Adult grip strength norms for the Baseline digital dynamometer

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Adult Grip Strength Norms for the Baseline® Digital Dynamometer

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Note: This scholarly project reflects individualized, original research conducted in partial fulfillment of the requirements for the Occupational Therapy Doctorate Program, The University of Toledo.
Abstract

Objective: Occupational therapists commonly assess grip strength during an evaluation in order to determine overall hand functionality. Currently, there is a wide variety of digital instruments that do not have normative data established. Therapists use the norm tables Mathiowetz et al. (1985) created for the Jamar hydraulic dynamometer with other brands. The purpose of the study is to increase the reliability and validity for the Baseline digital dynamometer by establishing norms for the healthy adult population.

Methods: This study was a part of larger study, which included testing of the Baseline digital pinch gauge. A total of 109 males and 111 females ages 20-75+ participated in this study. All participants self-reported to be healthy and be free from disease and injury that could affect their upper extremity. A computer program directed the randomization for the order of instruments to control for fatigue.

Results: The study had a sufficient number of subjects in three age categories to permit comparisons to Mathiowetz et al. (1985) for the 20-25 years, 26-29 years, and 75 and older groupings. Both males and females in the three age groups measured higher with the Baseline dynamometer compared to the Jamar dynamometer, except the 25-29 age group right and left handed males and the 20-24 age group right handed females.

Conclusions: Differences found between the measurements of the Baseline digital dynamometer and the Jamar dynamometer support the use of individualized norms for specific instruments in order to obtain more accurate data for best clinical practice. Further data collection will continue for the age groups lacking in participants in order to complete a standardized set of norms for the Baseline Digital dynamometer.
Adult Grip Strength Norms for the Baseline® Digital Dynamometer

Providing rehabilitative care for patients with hand problems has become an increasing responsibility and role for occupational therapists (Ager, Olivett, & Johnson, 1984). One way to measure the overall functionality of a person’s hands is to measure grip strength. The most commonly used device to measure grip strength is the Jamar hydraulic dynamometer, which was used previously to establish adult normative data for grip strength (Mathiowetz, Kashman, Volland, Weber, Dowe, & Rogers, 1985). The Jamar hydraulic dynamometer is considered to be the “gold standard” for measuring grip strength with studies showing that the instrument has high validity and reliability (Mathiowetz, Weber, Volland & Kashman, 1984; Svens & Lee, 2005). However, studies have shown differences comparing styles of dynamometers to the Jamar hydraulic dynamometer, and suggest that certain dynamometers should not be used interchangeably (Svens & Lee, 2005; Deaton, 2014). Recent research has shown the importance of establishing normative data for digital dynamometers due to the differences in grip strength measurements found between the Baseline digital dynamometer and the Jamar hydraulic dynamometer (Deaton, 2014). At this time there are no known normative data for the Baseline digital dynamometer. This study will provide normative data for a healthy adult population using the Baseline digital dynamometer to assess grip strength. In order to understand the present study, a review of literature outlining previous normative studies will be included. Past research on comparing the Baseline digital dynamometer to the Jamar hydraulic dynamometer will be discussed followed by a description of the present study.

Importance of grip strength

Balogun, Adenlola, and Akinloye (1991) consider gripping, manipulation, and hand gestures to be important functions of the hand. Grip strength is needed for daily occupations such
as eating, grooming, and leisure participation (Rice, Leonard & Carter, 1998). Studies have shown that difficulties with gripping and manipulating objects can lead patients to have impairments performing daily occupations (Ranganathan, Siemionow, Sahgal, & Yue, 2001; Shiffman, 1992). Ranganathan, Siemionow, Sahgal, and Yue (2001) concluded in their study of 27 participants that aging has a degenerative effect on grip strength making it more difficult for senior citizens to perform common occupations of daily living. Shiffman (1992) conducted a study that showed hand function to remain stable until age 65 years, after which hand function slowly diminishes and deficits become apparent after age 75. Research has also supported the importance of grip strength due to it being a possible determinant of future falls in older adults. In a study by Miller, Giles, Crotty, Harrison, and Andrews (2003), results showed that for both genders the percentage of fallers was highest for those with grip strength less than the 25th percentile. The results suggest that low grip strength is a risk factor for falls.

