retest reliability of grip-strength measurement in a group of Taiwanese older adults when the best value (ICC$_{2,1}$) was .85. The SEM was smaller for using either the best value or the mean of 2 measurements (SEM = 1.9), whereas the SEM was larger for using the first measure (SEM = 2.3–2.4), especially when assessing disabled older adults (SEM = 2.5; see table 2).

Discriminative ability (AUC) and the optimum and 75% sensitivity cutoff values are listed in table 3. The AUC was 0.7 for both men and women (see table 3). The optimum cutoff values for men and women were 28.5 and 18.5 kg, respectively, whereas the cutoff values with 75% sensitivity were 34 and 22 kg, respectively.

**Table 1: Demographics and Health Status Statistics for Participants in the Sex and Disability Subgroups**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Able Group (n = 156)</th>
<th>Disabled Group (n = 64)</th>
<th>Able Group (n = 155)</th>
<th>Disabled Group (n = 94)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>73.8 ± 6.0*</td>
<td>77.6 ± 6.8</td>
<td>70.2 ± 5.7*</td>
<td>73.7 ± 7.3</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.1 ± 4.3</td>
<td>23.2 ± 3.1</td>
<td>25.1 ± 3.2</td>
<td>24.3 ± 3.8</td>
</tr>
<tr>
<td>C-MMSE score</td>
<td>27.2 ± 2.5</td>
<td>26.4 ± 3.3</td>
<td>26.6 ± 2.4</td>
<td>25.7 ± 3.4</td>
</tr>
<tr>
<td>C-GDS score</td>
<td>6.7 ± 5.7</td>
<td>9.2 ± 5.2</td>
<td>8.0 ± 6.5*</td>
<td>12.0 ± 6.3</td>
</tr>
<tr>
<td>No. of comorbid conditions</td>
<td>2.0 ± 1.1*</td>
<td>2.4 ± 1.2</td>
<td>2.1 ± 1.2*</td>
<td>2.9 ± 1.3</td>
</tr>
<tr>
<td>Self-perceived healthier health status</td>
<td>85 (54.5)</td>
<td>26 (41.3)</td>
<td>56 (36.1)</td>
<td>26 (27.1)</td>
</tr>
<tr>
<td>Usual gait speed (m/s)</td>
<td>1.30 ± 0.25*</td>
<td>0.97 ± 0.24</td>
<td>1.22 ± 0.21*</td>
<td>1.01 ± 0.24</td>
</tr>
<tr>
<td>Fastest gait speed (m/s)</td>
<td>1.66 ± 0.28*</td>
<td>1.29 ± 0.32</td>
<td>1.47 ± 0.21*</td>
<td>1.21 ± 0.28</td>
</tr>
</tbody>
</table>

**Table 2: Reliability Indices for Grip Strength for All Participants and the Able and Disabled Subgroups**

<table>
<thead>
<tr>
<th>Grip Strength</th>
<th>Mean Value of 2 Measurements</th>
<th>Best Value of 2 Measurements</th>
<th>First Value of 2 Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ICC$_{2,2}$ (95% CI)</td>
<td>SEM</td>
<td>ICC$_{2,1}$ (95% CI)</td>
</tr>
<tr>
<td>All (N = 77)</td>
<td>0.97 (0.95–0.98)</td>
<td>1.89</td>
<td>0.94 (0.91–0.96)</td>
</tr>
<tr>
<td>Able (n = 53)</td>
<td>0.96 (0.94–0.98)</td>
<td>1.89</td>
<td>0.93 (0.88–0.96)</td>
</tr>
<tr>
<td>Disabled (n = 24)</td>
<td>0.96 (0.90–0.98)</td>
<td>1.86</td>
<td>0.92 (0.82–0.96)</td>
</tr>
</tbody>
</table>
risk for becoming disabled within 6 years, respectively. Grip strength also is a significant predictor of further mortality in older adults. Older men with grip strength less than 22 kg and women with grip strength less than 14 kg were 2.1 (95% CI, 1.31–3.38) and 1.76 times (95% CI, 1.05–2.93) more likely to die within 5 years than those in the highest quartile (men, ≥35 kg; women, ≥22.5 kg), respectively. We have not found in the literature other cutoff values for grip strength that were reported to discriminate whether older adults were able or unable to perform heavy tasks with their hands.

