Interinstrument Reliability of the Jamar Electronic Dynamometer and Pinch Gauge Compared With the Jamar Hydraulic Dynamometer and B&L Engineering Mechanical Pinch Gauge

Theodore I. King, II

OBJECTIVE. This study sought to determine interinstrument reliability of the Jamar electronic dynamometer and pinch gauge compared with the commonly used Jamar hydraulic dynamometer and B&L Engineering mechanical pinch gauge.

METHOD. Twenty men and 20 women were tested for grip strength with the two different dynamometers, and 17 men and 25 women were tested for lateral pinch strength with the two different pinch gauges.

RESULTS. Grip strength measurements were approximately 10% higher with the hydraulic dynamometer, and lateral pinch strength measurements were approximately 18% higher with the mechanical pinch gauge. Paired t tests and intraclass correlation coefficients (ICCs) were used for statistical analyses. The two-tailed p value was <.0001, and the ICC indicated poor to moderate reliability.

CONCLUSION. When retesting patients, it is recommended that occupational therapists use the same instrument to measure hand strength because interinstrument reliability may be lacking.


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Occupational therapists measure grip and pinch strength for a variety of reasons, including assessing impairment, measuring treatment efficacy, comparing with norms, and determining work capacity and demands. Interinstrument reliability is the extent to which different instruments measure equivalently under the same conditions. Because many different types of instruments have been developed for measuring grip and pinch strength, it has become important to establish interinstrument reliability of the various instruments.

Interinstrument Reliability Studies

Dynamometers

To determine whether measurements recorded by different dynamometers can be compared on an equitable basis within the clinic and whether readings from one dynamometer can be appropriately compared with norms established by a different dynamometer, many researchers have completed studies to determine interinstrument reliability among variously manufactured grip strength dynamometers. Flood-Joy and Mathiowetz (1987) compared three slightly different versions of the hydraulic Jamar dynamometer (Lafayette Instrument Company, Lafayette, IN) and found statistically significant differences in the measured grip strength of study participants using a repeated measures design. This study demonstrated lack of interinstrument reliability among dynamometer models manufactured by the same company. In studies comparing the Jamar with dynamometers manufactured by other companies, the Baseline (Fabrication Enterprises Inc., White Plains, NY) and Rolyan (Patterson Medical Supply Inc., Bolingbrook, IL) hydraulic dynamometers and the BTE–Primus (BTE, Hanover, MD) grip attachment demonstrated good interinstrument reliability with the Jamar (Mathiowetz, 2002; Mathiowetz, Vizenor, & Melander, 2000; Shechtman,
Davenport, Malcolm, & Nabavi, 2003). In a recent study comparing the Jamar, DynEx (MD Systems, Westerville, OH), and TKK (Takey, Tokyo, Japan) dynamometers with adolescents, España-Romero et al. (2010) reported that the “Jamar and DynEx dynamometers underestimate the hand-grip strength levels, whereas the TKK dynamometer provides the lowest systematic error” (p. 276). Instrument bias was also reported in a repeated measures design comparing grip strength measurements of the GripTrack (Fabrication Enterprises Inc., White Plains, NY) and Jamar dynamometers (Svens & Lee, 2005). Prior studies, therefore, have reported mixed results in determining interinstrument reliability among differing dynamometers used to measure grip strength.

**Pinch Gauges**

Fewer studies have reported on interinstrument reliability with pinch gauges. The B&L Engineering (Santa Ana, CA) pinch gauge was found not to measure pinch equivalently with the Baseline model (Mathiowetz et al., 2000). However, the consistency of readings between the B&L Engineering, JTech (JTech Medical, Salt Lake City, UT), and NK (NK Biotechnical Xorp, Minneapolis, MN) pinch gauges was shown to be excellent, with high intraclass correlation coefficients (ICCs; MackDermid, Evenhuis, & Louzon, 2001). As with studies of various dynamometers, disparity in readings has also been demonstrated among different pinch gauges.

**Electronic Dynamometers and Pinch Gauges**

Electronic, noncomputerized dynamometers and pinch gauges have recently been developed and entered common use. The purpose of this study was to determine the interinstrument reliability of the Jamar electronic dynamometer and pinch gauge compared with the commonly used Jamar hydraulic dynamometer and B&L Engineering mechanical pinch gauge.

**Method**

**Research Design**

A repeated measures design was used for this study; each participant was tested during the same data collection session with either both types of dynamometers or both types of pinch gauges. The institutional review board at Concordia University Wisconsin approved the study, and each participant signed a consent form before participation.

**Participants**

Participants for the study were a convenience sample obtained at Concordia University Wisconsin. Inclusion criteria were at least 20 yr old and no more than 50 yr old with no current physical limitations in either upper extremity and no previous injury or problem with the upper extremities affecting hand strength. Different participants were used for the grip strength and pinch strength measurements.

