Figure-of-eight Method of Measuring Hand Size: Reliability and Concurrent Validity

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ABSTRACT: The purpose of this study was to examine reliability and validity of a new method of measuring hand size in which a tape measure is wrapped around the hand in a figure-of-eight pattern. In the first experiment, two testers measured hand size in 60 individuals with no recent history of injury or surgery. Intraclass correlation coefficients of 0.99 and 0.97 indicated high intratester and intertester reliability. In the second experiment, concurrent validity of the figure-of-eight method was examined using volumetry as the criterion measure. Right hand size of 25 individuals with no recent history of injury or surgery was measured using the figure-of-eight method and volumetry. Pearson correlation coefficients of 0.94 indicated high concurrent validity. This study demonstrated reliability and validity of the figure-of-eight method of measuring hand size. To establish clinical usefulness, these findings must be replicated in individuals undergoing hand rehabilitation.

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Following trauma or surgery to the hand, edema is among the signs of pathology often examined by practitioners. Quantifications of edema are used to establish a baseline on initial examination and document changes in patient status. To provide meaningful information, the methods used to measure edema should have documented reliability and validity. In addition, to be clinically useful, a measurement procedure should be time-efficient and use equipment that is inexpensive, readily available, and easy to use.

Volumetry is a method of measuring hand size that is commonly used in clinical practice when edema is generalized over the hand and not localized to a digit. In this method, hand size is quantified as the amount of water displaced when the hand is lowered into the volumeter, a water-filled container. The reliability and validity of volumetry have been documented. There are several disadvantages, however, to using volumetry in clinical practice. This method requires a water source and specialized equipment that is not inexpensive. Furthermore, it takes time to fill the volumeter, carry out the hand immersion procedure, and measure the displaced water. Volumetry may be contraindicated or difficult to use when measuring hand size of individuals with external fixation devices; open wounds; skin rashes; or extremely large, swollen hands. It would be advantageous to have a method of measuring hand size that is not only reliable and valid, but time- and cost-efficient, as well as appropriate for use when volumetric measures are contraindicated.

Volumetry is also used to measure ankle edema, but this clinical practice has the same disadvantages as volumetric measures of hand size. A figure-of-eight method of wrapping a tape measure around the ankle has been described as an alternative to volumetric measures of ankle edema. The tape measure method is more time- and cost-efficient than volumetry, and its reliability and validity have been established.

It is possible that a figure-of-eight method could provide a clinically useful measure of hand size as well. A search of MEDLINE (1966–2002) and CINAHL (Cumulative Index of Nursing and Allied Health Literature, 1982–2002) yielded no publications describing the use of a figure-of-eight method of measuring hand size. Therefore, the twofold purpose of this first experiment was to (1) describe a figure-of-eight tape measure method of measuring hand size, and (2) examine the intratester and intertester reliability of this new procedure.
EXPERIMENT 1

Method

Participants

A convenience sample of 60 individuals, 23 men and 37 women, from the University of Hartford campus community volunteered to take part in this study. Participants ranged in age from 20 to 45 with a mean age of 26.6 years. All participants reported no injury to their right hand in the past six months. Each participant provided written informed consent before taking part in the study.

Equipment

A standard 1/4-in wide, retractable, fiberglass tape measure was used to perform figure-of-eight measurements of hand size. The side of the tape marked in English standard units was blackened to blind testers to the measurements. The side of the tape marked in metric units was left visible for the data recorder to read.

Procedure

Two testers performed the measurement procedure and a third person acted as a data recorder. All three were senior physical therapy students at the University of Hartford. Before data collection, testers completed a 30-minute training session to standardize measurement procedures. Both testers performed three figure-of-eight measures of each participant’s right hand. The order of testers was randomized. After the first tester completed three consecutive measurements, the second tester repeated the process.

Figure-of-eight measurements were performed in the following manner. The participant sat in a chair that was positioned next to a treatment table. The participant’s right forearm rested on the table with the forearm pronated and the hand extending over the end of the table. The tester used demonstration and verbal cues in instructing the participant to maintain a position of (1) wrist neutral flexion/extension and radial/ulnar deviation, and (2) fingers adducted. The medial aspect of the wrist just distal to the ulnar styloid process was used as the starting point. The tester aligned the zero point of the tape measure on this starting point with the blackened side visible to the tester. The tester then wrapped the tape across the ventral surface of the wrist to the most distal point of the radial styloid. Next, the tape was placed diagonally across the dorsum of the hand to the fifth metacarpophalangeal (MCP) joint. The tape was then wrapped across the ventral surface to the second MCP joint. The final step involved placing the tape diagonally across the dorsum of the hand back to the starting point. Figure 1 depicts the final position of the tape on the hand.