Why do occupational therapists measure grip strength?

A common way to assess the function of the hand is to measure the patient’s grip strength. Occupational therapists can use grip strength measurements to compare a patient’s strength relative to a normative standard. Grip strength measurements can also assist in creating baseline measurements, planning appropriate treatment procedures, and evaluating the effectiveness of a treatment (Clerke & Clerke, 2001; Mathiowetz, 1991; Robertson & Deitz, 1987; Mathiowetz, Weber, Volland, & Kashman, 1984). A grip strength measurement is also useful because it provides objective and quantifiable information for the occupational therapist (Kuzala & Vargo, 1991).
Devices occupational therapists use to measure grip strength

There are varied instruments that are used to measure grip strength in an assortment of settings, giving occupational therapists many choices. Grip strength instruments include sphygmomanometers, hydraulic dynamometers, various strain gauges, bulb dynamometers, and spring dynamometers (Fess, 1992). In response to the confusion associated with varied grip strength instruments available, the California Medical Association conducted a study to determine the most accurate instrument to use. The association determined that the hydraulic dynamometer provided the most accurate measurements of grip strength compared to a pneumatic instrument and a spring dynamometer (Kirkpatrick, 1956). Dynamometers measure grip strength by the amount of force used by the patient’s hand during an isometric muscle contraction (Svens & Lee, 2005; Allen & Barnett, 2011). A hydraulic dynamometer records static grip strength in kilograms or pounds of force (Innes, 1999). The most widely reported hydraulic dynamometer used by occupational therapists is the Jamar hydraulic dynamometer (Smith & Benge, 1985). The Jamar hydraulic dynamometer is also considered to be the “gold standard” for measuring grip strength by many clinicians with studies showing the instrument to have high validity and reliability (Mathiowetz, Weber, Volland, Kashman, 1984; Svens & Lee, 2005).

Digital and hydraulic grip dynamometers

Digital dynamometers are becoming more prevalent in clinics (Shechtman, Gestewitz, & Kimble, 2005). There are differences between digital and hydraulic dynamometers. Digital dynamometers offer benefits over hydraulic dynamometers. Benefits include increased sensitivity to direct force, digital readouts, and automated calculations (Shechtman, Gestewitz, & Kimble, 2005; Svens & Lee, 2005; Allen & Barnett, 2011). However, the published normative
data for grip strength was established using the Jamar hydraulic dynamometer (Mathiowetz, Kashman, Volland, Weber, Dowe, & Rogers, 1985). Therefore, occupational therapists must use norm tables that were created using the Jamar hydraulic dynamometer. This is a concern because differences between instruments can contribute to unreliable and invalid data.

**Previous normative research**

After an evaluation of grip strength, norms are used to interpret the data. The established norms can help determine the need for therapy and create appropriate treatment goals (Mathiowetz, Kashman, Volland, Weber, Dowe, & Rogers, 1985). When clinicians use the normative data, they are able to see how patients compare with healthy individuals of the same age and gender (Balogun, Adenlola, & Akinloye, 1991). When the data are interpreted by comparing the results to the given norms, the information can help aid in the communication process with the patient (Ager, Olivett & Johnson, 1984). Researchers have conducted a few norms studies using a variety of grip strength dynamometers for various age groups.