There was a difference of approximately 10 kg between the cutoff values for men and women. This difference might be caused by a difference in the meaning of “heavy housework” to men and women and to people with different social roles, as well as that men tend to be stronger than women, even at old ages. In this study, we adopted the self-reported measure of the ability of using the hands in performing heavy tasks as the criterion standard to determine the cutoff grip strength because this was one of the important characteristics of frailty and an indication of older adults’ ability in managing everyday tasks. Our assumption is that the ability to perform heavy tasks, such as heavy housework or lifting and carrying an 11-kg object, requires requisite use of their hands for older adults who lived independently in their homes in the community. In our population, there was no older adult who could not perform heavy tasks because of signs or symptoms from the central or peripheral nervous system, cardiopulmonary system, or musculoskeletal system, as indicated in our exclusion criteria. The validity of older adults’ self-reported physical disability status to reflect their physical, psychological, and mental health has been supported. In the present study, the able group showed better physical and mental health (they were younger, had less depression, perceived better health status, had fewer comorbid conditions, and showed significantly greater grip strength and faster gait speed) than the disabled groups.

Grip strength is a marker of the frailty phenotype. To better understand older adults’ changes in a wider spectrum of physical function, other markers of frailty also should be addressed. The cutoff value was determined from a group of older Taiwanese adults; therefore, generalization of our results is limited to older adults in Taiwan and other adults with a similar genetic background, social culture, and lifestyle who are living in other countries.

**Study Limitations**

A few limitations in this study need to be mentioned. Our participants constituted a convenience sample and represented community-dwelling older adults who were willing to participate in research- or health-related activities administered in local community centers. Therefore, our results can be generalized to only older adults who are similar to our study population. Because of the limited number of subjects in each sex-age subgroup, we were unable to determine the cutoff value for each subgroup in this study. Although previous studies have found that grip strength measures are homogeneous within sex and age strata across cultures for older white adults, significant differences in grip strength between older adults in Western and Eastern countries have been reported. Because grip strength is one of the important indicators of frailty, future studies are warranted to determine the specific cutoff values for each age range by using a population-representative sample to replicate this study in a Western older population by using objective criteria as the criterion standard.

**CONCLUSIONS**

Test-retest reliability of grip-strength measurement was acceptable in a group of Taiwanese older adults when the first value, the best value, or the mean value of 2 measurements was used. Older adults at an early stage of physical decline are in danger of further decline, but they may respond well to timely identification and intervention. The reported mean and cutoff values could provide clinicians with a reference to interpret test results when assessing older adults and also could serve as a reference value for the public to monitor their grip-strength performance.

**Table 3: Grip-Strength Cutoff Value for Separating the Able From the Disabled Groups for Men and Women**

<table>
<thead>
<tr>
<th>Sex</th>
<th>n</th>
<th>Mean ± SD</th>
<th>AUC</th>
<th>Cutoff</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Cutoff With 75% Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>156</td>
<td>33.9 ± 6.1</td>
<td>68.5</td>
<td>28.5</td>
<td>53.1</td>
<td>84.0</td>
<td>34.0</td>
</tr>
<tr>
<td>Women</td>
<td>155</td>
<td>23.0 ± 4.8</td>
<td>69.2</td>
<td>18.5</td>
<td>45.7</td>
<td>83.9</td>
<td>22.0</td>
</tr>
</tbody>
</table>

**References**


**Suppliers**

a. Sammons Preston Rolyan, 4 Sammons Ct, Bolingbrook, IL 60440.
b. Version 10.0; SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.