Brief Report

Effect of Wrist Positioning on the Repeatability and Strength of Power Grip

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Key Words: hand strength testing • posture and positioning evaluation • wrist joint

Objective. This study tested the between-day repeatability and effect of wrist positioning on grip strength measurement.

Method. Thirty healthy men 20 years to 69 years of age were tested twice, 1 week apart, in six wrist positions.

Results. The findings showed good repeatability for grip strength, with the intraclass correlation coefficient (ICC(1, 3)) ranging from .9043 to .9663. Significant differences were found in grip strength among the six positions (p < .001), with grip strength measured at 15° or 30° of wrist extension (EXT) and 0° ulnar deviation (UD) significantly greater than that of 0° UD and 0° EXT or 15° UD with or without EXT. This finding suggests the clinical importance of standardizing the testing position for grip strength measurement.

Conclusion. The high repeatability of the tests supports the use of the grip strength measurement to evaluate treatment progress.


Power grip is a commonly used index to assess impairment and treatment outcome for hand function (Talsania & Kozin, 1998). Occupational therapists measure grip strength in their evaluation of hand function. Body positioning appears to be a key factor that affects hand function because the fine motor control of the fingers and hand could be augmented by an optimal position of the upper limb (Stuchin, 1989).

Teraoka (1979) studied the effects of different body positions on grip strength and found that grip strength measured in supine was the weakest, whereas grip strength measured in standing was the strongest. However, Richards (1997) found no difference in grip strength measured in either sitting or supine. Su, Lin, Chien, Cheng, and Sung (1993, 1994) compared grip strength at 0°, 90°, and 180° of shoulder flexion in standing. They found that the strongest grip was produced when the shoulder was in 180° of flexion with elbow fully extended, whereas the weakest grip was associated with 0° of shoulder flexion and 90° of elbow flexion. Coincidentally, 0° of shoulder flexion with 90° of elbow flexion was the recommended testing position by the American Society of Hand Therapists for grip strength measurement (Fess & Moran, 1981).

Contrary to the findings of Su et al. (1993, 1994), Mathiowetz, Rennells, and Donahoe (1985) demonstrated that grip strength was significantly stronger at 90° of elbow flexion than at full extension (EXT). This finding was supported by a recent report that grip strength was greater at 90° of elbow flexion than at either full EXT or 120° of flexion (Fan & Ng, 1999). Hence, no consensus exists on the...
optimal body posture or positions of shoulder and elbow for measuring power grip.

Wrist position is another factor that affects grip strength. However, study findings of the optimal wrist position to facilitate grip strength are equivocal. Hazelton, Smidy, Flatt, and Stephens (1975) found that ulnar deviation (UD) and EXT of the wrist resulted in greater strength in the middle and distal phalanges. They also found a slight increase in grip strength at 21° UD or 14° radial deviation (RD) at the wrist, and the highest grip strength was recorded with the wrist in 30° UD. On the contrary, Terrell and Purswell (1976) reported a reduction of 15% in grip strength at 20° UD and 18% reduction at 20° RD.

Pryce (1980) reported that power grip strength was facilitated with the wrist in 0° to 15° EXT and 0° to 15° UD, whereas the measurements taken in 30° UD or 15° flexion and 30° UD of the wrist were significantly weaker. O’Driscoll et al. (1992) reported that the optimum wrist position for grip strength was 33° to 40° EXT and 7° UD. Any other position for the wrist would result in reduction of grip strength.

Among these studies, the discrepancy in the reported degree of UD associated with maximal grip strength could be due to the different testing methods. Pryce (1980) used an apparatus with a load cell and four straps that restrained the forearm on a table, whereas O’Driscoll et al. (1992) asked their participants to actively maintain their forearms and wrists in a predetermined position without external aids. The synergistic actions of other muscles of the upper extremity during gripping could vary with positioning, which may account for the difference in grip strength. Swanson, Matev, and De Groot (1970) stated that grip strength would become stronger when the upper limb was not supported.

More recently, Lamoreaux and Hoffer (1995) studied the effect of wrist deviation on grip strength and found that maximal RD and UD resulted in a significant decrease in grip strength compared with no deviation. In summary, little agreement exists among previous research studies on the optimum position of the wrist to facilitate grip strength. However, because the upper-limb position was not standardized across the studies during grip strength measurement, the validity of their results might be questioned.

From the literature, it is clear that wrist position can affect grip strength, but no consensus exists on which position is most facilitative for greater gripping force. Furthermore, the repeatability of power grip measurement at different wrist positions has not been reported. Therefore, the purpose of this study was to examine (a) the effect of wrist positioning and (b) the between-day reproducibility of power grip measurement.

Method

Participants

Thirty healthy men 20 years to 69 years of age ($M = 45.17$ years, $SD = 14$) participated in the study. They were without history of neurological disorders, rheumatic diseases, or injuries to the tendons, nerves, or bones in the hand or forearm, and they were naive to the aims and objectives of the study. None engaged in a regular upper-limb exercise program. This study was approved by the Ethics Review Committee of the administering institution.