Immediately after each measurement, the tester removed the tape from the participant’s hand, taking care to maintain a grip on the tape at the measurement end point. During the entire procedure, the tester did not view the metric side of the tape. The tester then displayed the metric side of the tape to the data recorder. The recorder read the tape to the nearest millimeter and documented the measurement on a data collection form immediately after making each reading. To sum, two testers measured right hand size three times for each of 60 participants.

Data Analysis

Data from the first four participants entered into the study were not included in the analyses because of a procedural error recognized after data collection had begun. Consequently, analyses were performed on data from 56 participants. Descriptive statistics for each tester’s measurements of hand size were calculated. Intraclass correlation coefficients (ICCs) were computed using SPSS 10.0.5 (SPSS Inc., Chicago, IL) to determine intertester and intratester reliability. Means of the three trials of each participant were determined for both testers. These mean values were used in calculating intertester reliability. In addition, standard errors of measurement (SEMs) were calculated as $SEM = SD \times (1-ICC)^{1/2}$, in which SD is the standard deviation of the measures and ICC is the reliability coefficient for that measurement.14,15

Results

Descriptive statistics for the figure-of-eight measurements are presented in Table 1. The ICCs for intratester reliability exceeded 0.99 (SEM = 0.29 cm) for both testers. The ICC for intertester reliability was 0.97 (SEM = 0.50 cm).
Discussion

There are no universally agreed upon standards for interpreting reliability coefficients. Using guidelines for interpretation offered by Currier, the present project demonstrated high intratester and intertester reliability using the figure-of-eight method to measure hand size of individuals with no condition affecting the hand. Furthermore, results showed that novice testers, after minimal practice, can be highly reliable when using the figure-of-eight method to measure hand size. Having established the reliability of this new method, a second experiment was conducted to examine its concurrent validity using volumetry as the criterion measure.

EXPERIMENT 2

Method

Participants

A convenience sample of 25 individuals from the University of Hartford campus community volunteered to participate. Participants were seven men and 18 women ranging in age from 18 to 46 years old (mean age, 25.5 years). Individuals were excluded from participating if they had any condition affecting the right hand or if skin on any portion of the hand was not intact. Each individual provided written informed consent before participation.

Equipment

A 1/4-in wide, retractable, fiberglass tape measure, similar to the one used in experiment 1, was used to take figure-of-eight measures. The methods of blinding testers differed in the two experiments. For experiment 2, the side of the tape marked in English standard units was covered with 1/2-in wide athletic tape. A hand volumeter set (Fabrication Enterprise, Irvington, NY) was used to take volumetric measures. The set consisted of a plexiglass hand volumeter, two 1,000-mL plastic beakers, and a 500-mL graduated cylinder marked in 5-mL increments.

Procedure

Two testers and two data recorders were senior physical therapy students at the University of Hartford. One tester performed the figure-of-eight procedure, and a second tester carried out the volumetric measurements. Before data collection, testers practiced their respective examination procedures to standardize their techniques.

The right hand of each participant was measured three times using the figure-of-eight method and twice using volumetrics. The figure-of-eight measures were taken first. The procedure for wrapping the tape around the hand was the same as described for experiment 1. After positioning the tape on the patient’s hand in the figure-of-eight pattern, the tester marked the end point by placing a pencil mark on the athletic tape covering the tape measure. The tester then removed the tape measure from the participant’s hand and gave it to the data recorder, who read the metric side of the tape to the nearest millimeter and documented this measure of hand size. After each measurement, the data recorder removed the pencil-marked athletic tape and placed a new piece on the tape measure. The procedure was repeated to attain three measurements of hand size.

After completion of the figure-of-eight measures, volumetric measurements of right hand size were taken using the procedure described by Schultz-Johnson, Waylett-Rendall and Seibly, and King. The volumeter was placed on a 74 cm high, wooden-top table, and the plastic beaker was positioned under the overflow spout of the volumeter. The volumeter was filled until water overflowed into the beaker. When water stopped dripping from the spout, the beaker collecting the overflow was replaced with an empty beaker. A thermometer was used to ensure that water temperature remained between 20°C and 32°C.

The participant stood with the right side facing the volumeter. The right hand was positioned above the volumeter with the forearm in pronation and thumb toward the spout. The participant was instructed to slowly lower the hand into the volumeter until the web space between the ring and middle finger rested on the stop dowel in the volumeter, as shown in Figure 2. The participant’s hand remained in the volumeter for 45 seconds, during which time the displaced water accumulated in the beaker. After 45 seconds, the participant’s hand was removed from the volumeter. The water in the beaker was then poured into the graduated cylinder, which was resting on a flat surface. The data recorder positioned herself so that the water surface in the graduated cylinder was at eye level. From this position, she read the volume of water to the nearest milliliter using interpolation if the water level fell between the 5-mL markings on the graduated cylinder. When more than 500 mL of water was

