The Rapid Exchange Grip Strength Test and the Detection of Submaximal Grip Effort

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This study assessed the reliability of the rapid exchange grip test for detecting submaximal grip effort, particularly evaluating its performance with motivated subjects with genuine hand weakness secondary to pain. Fifty normal participants performing with maximum effort then feigning hand weakness and 50 patients recovering from carpal tunnel surgery were studied. The results showed that the dynamic measure of grip strength equaled or exceeded the static measure in 28% of maximally performing participants (72% specificity), 58% of the carpal tunnel decompression patients (42% specificity), and 74% of participants giving submaximal grip effort (74% sensitivity). sensitivities and specificities for other criteria of a positive test were also determined. Our findings suggest that the rapid exchange grip strength test cannot reliably detect voluntary submaximal effort. (J Hand Surg 2002; 27A:329-333. Copyright © 2002 by the American Society for Surgery of the Hand.)

Key words: Grip strength, measurement, submaximal effort.

For social, financial, or psychological reasons, people injured at work may not give their true maximal effort when assessing grip strength. Thus it is important to develop sensitive and specific tests to detect submaximal grip effort after injury or surgery. A number of techniques have been described to detect submaximal effort. Some use methods more appropriate to a research laboratory, others can be more readily performed in the clinical setting using a Jamar dynamometer (Asimov Engineering, Santa Monica, CA) in a structured test. The 5-position grip strength test and the rapid simultaneous exchange and repeat grip strength test have been devised to detect submaximal effort in isolation or in combination. Previous studies by our group and others, however, suggest that the sensitivity and specificity of both the 5-position grip strength test and the rapid repeat measurement of grip strength are unsatisfactory.

The rapid exchange grip (REG) strength test is used in clinical practice to identify submaximal grip effort. Grip strength is first measured at each of the 5 settings of a Jamar dynamometer (Asimov Engineering, Santa Monica, CA) in a structured test. The 5-position grip strength test and the rapid simultaneous exchange

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Although the REG strength test has been found to discriminate between normal subjects and malingerers who feign hand weakness, its validity for detecting submaximal effort in patients complaining of genuine hand pain is uncertain. It is not known whether motivated patients with genuine hand pain and weakness have the same REG strength test pattern as normal people or if the pattern between the former group is indistinguishable from that of people voluntarily performing submaximally. This study investigates the pattern of the REG strength test in patients with genuine hand pain and assesses whether it can differentiate such patients from those giving submaximal effort.

**Patients and Methods**

Three groups of subjects underwent REG testing. The first group consisted of 50 healthy volunteers with no history of upper limb pain, injury, or disability. Twenty-five were women, and the mean age was 38 years (range, 22–66 years). This group performed an REG strength test on both hands while giving maximum effort.

The second group consisted of the same 50 healthy volunteers who 1 week later repeated the REG strength test. This time they were instructed to feign 50% weakness of their dominant hand.

The third group consisted of 50 patients who had undergone unilateral open carpal tunnel decompression 6 weeks previously. Thirty-one of these patients had undergone operations on their dominant hand. Thirty-seven of the 50 were women, and the mean age was 53 years (range, 22–85 years). All complained of some residual pain and scar tenderness. Each was asked to perform an REG strength test.

The strength testing procedure was identical in all 3 groups. Two calibrated hydraulic Jamar dynamometers were used, and participants received standardized instructions. Each subject was seated with both shoulders adducted and in neutral rotation, the elbows at 90° flexion, and the forearms and wrists in neutral alignment. Each participant first performed a 5-position grip strength test for each hand to ascertain the grip width at which maximum static grip strength occurred. This handling of the dynamometers were used, and participants received standardized instructions. Each subject was seated with both shoulders adducted and in neutral rotation, the elbows at 90° flexion, and the forearms and wrists in neutral alignment. Each participant first performed a 5-position grip strength test for each hand to ascertain the grip width at which maximum static grip strength occurred. This handling was then used for the rapid exchange test, during which the clinician supported both dynamometers. Participants were asked to alternately grip each dynamometer as hard as possible at a rate of 60 per minute on 10 occasions or until the subject had to stop because of fatigue or discomfort. The maximum dynamic grip strength achieved for each hand was then expressed as a percentage of the initial static measure at the same grip width (dynamic/static × 100%).