Instrument

A computerized Jamar Dynamometer of Dexter Evaluation System was used to measure power grip strength. The dynamometer is a new model that has a force transducer interfaced with a computer, is used extensively in clinical settings, and has an established database. The handle of the dynamometer can be adjusted to five positions. For this study, the second handle position was used because it has been reported that peak grip strength usually developed in this position in most persons (Goldman, Cahalan, & An, 1991; Hamilton, Balnave, & Adams, 1994).

A testing board was fabricated to immobilize the wrist and forearm during the tests. Holes were drilled onto a 1-cm thick rectangular wooden board to accommodate wooden struts such that the spacing could cater to different hand sizes and be adjustable for different wrist positions. All the struts were covered with soft padding. Hook-and-loop straps were attached to the struts and strapped around the hand to prevent RD. The distal end of the board could be adjusted with a screw lock to between neutral and 15° UD at the wrist (see Figure 1).

Procedure

All participants attended a trial session 2 days before the actual test in order to control for the effect of motor learning (Pryce, 1980). Further, the participants performed warm-up and stretching exercises of the wrist and fingers before the actual test.

The tests were conducted in a quiet room, with the participants sitting comfortably on a chair without armrests. They were instructed to remain seated during the test with their hips and knees flexed at 90° and both feet resting on the floor.

Each participant’s dominant hand (defined as the hand used for writing) was used for testing. The dominant forearm was secured on the testing board to immobilize the wrist in the predetermined position. The board was stabilized on a table beside the participant, and the chair was adjusted until the arm rested comfortably with shoulder in neutral adduction and rotation, elbow at 90° flexion, and forearm in neutral pronation and supination as suggested by Fess and Moran (1981). Power grip was then measured with the wrist in six positions in randomized order: (a) 0° EXT and 0° radial–ulnar deviation (RUD), (b) 15° EXT...
and 0° RUD, (c) 30° EXT and 0° RUD, (d) 0° EXT and 15° UD, (e) 15° EXT and 15° UD, and (f) 30° EXT and 15° UD. During the tests, the examiner stabilized the dynamometer to prevent it from being lowered during the testing (see Figure 1). These positions were chosen for the testing because (a) wrist extensors work as synergists to prevent both flexion of the wrist joint during gripping and subsequent finger flexion restrictions (Lehmkuhl & Smith, 1985; Snell, 1995), and (b) wrist EXT and UD have been reported to facilitate power grip strength (Hazelton et al., 1975; Pryce, 1980; O’Driscoll et al., 1992).

The degrees of wrist EXT and UD were measured with a universal goniometer according to the procedures of Clarkson and Gilewich (1989). The same person conducted all tests to control for intertester variability.

The dynamometer was calibrated before the study, using the procedures suggested by Fess (1987). Participants were allowed to perform three practice trials in each testing position in order to become familiar with the instrument and actions. After the practice trials, participants then squeezed the handle of the dynamometer maximally for 3 sec in each testing position. According to Caldwell et al. (1974), healthy persons are able to build up force to the maximum level in less than 2 sec and maintain the force for at least 3 sec. The participants received no feedback on their performance, but verbal encouragement was given throughout the testing to ensure maximum effort.

Each test was conducted for three trials, as suggested by Fess and Moran (1981). To ensure that the participants performed with maximal effort in all trials, any score with a coefficient of variation greater than 10% was not accepted (Niemeyer, Matheson, & Carlton, 1989). The average of the three recordings was used for analysis. One minute of rest was given between each trial to eliminate muscle fatigue (Niebuhr, Marion, & Fike, 1994; Trossman & Li, 1989). During the tests, the participant rested his opposite, nondominant hand on his thigh.

To test for repeatability of the grip strength measurements, participants attended another testing session 1 week later at approximately the same time of day. The testing procedure was the same as that for the first testing session. Participants were instructed not to change their usual activities during the intervening week. One week provided adequate rest with minimal memory effect yet was short enough to avoid genuine changes in power grip strength over time (Portney & Watkins, 2000).

Data Analysis

Intraclass correlation coefficients [ICC (1, 3)] were calculated for the between-day repeatability of the grip strength. One-way repeated-measures analysis of variance (ANOVA) was used to analyze the effects of wrist positioning on grip strength. Post hoc linear contrasts were used to analyze the data pairs when the result of the ANOVA was significant.

Results

The ICCs(1, 3) ranged from .9043 to .9663, indicating high repeatability for all the tests. The ANOVA was significant, with $p < .001$. Post hoc linear contrasts revealed that dynamometer positions 2 and 3 produced greater grip strength than positions 4, 5, and 6, with $p$ ranging from .021 to .001, and position 1 produced greater strength than position 6, $p = .023$ (see Table 1).