Mathiowetz, Kashman, Volland, Weber, Dowe, and Rogers (1985) published grip and pinch strength normative data for adults. The Jamar hydraulic dynamometer was used to assess grip strength and the B&L pinch gauge was used to assess pinch strength. A purpose of their study was to establish norms for men and women aged 20-75 plus years. There were 628 participants divided into 12 groups with five-year intervals, characterized by age, sex, and hand dominance. For each test the subjects were seated with their shoulders adducted and neutrally rotated, elbows flexed to 90° and forearms in neutral position. Wrists were between 0° and 30° of dorsiflexion. Grip strength was tested first followed by pinch strength and three successive trials for each test were recorded. The researchers calibrated the instruments throughout the study. Results concluded that grip strength peaks within the 25 to 39 age group for both men and
women and declines thereafter. Data also demonstrated that the right hand was stronger than the left hand and men were stronger than women on pinch and grip strength tests. Limitations include the subjects being only from the Milwaukee area and that they were not randomly selected. The authors suggest that to improve the reliability of hand strength evaluations one should use standardized positioning along with standardized instructions. When taking grip measurements, the authors recommend using the average of three trials along with using the same instrument for pre-tests and post-tests (Mathiowetz, Kashman, Volland, Weber, Dowe, & Rogers, 1985).

A study by Desrosiers, Bravo, Hebert, and Dutil (1995) published normative grip strength data using the Jamar hydraulic dynamometer and the Martin vigorimeter for persons aged 60 to 80 years and older. Participants included 360 men and women. The subjects were stratified for age and gender. The participant’s upper extremities were positioned in accordance to the American Society of Hand Therapists recommendations. Three grip strength measurements were taken and the highest score was documented. Both hands were tested with the dominant hand tested first. The Jamar hydraulic dynamometer was set at the second handle position for all participants. The results showed that grip strength decreased with increased age and men were consistently stronger than women. A few limitations of the study should be noted. The majority of the participants were right handed and all were from an urban environment. Overall, this study “shows that the grip strength of persons aged 60 years and older varies negatively and curvilinearly with age and that the loss seems more marked among the older subjects” (Desrosiers, Bravo, Hebert, & Dutil, 1995, pp. 642). This supports the need for occupational therapists to use grip strength norms developed for the instrument being used as well as for
comparing patients to the correct age group. In addition, normative research assists in having reliable and valid grip strength results for occupational therapists to use.

**Reason to develop new normative data**

Studies have concluded that different styles and models of dynamometers should not be used interchangeably. Svens and Lee (2005) compared the Jamar hydraulic dynamometer to a computer-connected GripTrack dynamometer. They conducted inter-instrument reliability and concurrent validity tests to compare the instruments. The study included 46 female participants between the ages of 21 and 40. Authors found that the Jamar hydraulic dynamometer resulted in higher measurements than the GripTrack. Results showed up to a 10.24 kg strength reading difference between the two instruments. The authors concluded that the GripTrack dynamometer and the Jamar hydraulic dynamometer were not interchangeable. Therefore, occupational therapists cannot compare the Jamar hydraulic and GripTrack dynamometer results with confidence. The authors recommend that future studies establish population norms using the GripTrack dynamometer (Svens & Lee, 2005).

A recent study by Deaton (2014) investigated the inter-instrument reliability and concurrent validity between the Baseline digital dynamometer and the Jamar hydraulic dynamometer to determine whether there is a difference in grip strength measurements between the two instruments. The study used 102 participants ranging in age from 18 to 50 years. This study found statistically significant differences in the readings between the Jamar hydraulic dynamometer and the Baseline digital dynamometer. The Jamar hydraulic dynamometer measured higher than the Baseline digital dynamometer in the majority of participants. Results found that between the instruments, the grip strength measurements can vary up to 27.32 pounds. Deaton (2014) recommended that the Baseline digital dynamometer and the Jamar hydraulic
dynamometer should not be used interchangeably. Measurements taken with the Baseline digital dynamometer should not be compared to the published norms that were established with the Jamar hydraulic dynamometer. The author suggests that future research be conducted to establish normative data using the Baseline digital dynamometer (Deaton, 2014).