<table>
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<th>Measurement</th>
<th>Mean</th>
<th>Range</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
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<td>First</td>
<td>42.0</td>
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<td>2.84</td>
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<tr>
<td>Third</td>
<td>42.1</td>
<td>37.0–47.8</td>
<td>2.84</td>
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<tr>
<td>Tester 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>41.4</td>
<td>36.0–47.3</td>
<td>2.84</td>
</tr>
<tr>
<td>Second</td>
<td>41.3</td>
<td>36.0–48.0</td>
<td>2.98</td>
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<tr>
<td>Third</td>
<td>41.2</td>
<td>36.0–47.4</td>
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TABLE 1. Descriptive Statistics for Figure-of-eight Measurements (in cm) of Hand Size in Experiment 1
displaced, the graduated cylinder was filled twice and the two quantities of water were summed. The recorder documented the water volume immediately after making each reading. Two trials of volumetric measures of right hand size were performed on each participant. Although reliability of volumetry is well established, performing two trials provided a means of confirming reliability of the measurements taken by the tester in this experiment.

**Data Analysis**

Descriptive statistics were calculated for figure-of-eight and volumetric measures of hand size. ICCs and SEMs were calculated to determine intratester reliability of figure-of-eight and volumetric measures of hand size. The Pearson product-moment correlation coefficient was used to examine the concurrent validity of the figure-of-eight method using volumetry as the criterion measure.

**Results**

Descriptive statistics are presented in Table 2. The ICC for intratester reliability of the figure-of-eight measures was greater than 0.99 (SEM = 0.30 cm). Similarly, the ICC for intratester reliability of the volumetric measures was 0.99 (SEM = 7.4 mL). The Pearson product-moment correlation coefficient examining the relationship between the mean of the two volumetric measures and the mean of the three figure-of-eight measures was 0.94. The Pearson product-moment correlation coefficient for the first volumetric and first figure-of-eight measures was also 0.94.

**Discussion**

The results of this second experiment replicate the high intratester reliability of the figure-of-eight method demonstrated in the first experiment. The correlation between the mean values of the volumetric and figure-of-eight measures was very high, providing evidence of concurrent validity of this new method. Furthermore, the same very high correlation was obtained when the first trials of each method were correlated. These findings, along with high intratester reliability, suggest that only one measure using the figure-of-eight method is needed to provide meaningful information about hand size.

This article describes a new method of measuring hand size. The present results demonstrate high intratester reliability, intertester reliability, and concurrent validity of the figure-of-eight method of measuring hand size. There are practical benefits to this new method as well. The figure-of-eight method uses less costly equipment, with typical 2003 prices of $6 and $170 for a standard tape measure and volumetric set, respectively. Also, the figure-of-eight method is more time-efficient than the gold standard of volumetry. The tape measure method requires less than 1 minute, whereas volumetry takes several minutes to complete. Another advantage of the figure-of-eight method is that it provides an alternative when measuring individuals who have very large, swollen hands, or open wounds and external fixation devices for which volumetry is contraindicated.

All participants in both experiments had no history of hand injury, surgery, or overuse condition in the six months before their participation in this study. To truly establish the clinical usefulness of this new method, its reliability and validity must be documented when used to measure hand size of individuals with conditions affecting the hand. Such a project is currently under way. Sensitivity and specificity of the figure-of-eight method were not determined in the present project, but are topics that warrant future investigation.

**CONCLUSION**

The first experiment demonstrated high intratester and intertester reliability of the figure-of-eight method demonstrated in the first experiment. The correlation between the mean values of the volumetric and figure-of-eight measures was very high, providing evidence of concurrent validity of this new method. Furthermore, the same very high correlation was obtained when the first trials of each method were correlated. These findings, along with high intratester reliability, suggest that only one measure using the figure-of-eight method is needed to provide meaningful information about hand size.

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**TABLE 2. Descriptive Statistics for Figure-of-eight Measurements (in cm) and Volumetric Measurements (in mL) of Hand Size in Experiment 2**

<table>
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<th>Measurement</th>
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<th>Standard Deviation</th>
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</tr>
<tr>
<td>First</td>
<td>41.8</td>
<td>37.7–47.6</td>
<td>3.02</td>
</tr>
<tr>
<td>Second</td>
<td>41.6</td>
<td>37.6–47.1</td>
<td>3.01</td>
</tr>
<tr>
<td>Third</td>
<td>41.7</td>
<td>37.8–47.3</td>
<td>3.00</td>
</tr>
<tr>
<td>Volumetry</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>First</td>
<td>423.7</td>
<td>319–550</td>
<td>72.05</td>
</tr>
<tr>
<td>Second</td>
<td>429.9</td>
<td>324–562</td>
<td>77.36</td>
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</table>
method of measuring hand size in a sample of individuals with no recent hand injury or surgery. The second experiment replicated the findings of high intratester reliability and established the concurrent validity of the figure-of-eight method using volumetry as the criterion measure.

Acknowledgments

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REFERENCES