Brief Report

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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O ccupational 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,
Recent studies 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 intrument 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; MacDermid, 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, 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 recorded to the first decimal place 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 recorded 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.
Note

Women (a)
Men (b)
with both the right and the left hands, the
pared readings between the instruments
NY). Because the statistical analyses com-
using SPSS Version 20 (IBM, Armonk,
readings. Statistical analyses were completed
statistical analysis to determine both consis-
tency and agreement between the paired
readings. As suggested by Portney and Watkins (2009), ICCs above .75 in-
dicate 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 when measuring lateral pinch
strength. As with comparing the dyna-
meters 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 in-
dicate good reliability, whereas those below
.75 indicate poor to moderate reliability.

Data Collection

Data collection was done by the author and
students in a graduate-level scientific inquiry
course in the Transitional Program for Oc-
cupational 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 proce-
dures. 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 consis-
tency and agreement between the paired
readings. Statistical analyses were completed
using SPSS Version 20 (IBM, Armonk,
NY). Because the statistical analyses com-
pared 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 ex-
ample, 20 men were tested to compare grip
strength between the two different dyna-
mometers 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
and hydraulic dynamometers when mea-
suring grip strength. In every case, the
 electronic dynamometer readings were lower
than those taken with the hydraulic dynamo-
meter. For the male participants, the
hydraulic dynamometer resulted in readings
11.27% higher than those taken with the
electronic dynamometer. The mean male
grip strength readings were 108.57 lb for the
electronic dynamometer and 121.54 lb for
the hydraulic dynamometer. For the female
participants, the hydraulic dynamometer
resulted in readings 8.88% higher than those
taken with the electronic dynamometer. The
mean female grip strength readings were
63.71 lb for the electronic dynamometer and
69.63 lb for the hydraulic dynamometer.
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 in-
dicate good reliability, whereas those below
.75 indicate poor to moderate reliability.

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>Men (M age = 32.80 yr)</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>
<td></td>
</tr>
<tr>
<td>Women (M age = 31.25 yr)</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>8.88</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></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.
(a) Right and left hands combined. (b) Difference between the means divided by the average of the two means.
**Discussion**

As other researchers have found (Espan˜a-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.

**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><strong>Men (Mage = 31.65 yr)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<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><strong>Women (Mage = 34.04 yr)</strong></td>
<td></td>
<td></td>
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<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>18.54</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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<td></td>
</tr>
</tbody>
</table>

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

*Right and left hands combined. *Difference between the means divided by the average of the two means.

**References**