Currently, there are no known normative studies for the Baseline digital dynamometer. The purpose of this normative study is to increase the reliability and validity for the Baseline digital dynamometer by establishing norms for a healthy adult population. This will give occupational therapists a set of values to compare their patient’s measurements with to determine if their patient has functional or dysfunctional grip strength. In addition, these new norms will help occupational therapists interpret their patients’ performance and assist them in making a more effective treatment plan for their patients.

Methods

The study used the same protocol and procedure used by Mathiowetz, Kashman, Volland, Weber, Dowe, and Rogers (1985) that established grip strength normative data for adults using the Jamar hydraulic dynamometer however, this study randomized the order of grip and pinch measurements to control for fatigue. Using comparable protocols and procedures in our study assists occupational therapists to accurately compare similarities and differences between the Baseline digital dynamometer and the Jamar hydraulic dynamometer. This study was a part of a larger study that established normative data for the Baseline digital pinch gauge in addition to the Baseline digital dynamometer.

Participants

The participants included both males and females, ranging in age from 20 to 75+ years. All participants were divided into 12 age groups of five-year intervals except for the 75+ age...
group. Participants in the 20-59 year groups reported to be free from disease and injury that could affect their upper extremity strength. The participants 60 and older were included if they had no acute pain in their arms or hands, at least 6 months post-hospitalization, and could carry on a normal lifestyle without limitations in their activity level because of a health problem (Mathiowetz et al., 1985). Participants were excluded if they had a learning and or cognitive disability. Furthermore, prior to data collection, participants provided self-reported information that included age, gender, hand dominance, and ethnicity.

Participants were recruited from the University of Toledo’s Medical Center, the YMCA, the UTMC recreation center and general campus. Participants were also recruited from the Wood County Committee on Aging in Bowling Green, Ohio. Participants were asked to partake in the study by word of mouth. Fliers and letters were also used to advertise for additional participant recruitment.

**Instrument**

The Baseline digital dynamometer (Figure 1) was used for measuring grip strength of each participant. Grip strength norms were established using the 300 lb. (135 kg) Baseline digital dynamometer (Fabrication Enterprises, Inc., White Plains, NY). The Baseline digital dynamometer is a hydraulic dynamometer that includes an LCD display. It features an electric zero calibration system. The Baseline digital dynamometer includes numerous options that allow the occupational therapist to return to zero, store the last measurement, and display the highest recorded measurement from the stored memory. The Baseline digital dynamometer can also convert the measurement readout between pounds and kilograms (Fabrication Enterprises, Inc, 2011; Deaton, 2014).
Before the start of data collection, the Baseline digital dynamometer was sent to Fabrication Enterprises for calibration purposes. During the beginning of data collection the max clear button and zeroing functions were working inconsistently. The instruments were sent for repair and recalibration on September 2, 2013. Fabrication Enterprises repaired the dynamometer with a new display. On October 3, 2013, Fabrication Enterprises checked the instrument’s calibration and reported that the instrument did not need recalibration. There were no further instrument issues during the completion of data collection.

**Procedure**

Participants entered the testing location and were asked to sit on a standard height chair with no arm rests. After interviewing the participant, the researcher determined if he/she could be included in the study based on the inclusion criteria previously mentioned. If the participant met the inclusion criteria he/she was then presented with an inform consent form to review. The researcher explained the purpose of the study along with any risks that may occur and answered participants’ questions. The participant then signed the consent form or opted out of the study. If the participant chose to sign the consent form, the data collection then began.

A computer program directed the randomization for which instrument was tested first (grip vs. pinch); the order of right vs. left hand; and the order of the pinch pattern. Three trials were measured for both the dynamometer and the pinch gauge on the right and left hands. As this is part of a larger study, the procedures for pinch strength measurements are reported in a manuscript authored by Courtney Lea.