No participant had any prior experience or knowledge of either the REG strength test or of the purpose of the study, and a single investigator supervised all the tests.

Sensitivities, specificities, and positive and negative predictive values for the grip test were calculated using 8 different criteria to indicate a positive (submaximal) effort. These criteria were the dynamic measure of grip strength equaling or exceeding 85%, 90%, 95%, 100%, 101%, 105%, 110%, and 115% of the static measure. At each of these criteria for a positive test, sensitivity was determined by calculating the percentage of participants giving submaximal grip effort who were correctly identified. Specificity was calculated by using the results for the normal participants when performing with maximal effort, the carpal tunnel surgery patients, and both these groups combined. For each of these 3 groups the specificity was equal to the percentage of the group with a negative test (correctly diagnosed true hand weakness). A receiver operating characteristic (ROC) curve of sensitivity and specificity of the REG test was also calculated to help determine the optimum criteria for a positive REG test.

**Results**

All 50 normal volunteers and the 50 carpal tunnel decompression patients completed the 10 repetitions of the dynamic grip strength measurement. Values for mean static grip strength at each of the 5 handle settings are shown in Table 1. In 37 of the 50 normal participants, maximum grip strength of the dominant hand occurred at the second position. Mean grip strength was lower in the operated hands of the carpal tunnel decompression patients, but maximum grip strength was at position 2 in 33 of the 50. The results for the nondominant hands of the normal participants and the nonoperated hands of the carpal tunnel patients showed similar results. The maximum grip strength in the participants asked to feign 50% weakness was at position 2 in 24 and position 3 in 20 of the 50. The mean dynamic grip strength was 94% (95% CI, 92–96) of the static measure for the normal motivated group and 95% (95% CI, 91–99) of the static measure for the carpal tunnel decompression group. The mean dynamic grip strength was 126%
Table 1. Mean (Range) Grip Strength as Measured by a Jamar Dynamometer

<table>
<thead>
<tr>
<th>Grip Handle Position</th>
<th>Normal, Motivated Participants (Dominant Hand)</th>
<th>Participants Feigning 50% Weakness (Dominant Hand)</th>
<th>Carpal Tunnel Decompression Patients (Operated Hand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26 (10-68)</td>
<td>14 (1-32)</td>
<td>11 (2-25)</td>
</tr>
<tr>
<td>2</td>
<td>41 (18-67)</td>
<td>18 (3-44)</td>
<td>18 (6-39)</td>
</tr>
<tr>
<td>3</td>
<td>38 (18-71)</td>
<td>18 (2-49)</td>
<td>16 (4-38)</td>
</tr>
<tr>
<td>4</td>
<td>35 (12-59)</td>
<td>17 (3-44)</td>
<td>14 (3-34)</td>
</tr>
<tr>
<td>5</td>
<td>29 (10-55)</td>
<td>15 (1-38)</td>
<td>12 (2-30)</td>
</tr>
</tbody>
</table>

Position 1 is the narrowest handle setting and position 5 is the largest handle setting.

(95% CI, 114–138) of the static measure for the normal subjects when asked to feign 50% hand weakness.

If dynamic grip equaling or exceeding (≥100%) static grip is used to indicate a positive test, as is usually the case, then 14 of 50 maximally performing participants (72% specificity) and 29 of 50 carpal tunnel decompression patients (42% specificity) would be suspected of voluntary submaximal effort (Fig. 1), and 26% of participants asked to feign 50% hand weakness would not have been detected (74% sensitivity). Using the data from the ROC curve (Fig. 2) and Table 2, we found the optimum criterion for a positive test if the dynamic measure equaled or exceeded the static measure by 105%. Using this criterion gave a specificity of 90% for the maximally performing participants and 82% for the carpal tunnel decompression patients. The sensitivity of the test using this criterion was 70%. Table 2 shows the specificities and sensitivities and positive and negative predictive values of the REG test at the other criteria of a positive test. These values enable an examiner to calculate from the results of a given patient the chances of voluntary submaximal effort going undetected or being falsely diagnosed.

Further analysis of our data revealed that the specificity of the test for the nondominant hand was similar to that for the dominant hand and that the pattern of strength in the normal hands of patients with real and voluntary hand weakness behaved as our normal controls.