**Procedures**

The Jamar Plus® electronic dynamometer and pinch gauge were purchased new to be used in this study. The manufacturer requests the units to be returned for recalibration after 12 mo of use. The Jamar hydraulic dynamometer and the B&L Engineering mechanical pinch gauge were sent to Grip Repair, Inc. (Henderson, NV) for recalibration immediately prior to the start of the study. A visual comparison of the two different dynamometers and pinch gauges can be seen in Figures 1 and 2.

For grip strength measurement, both hands were tested using both the hydraulic and electronic Jamar dynamometers. The second handle position was used for all participants. As recommended by the American Society of Hand Therapists (1992), all participants were seated with the shoulder adducted, 90° of elbow flexion, and the forearm in a neutral position. Participants naturally extended the wrist to approximately 30° extension during testing. The dynamometers were naturally positioned so participants could not see the readout while being tested, and no feedback was given by the tester. The right hand was tested first for each participant. A coin was flipped to determine whether to begin with the hydraulic or electronic dynamometer, and three consecutive readings were taken with each dynamometer with a 1-min rest between devices. The average of the three readings with each device was used for data analysis. Readings for the hydraulic dynamometer were estimated to the nearest whole number, and readings for the electronic dynamometer were recorded to the first decimal place. All readings were recorded in pounds.

Lateral pinch was used to measure pinch strength because it is one of the strongest types of pinch and is easily tested. Both hands were tested using the mechanical B&L Engineering pinch gauge and the Jamar electronic pinch gauge. As with grip strength testing, the right hand was tested first, and a coin was flipped to determine whether to begin with the mechanical or electronic pinch gauge. Participants were seated with the shoulder adducted, 90° of elbow flexion, the forearm in a neutral position, and the wrist extended approximately 30°. The pinch gauges were positioned with the readout area face down so participants had no visual feedback during testing. Three consecutive readings were taken with each pinch gauge, and a 1-min rest was given between devices. The average of the three readings with each device was used for data analysis. Readings for the mechanical pinch gauge were rounded to the nearest whole number, and readings for the electronic pinch gauge were recorded to the first decimal place. All readings were recorded in pounds.
Data Collection

Data collection was done by the author and students in a graduate-level scientific inquiry course in the Transitional Program for Occupational Therapy Assistants at Concordia University Wisconsin. The students who assisted with data collection were trained and evaluated by the author as they tested classmates with the devices during a 4-hr class meeting to ensure consistent procedures. Data collection occurred as part of the course beginning midway into the semester and was completed within a 1-mo period.

Data Analysis

The study was a repeated measures design comparing two pairs of instruments to determine interinstrument reliability. As suggested by Portney and Watkins (2009), the paired t test and the ICC were used for statistical analysis to determine both consistency and agreement between the paired readings. Statistical analyses were completed using SPSS Version 20 (IBM, Armonk, NY). Because the statistical analyses compared readings between the instruments with both the right and the left hands, the total number of readings compared was twice the number of participants. For example, 20 men were tested to compare grip strength between the two different dynamometers with both the right and the left hands, for a total comparison of 40 readings.

Results

Twenty men and 20 women ages 20–50 participated in the comparison of the Jamar electronic and hydraulic dynamometers. Seventeen men and 25 women ages 20–50 participated in the comparison of the Jamar electronic pinch gauge and the mechanical B&L Engineering pinch gauge. Readings between the two dynamometers and two pinch gauges were compared on both the right and the left hands of all participants.

Table 1 is a summary of the results obtained in comparing the Jamar electronic pinch gauge and the mechanical B&L Engineering pinch gauge when measuring lateral pinch strength. As with comparing the dynamometers for grip strength, in every case the electronic pinch gauge recordings were lower than those of the mechanical pinch gauge. For the male participants, the hydraulic pinch gauge resulted in readings 18.38% higher than those taken with the electronic pinch gauge. The mean male lateral pinch strength readings were 20.70 lb for the electronic pinch gauge and 24.89 lb for the hydraulic pinch gauge. For the female participants, the hydraulic pinch gauge resulted in readings 18.54% higher than those taken with the electronic pinch gauge. The mean female lateral pinch strength readings were 15.07 lb for the electronic pinch gauge and 18.15 lb for the hydraulic pinch gauge. The two-tailed p value for the paired t test was less than .0001 for both men and women. The ICC for the men was .615 and for the women .739. According to Portney and Watkins (2009), ICCs above .75 indicate good reliability, whereas those below .75 indicate poor to moderate reliability.

Table 2 summarizes the results obtained in comparing the Jamar electronic pinch gauge and the mechanical B&L Engineering pinch gauge. The mean female lateral pinch strength readings were 15.07 lb for the electronic pinch gauge and 18.15 lb for the hydraulic pinch gauge. The two-tailed p value for the paired t test was less than .0001 for both men and women. The ICC was .288 for the men and .527 for the women.