**Positioning**

The study used the procedure for positioning recommended by the American Society of Hand Therapists (Fess, 1992). This was the same procedure for positioning that Mathiowetz et
al. (1985) used to measure grip strength. During testing the participant was seated with his/her shoulder adducted and neutrally rotated. The elbow was flexed at 90° and the forearm was in neutral position. His/her wrist was between 0° and 30° of dorsiflexion and between 0° and 15° of ulnar deviation (Fess, 1992). After the participant was positioned correctly, we gave verbal instructions of, “I want you to hold the handle like this and squeeze the dynamometer as hard as you can.” The researcher then demonstrated holding the dynamometer and handed it to the participant. The researcher said, “Are you ready? Squeeze as hard as you can.” When the participant began to squeeze, the examiner said, “Harder!...Harder!...Relax” (Mathiowetz, 1984, pp. 224). The procedure was then repeated using the same verbal instructions from the researcher for the second and third trials. We gave participants a 15 second rest break between each trial and a one minute rest period between instruments to reduce fatigue. This allowed adequate time for the researcher to read and record each trial measurement. Past studies have shown excellent inter-rater reliability and good to excellent test-retest reliability when using these standard procedures (Mathiowetz et al., 1984; Mathiowetz, 2002). After one hand’s grip measurement was completed, the other hand was then assessed using the same procedure mentioned above.

**Preliminary Results**

Preliminary results of data collected to date will be presented. The study included a sample of 220 participants aged 20 to 75 and older. A sample of 109 male and 111 female adults, ages 20-75 and older were tested using the Baseline digital dynamometer. The average age male was 42.35 (SD=20.35) years and the average age female was 41.44 (SD=19.67) years. Right-handed dominance was reported by 86.8% of participants, left-handed dominance by 9.5% of participants, and 3.6% reported to have no preference. The ethnicities the participants reported were 83.2% Caucasian, 8.6% African American, 2.3% Hispanic, 2.3% Asian and 3.6% as other.
Microsoft Excel and IBM Statistical Package for the Social Sciences were the programs used to obtain the descriptive statistics for all of the hand strength measurements (IBM Corp., 2012). The programs were used to calculate the mean of the three trials, standard deviation (SD), standard error (SE), and demographic statistics of age, gender, and ethnicity. Table 1 displays the mean, SD, and SE of all subjects by gender and age categories for the Baseline digital dynamometer.

**Discussion**

The purpose of this normative study was to increase the reliability and validity for the Baseline digital dynamometer by establishing norms for a healthy adult population. This will give occupational therapists a set of values to compare their patient’s measurements with in order to identify a level of development, or degree of impairment. This data will also contribute to the development of a treatment plan and provide a baseline for future comparisons. The procedures used in this study were similar to the methods used by Mathiowetz et al. (1985). The similarities include the age intervals for groups, data collection procedure, and exclusion and inclusion criteria. In contrast to Mathiowetz, we chose to randomize the order of grip and pinch instruments and prehension patterns within the pinch measurements to control for fatigue. Also, the location in which participants were recruited differed in that this study was conducted in Northwest, Ohio and the Mathiowetz et al. (1985) study was conducted in the Milwaukee region. Lastly, the number of participants in this study totaled 220 and the Mathiowetz et al. (1985) study totaled 628. For this reason, data collection for this study will continue for the age groups that are lacking in participants.

Male subjects had greater grip strength than females in all of the age categories represented. This finding is similar to the results of Mathiowetz et al. (1985) and the Desrosiers
et al. (1995) normative studies where men were consistently stronger than women in all age categories. The highest mean score for males was in the age range of 20-24 year olds for both the right and left hand (see table 1). This is also a common similarity between this study and Mathiowetz et al. (1985) study where grip strength peaked within the 25-39 age group for both men and women. Another common finding of other norm studies compared to our preliminary results was that grip strength decreased with age (Shiffman, 1992; Desrosiers, Bravo, Hebert, & Dutil, 1995; Ranganathan, Siemionow, Sahgal, & Yue, 2001).