Discussion

The Jamar dynamometer provides an accurate, reliable, and valid measure of isometric grip strength in motivated participants. It is also used in a number

![Figure 1. Graphs of the sensitivity and specificity of the REG test using different normal control groups to determine specificity and different criteria for a positive (feigned weakness) test.](image-url)
of structured tests that attempt to determine sincerity of effort. The rapid exchange and rapid simultaneous grip strength tests have been reported to accurately detect submaximal grip effort with up to 80% sensitivity and 87% specificity.6,7

The 5-position grip strength test exhibits a skewed bell-shaped curve when grip strength is plotted against grip handle position for both normal motivated subjects and those with genuine hand weakness. A flatter plot has been described for participants with voluntary submaximal effort.5 This difference could theoretically be used to distinguish between these populations; however, considerable variability exists between individuals, and this makes it difficult to detect submaximal effort.10 The REG test was devised to overcome this problem.6,12 The present study found that the standard criterion for a positive test, a dynamic measure equal to or greater than (≥100%) the static measure, has reasonable specificity (72%) in normal subjects and sensitivity (74%), although it is not as high as previously reported.6,7 Furthermore, the results for the post–carpal tunnel decompression group show that the specificity (42%) of the test is much less if it is used to assess weakness in people with hand pain and incorrectly labels 58% of such motivated patients as voluntarily performing submaximally. If the criterion of a positive test is changed to the dynamic measure (≥105%) of the static measure, however, the REG test has reasonable specificity, both for normal subjects (90%) and subjects with valid weakness caused by hand pain (82%).

Hildreth et al6 reported that in normal healthy motivated participants the dynamic measure of grip strength should be approximately 85% of the static measure. According to our results, if this criterion of a positive test is used, it has very poor specificity (14% to 20%), although the sensitivity of the test is very high (86%).

We cannot generalize from our results to say that a positive REG test for a specific individual indicates malingering because it cannot consistently distinguish between maximal and submaximal performance. It is, however, more effective than the 5-position grip strength test and rapid repeat measurement of grip, and our results allow clinicians to estimate the likelihood of falsely detecting or failing to detect voluntary submaximal grip effort.

### Table 2. Sensitivity and Specificity of the Rapid Exchange Grip Test Using Different Control Groups to Determine Specificity and Different Criteria for a Positive Test

<table>
<thead>
<tr>
<th>Positive Test Criterion</th>
<th>Dynamic × 100</th>
<th>Static</th>
<th>Normal Motivated Participants (n = 50)</th>
<th>CTD Patients (n = 50)</th>
<th>Combined Normal and CTD Patients (n = 100)</th>
<th>Sensitivity (%)</th>
<th>Participants Feigning 50% Weakness (n = 50)</th>
<th>Positive Predictive Value (%)</th>
<th>Negative Predictive Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 85%</td>
<td>14</td>
<td>20</td>
<td>17</td>
<td></td>
<td></td>
<td>86</td>
<td>34</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>≥ 90%</td>
<td>28</td>
<td>32</td>
<td>30</td>
<td></td>
<td></td>
<td>86</td>
<td>38</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>≥ 95%</td>
<td>52</td>
<td>36</td>
<td>44</td>
<td></td>
<td></td>
<td>78</td>
<td>41</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>≥ 100%</td>
<td>72</td>
<td>42</td>
<td>57</td>
<td></td>
<td></td>
<td>74</td>
<td>46</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>≥ 101%</td>
<td>88</td>
<td>78</td>
<td>83</td>
<td></td>
<td></td>
<td>70</td>
<td>67</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>≥ 105%</td>
<td>90</td>
<td>82</td>
<td>86</td>
<td></td>
<td></td>
<td>70</td>
<td>71</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>≥ 110%</td>
<td>98</td>
<td>90</td>
<td>94</td>
<td></td>
<td></td>
<td>56</td>
<td>82</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>≥ 115%</td>
<td>100</td>
<td>96</td>
<td>98</td>
<td></td>
<td></td>
<td>54</td>
<td>93</td>
<td>81</td>
<td></td>
</tr>
</tbody>
</table>

CTD, carpal tunnel decompression.
References