Fifteen pair-wise comparisons were performed in the post hoc linear contrasts, and seven tests were significant at .05 level. To control for the inflated Type I error, $\alpha$ was adjusted to .023 (Ottenbacher, 1988). Because all the original significant $p$ values before $\alpha$ adjustment were smaller than .023, adjusting the $\alpha$ value did not change the results (see Table 1). The results suggest that wrist EXT at 15° or

Table 1

Table 1: Results of Post Hoc Linear Contrasts Between Testing Positions

<table>
<thead>
<tr>
<th>Wrist Position</th>
<th>Grip Strength (kgf)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$ (SD)</td>
<td>0° RUD</td>
<td>15° RUD</td>
<td>0° RUD</td>
<td>15° RUD</td>
<td>0° UD</td>
<td>15° UD</td>
</tr>
<tr>
<td>1</td>
<td>33.81 (8.67)</td>
<td>—</td>
<td>.086</td>
<td>.335</td>
<td>.101</td>
<td>.178</td>
<td>.023*</td>
</tr>
<tr>
<td>2</td>
<td>35.01 (8.77)</td>
<td>—</td>
<td>—</td>
<td>.635</td>
<td>.006*</td>
<td>.004*</td>
<td>.000*</td>
</tr>
<tr>
<td>3</td>
<td>34.66 (8.93)</td>
<td>.335</td>
<td>.635</td>
<td>—</td>
<td>.021*</td>
<td>.009*</td>
<td>.000*</td>
</tr>
<tr>
<td>4</td>
<td>32.55 (9.45)</td>
<td>.101</td>
<td>.006*</td>
<td>.021*</td>
<td>—</td>
<td>.758</td>
<td>.155</td>
</tr>
<tr>
<td>5</td>
<td>32.32 (9.71)</td>
<td>.178</td>
<td>.004</td>
<td>.009*</td>
<td>.758</td>
<td>—</td>
<td>.101</td>
</tr>
</tbody>
</table>

Note. EXT = extension; RUD = radial-ulnar deviation; UD = ulnar deviation.

*Significant at .023 level.
30° with neutral RUD results in stronger grip strength than when the wrist is at 15° UD with or without EXT.

Discussion
In this study, between-day repeatability for measurement of power grip strength and the effects of wrist position on grip strength were investigated in 30 healthy adult men. Results revealed that power grip measurement was highly repeatable for between-day comparisons in all testing positions and that wrist position significantly affected grip strength.

O’Driscoll et al. (1992) reported that grip strength decreased even with a small change of UD (7°–2°). In the present study, 15° UD resulted in lower grip strength than neutral RUD. Both the present study and that of O’Driscoll et al. have demonstrated that grip strength is sensitive to the degree of UD of the wrist. The finding of Armstrong and Chaffin (1979) may explain ours in that deviation of the wrist in the coronal plane led to compression of the flexor tendons against the structures of the carpal tunnel, thus redirecting the forces onto these structures instead of to the gripping action. Hazelton et al. (1975) also found that deviation of the wrist in the coronal plane could affect the leverage or angle of pull of the tendons. The angles between the tendons and their bony insertions would change as the wrist deviated, thus affecting the gripping force.

The results of the present study contrast previous findings that maximum power grip strength was produced with the wrist in extreme UD (Hazelton et al., 1975) or reports of no difference in grip strength between neutral RUD and 15° EXT and 15° UD and 15° EXT (Pryce, 1980). Variations in methodology among these studies could account for the differences. In Hazelton et al. (1975), only the wrist was stabilized, whereas Pryce (1980) stabilized the elbow and forearm but not the wrist. The present study controlled all body positions to eliminate the variable of body position affecting grip strength (Mathiowetz et al., 1985; Stuchin, 1989; Su et al., 1993, 1994; Swanson et al., 1970; Teraoka, 1979).

A possibility exists that the positions tested in the present study did not provide the optimum position for maximal power grip. Drury, Begbie, Ulate, and Deeb (1985) reported that the hand was less vulnerable to injury when the wrist was between 5° RD and 10° UD. A small change in wrist position may change the physiological advantage of the muscles. Further studies with smaller increments of wrist angles would be necessary to identify the optimal position for grip strength.

Clinically, it is very difficult to control every joint of the body during grip strength measurement, but the significant effects of wrist positioning on grip strength found in this study point to the importance of a standard position during testing. If positioning is standardized, the measurements appear to be highly repeatable. Given that grip strength measured in this study at 15° or 30° EXT and neutral RUD was stronger than at 0° UD and 0° EXT or 15° UD with or without EXT, it would seem appropriate to assess grip strength clinically in a position of 15° or 30° EXT and neutral RUD.

Because only healthy participants were tested, our results may not be directly extrapolated to persons who may have pain or discomfort with gripping. Nevertheless, this study provides useful guidelines for occupational therapists in assessing grip strength in clinical settings as well as implications of the wrist positions that may facilitate power grip strength.

Conclusion
This study demonstrated that grip strength measurement was highly repeatable for between-day measurements, using the Jamar dynamometer with the forearm and wrist properly stabilized on a stabilizing board. Grip strength measured at 15° and 30° of wrist EXT and neutral RUD was higher than that of UD with or without EXT. These findings highlight the importance for clinicians to adopt a standard testing position to assess grip strength. The finding of generally higher grip strength with wrist EXT and neutral RUD has clinical implications for hand rehabilitation and grip strength training. ▲

References