This study had a comparable number of subjects in three age categories to the Mathiowetz et al. (1985) study including the 20-24 years, 25-29 years, and 75+. Tables 2 and 3 demonstrate the differences in the results for the Baseline digital dynamometer and the Jamar dynamometer for these three age categories. The studies showed large differences for males in the 20-24 and the 75+ age ranges. The most prominent difference was found in the 75+ age range with the Baseline digital dynamometer measuring 23.3 lbs. higher, on average, than the Jamar for the left hand. Also, the 20-24 male age group measured 22 lbs. higher, on average with the Baseline digital dynamometer, compared to the Jamar for the left hand. However, the 25-29 male age group measured 2 lbs. lower, on average, with the Baseline digital dynamometer compared to the Jamar for the right hand. For females, the studies showed large differences for the 25-29 and the 75+ age categories. The most prominent difference was found in the 75+ age range with the Baseline digital dynamometer measuring 10.4lbs. higher, on average, than the Jamar for the left hand. In addition, the 25-29 age group measured 3.7lbs. higher, on average with the Baseline digital dynamometer, compared to the Jamar dynamometer for the left hand.

Grip strength is commonly assessed and documented by occupational therapists in order to monitor individual progress and to assess the effectiveness of the current treatment plan.
Rahman, Thomas, and Rice (2002) concluded that as little as 2.31lbs of pressure is all that is needed to use a trigger pump spray bottle. A difference of 23lbs, as shown between the instruments in this study, is a considerable difference when it comes to overall hand ability in order to perform occupations of daily living with greater independence. These measurement differences shown between the Jamar dynamometer and the Baseline dynamometer are large enough to have practical implications in a clinical setting. These differences demonstrate why it is not valid to compare measurements that are taken with the Baseline digital dynamometer to the norms for the Jamar hydraulic dynamometer. These differences support the development and use of individualized normative data for the Baseline digital dynamometer to control for variations between instruments.

It is recommended that data collection continues in order to gather more data on males and females between 30-74 years of age so that the Baseline digital dynamometer will have its own set of norms for occupational therapists to use in order to get the best accurate data. Additionally, consistency is important and occupational therapists should use the same instrument with the same patient and use the norms created for that specific brand of instrument. Occupational therapists should also use the procedure for positioning recommended by the American Society of Hand Therapists and calibrate instruments on a regular basis to improve accuracy (Fess, 1992, Mathiowetz et al., 1985; & Mathiowetz et al., 1984).

**Limitations**

Data collection occurred only in Northwest, Ohio therefore, our study lacks broad geographical representation. The study also lacks ethnic diversity and caution should be noted with generalizing the results to the overall population. There are also differences in the Mathiowetz et al. (1985) study and this current study. Mathiowetz measured all pinch types with
the same order following grip strength measurements for each participant. We chose to randomize the order of instruments and pinch prehension patterns in order to control for possible fatigue. We felt it was important to control for fatigue and therefore randomized the order of presentation. We also could not find research to support a universal or common order for grip/pinch strength measurements in occupational therapy practice. We, therefore, do not know whether our results would have been more similar to Mathiowetz et al. (1985) study if we would have replicated his procedures exactly. In addition, this study totaled 220 participants compared to the Mathiowetz et al. (1985) study which totaled 628 participants. Data collection will continue for the age groups that are lacking in participants.

**Future Research**

In order to develop a full set of norms for the Baseline digital dynamometer, we need data for all of the age groupings for men and women. It is important that data collection continues for the age groups that are lacking in participants specifically, males and females between 30-74 years of age. The increased number of participants will help to determine additional differences and similarities between the Jamar hydraulic dynamometer measurements and the Baseline digital dynamometer measurements. A larger sample size will strengthen the current study and help to increase the reliability and validity of the Baseline digital dynamometer.