Table 1. Comparison of Results for Electronic Versus Hydraulic Grip Dynamometers

<table>
<thead>
<tr>
<th>Gender and Instrument</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>SEM</th>
<th>% Difference</th>
<th>t(39)</th>
<th>ICC [95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men (M age = 32.80 yr)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic dynamometer</td>
<td>40</td>
<td>108.57</td>
<td>14.72</td>
<td>2.33</td>
<td>11.27</td>
<td>9.98</td>
<td>.615 [.381, .775]</td>
</tr>
<tr>
<td>Hydraulic dynamometer</td>
<td>40</td>
<td>121.54</td>
<td>17.53</td>
<td>2.77</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Women (M age = 31.25 yr)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic dynamometer</td>
<td>40</td>
<td>63.71</td>
<td>11.03</td>
<td>1.74</td>
<td></td>
<td>6.76</td>
<td>.739 [.560, .853]</td>
</tr>
<tr>
<td>Hydraulic dynamometer</td>
<td>40</td>
<td>69.63</td>
<td>10.51</td>
<td>1.66</td>
<td>8.88</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. CI = confidence interval; ICC = intraclass correlation coefficient; M = mean; SD = standard deviation; SEM = standard error of the mean.
aRight and left hands combined. bDifference between the means divided by the average of the two means.
Discussion

As other researchers have found (España-Romero et al., 2010; Flood-Joy & Mathiowetz, 1987; Mathiowetz et al., 2000; Svens & Lee, 2005), interinstrument reliability with different dynamometers and pinch gauges is often poor. Our study found the same in comparing the newer Jamar electronic dynamometer and pinch gauge with the commonly used Jamar hydraulic dynamometer and B&L Engineering mechanical pinch gauge. On the basis of the results of this study, we recommend that occupational therapists do not interchange these devices when measuring grip and pinch strength with patients and that they note in their documentation which specific instrument they used with each patient.

The electronic devices offer some advantages. The devices store input and can automatically average three trials. In addition, the readout on the devices is digital and does not require the practitioner to estimate a reading, as with devices using a needle pointer.

Limitations and Future Research

The hydraulic dynamometers and mechanical pinch gauges used in the study were sent in for recalibration immediately before use with study participants, but calibration of the instruments was not independently verified. It is recommended that dynamometers and pinch gauges used in future studies have their calibration independently verified to determine concurrent validity. Additional studies investigating the intra- and interrater reliability of the electronic dynamometer and pinch gauge should be conducted to substantiate the results of the current study. Because the commonly used norms for grip and pinch strength (Mathiowetz et al., 1985) are more than 25 yr old, norms should be redeveloped with consideration of different measurement devices.

Implications for Occupational Therapy Practice

The results of this study have the following implications for occupational therapy practice:

- This study found a statistically significant difference in strength readings between electronic and hydraulic dynamometers and between electronic and mechanical pinch gauges.
- Because of the difference in strength readings between devices, also found in other studies, occupational therapy practitioners should consistently use the same devices when retesting patients’ grip and pinch strength and record in evaluation notes the specific device used.
- Care should be taken in applying norms established with hydraulic and mechanical dynamometers and pinch gauges to strength measurements taken with electronic devices.

Acknowledgment

The author thanks the students in the 2009 cohort of the Transitional Program for Occupational Therapy Assistants at Concordia University Wisconsin for their assistance in data collection for this study.

References


Table 2. Comparison of Results for Electronic Versus Mechanical Lateral Pinch Gauges

<table>
<thead>
<tr>
<th>Gender and Instrument</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>SEM</th>
<th>% Difference</th>
<th>t Test(33)</th>
<th>ICC [95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men (M age = 31.65 yr)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Electronic pinch gauge</td>
<td>34</td>
<td>20.70</td>
<td>2.63</td>
<td>0.45</td>
<td>18.38</td>
<td>11.66, p &lt; .0001</td>
<td>.288 [.107, .519]</td>
</tr>
<tr>
<td>Mechanical pinch gauge</td>
<td>34</td>
<td>24.89</td>
<td>2.50</td>
<td>0.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women (M age = 34.04 yr)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic pinch gauge</td>
<td>50</td>
<td>15.07</td>
<td>2.99</td>
<td>0.42</td>
<td></td>
<td>10.00, p &lt; .0001</td>
<td>.527 [.295, .700]</td>
</tr>
<tr>
<td>Mechanical pinch gauge</td>
<td>50</td>
<td>18.15</td>
<td>4.02</td>
<td>0.57</td>
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</tr>
</tbody>
</table>

Note. CI = confidence interval; ICC = intraclass correlation coefficient; M = mean; SD = standard deviation; SEM = standard error of the mean.

*aRight and left hands combined. *bDifference between the means divided by the average of the two means.