**Conclusions**

The purpose of the study was to increase the reliability and validity for the Baseline digital dynamometer by establishing norms for the healthy adult population. Results of this study showed differences between the measurements of the Baseline digital dynamometer and the Jamar dynamometer. These results support the use of individualized norms for specific
instruments in order to obtain more accurate data for best clinical practice. Further data collection will continue for the age groups lacking in participants in order to complete a standardized set of norms for the Baseline Digital dynamometer.

Acknowledgements

There are several important individuals who have contributed their time during the completion of this scholarly project. I would first like to express my appreciation and gratitude to my research advisor, Julie Jepsen Thomas, Ph.D., OTR/L, FAOTA for all of her guidance, knowledge, and encouragement throughout the process. Courtney Lea, my research partner, for all of her hard work and dedication gathering participants, collecting data, and presenting at conference. I would also like to thank Martin Rice, Ph.D., OTR/L, FAOTA for creating the randomization program we used to collect data. All of the contributions of those individuals mentioned above are greatly appreciated.
References


http://www.fabricationenterprises.com/mm5/merchant.mvc


### Table 1

**Grip Strength: Mean, Standard Deviation, and Standard Error for Age Groupings by Gender**

<table>
<thead>
<tr>
<th>Age</th>
<th>Hand</th>
<th>N</th>
<th>Mean (SD, SE) Men</th>
<th>N</th>
<th>Mean (SD, SE) Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-24</td>
<td>R</td>
<td>26</td>
<td>138.0 (25.8, 4.0)</td>
<td>26</td>
<td>69.8 (12.0, 4.0)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>126.5 (23.8, 3.6)</td>
<td>63.3 (10.1, 3.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-29</td>
<td>R</td>
<td>20</td>
<td>118.8 (24.2, 4.5)</td>
<td>24</td>
<td>74.9 (13.8, 4.1)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>109.5 (26.2, 4.1)</td>
<td>67.2 (10.9, 3.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-34</td>
<td>R</td>
<td>7</td>
<td>110.7 (22.8, 7.7)</td>
<td>8</td>
<td>73.9 (17.6, 7.2)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>110.4 (27.7, 7.0)</td>
<td>67.0 (15.2, 6.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35-39</td>
<td>R</td>
<td>7</td>
<td>132.3 (16.2, 7.7)</td>
<td>3</td>
<td>76.1 (7.6, 11.7)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>125.7 (21.1, 7.0)</td>
<td>65.6 (13.2, 10.7)</td>
<td></td>
<td></td>
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<tr>
<td>40-44</td>
<td>R</td>
<td>9</td>
<td>124.3 (28.7, 6.8)</td>
<td>7</td>
<td>79.0 (10.6, 7.7)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>116.8 (26.2, 6.2)</td>
<td>73.2 (7.4, 7.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45-49</td>
<td>R</td>
<td>3</td>
<td>119.6 (17.0, 11.7)</td>
<td>6</td>
<td>63.8 (15.8, 8.3)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>102.9 (8.2, 10.7)</td>
<td>62.7 (9.2, 7.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-54</td>
<td>R</td>
<td>3</td>
<td>131.8 (41.6, 11.7)</td>
<td>9</td>
<td>67.2 (22.0, 6.8)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>114.2 (30.2, 10.7)</td>
<td>63.0 (17.9, 6.2)</td>
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<td></td>
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<tr>
<td>55-59</td>
<td>R</td>
<td>4</td>
<td>114.3 (20.4, 10.1)</td>
<td>4</td>
<td>58.2 (7.0, 10.1)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>102.4 (17.2, 9.3)</td>
<td>54.3 (9.8, 9.3)</td>
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<tr>
<td>60-64</td>
<td>R</td>
<td>6</td>
<td>88.1 (38.2, 8.3)</td>
<td>6</td>
<td>70.6 (15.3, 8.3)</td>
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<tr>
<td></td>
<td>L</td>
<td>87.0 (28.7, 7.6)</td>
<td>67.7 (17.7, 7.6)</td>
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<td></td>
</tr>
<tr>
<td>65-69</td>
<td>R</td>
<td>9</td>
<td>87.3 (17.7, 6.8)</td>
<td>4</td>
<td>66.9 (4.8, 10.1)</td>
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<tr>
<td></td>
<td>L</td>
<td>82.9 (13.0, 6.2)</td>
<td>58.1 (6.7, 9.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70-74</td>
<td>R</td>
<td>4</td>
<td>74.3 (32.0, 10.1)</td>
<td>2</td>
<td>59.5 (4.9, 14.3)</td>
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<td></td>
<td>L</td>
<td>68.4 (18.1, 9.3)</td>
<td>52.8 (6.8, 13.1)</td>
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<td></td>
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<tr>
<td>75+</td>
<td>R</td>
<td>11</td>
<td>85.5 (21.6, 6.1)</td>
<td>12</td>
<td>50.9 (11.3, 5.9)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>78.3 (20.5, 5.6)</td>
<td>48.0 (9.8, 5.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>R</td>
<td>109</td>
<td>115.1 (31.5, 2.3)</td>
<td>111</td>
<td>68.7 (15.3, 2.3)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>106.8 (28.8, 2.8)</td>
<td>62.9 (12.9, 1.2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: All strength data are in pounds.
Table 2

*Comparison of Baseline and Jamar dynamometer mean for males*

<table>
<thead>
<tr>
<th>Age/N</th>
<th>Hand</th>
<th>Baseline Dynamometer</th>
<th>Jamar Dynamometer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>SE</td>
</tr>
<tr>
<td>20-24</td>
<td>L</td>
<td>126.5</td>
<td>23.8</td>
</tr>
<tr>
<td>N=26</td>
<td>R</td>
<td>138.0</td>
<td>25.8</td>
</tr>
<tr>
<td>25-29</td>
<td>L</td>
<td>109.5</td>
<td>26.2</td>
</tr>
<tr>
<td>N=20</td>
<td>R</td>
<td>118.8</td>
<td>24.2</td>
</tr>
<tr>
<td>75+</td>
<td>L</td>
<td>78.3</td>
<td>20.5</td>
</tr>
<tr>
<td>N=11</td>
<td>R</td>
<td>85.5</td>
<td>21.6</td>
</tr>
</tbody>
</table>

Note: All strength data are in pounds.

Table 3

*Comparison of Baseline and Jamar dynamometer mean for females*

<table>
<thead>
<tr>
<th>Age/N</th>
<th>Hand</th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
<th>Age/N</th>
<th>Hand</th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-24</td>
<td>L</td>
<td>63.3</td>
<td>10.1</td>
<td>3.6</td>
<td>20-24</td>
<td>L</td>
<td>61.0</td>
<td>13.1</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>69.8</td>
<td>12.0</td>
<td>4.0</td>
<td></td>
<td>R</td>
<td>70.4</td>
<td>14.5</td>
<td>2.8</td>
</tr>
<tr>
<td>25-29</td>
<td>L</td>
<td>67.2</td>
<td>10.9</td>
<td>3.8</td>
<td>25-29</td>
<td>L</td>
<td>63.5</td>
<td>12.2</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>74.9</td>
<td>13.8</td>
<td>4.1</td>
<td></td>
<td>R</td>
<td>74.5</td>
<td>13.9</td>
<td>2.7</td>
</tr>
<tr>
<td>75+</td>
<td>L</td>
<td>48.0</td>
<td>9.8</td>
<td>5.3</td>
<td>75+</td>
<td>L</td>
<td>37.6</td>
<td>37.6</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>50.9</td>
<td>11.3</td>
<td>5.9</td>
<td></td>
<td>R</td>
<td>42.6</td>
<td>42.6</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Note: All strength data are in pounds.

Figure 1. Baseline digital dynamometer