Assessing the Motor Status Score: A Scale for the Evaluation of Upper Limb Motor Outcomes in Patients after Stroke

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The Motor Status Scale (MSS) measures shoulder, elbow (maximum score = 40), wrist, hand, and finger movements (maximum score = 42), and expands the measurement of upper extremity impairment and disability provided by the Fugl-Meyer (FM) score. This work examines the interval reliability and criterion validity of the MSS performed in patients admitted to a rehabilitation hospital 21 ± 4 days after stroke. Using the MSS and the FM, 7 occupational therapists matched to each other's judgments, evaluated 12 consecutive patients with stroke. Two therapists evaluated 6 additional patients on consecutive days. Intraclass correlation coefficients were significant for each group of raters for the shoulder/elbow and for the wrist/hand (P < 0.0001); test-retest measures were also significant for the shoulder/elbow (Pearson correlation coefficient r = 0.99, P < 0.004) and for the wrist/hand (Pearson correlation coefficient r = 0.99, P < 0.003). The internal item consistency for the overall MSS was significant (Cronbach alpha = 0.98, P < 0.0001). Finally, the correlation between the MSS and the FM (r² = 0.964) was significant (P < 0.0001). The MSS affords a reliable and valid assessment of upper-limb impairment and disability following stroke.

Key Words: Stroke—Motor Impairment—Disability—Upper limb.

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The initial success of recent novel training protocols to enhance motor outcome after stroke have required subjective scales of greater specificity and detail in order to measure accurately the observed motor changes. Particularly because the training protocols have demonstrated a beneficial effect for the motor abilities at which the training was specifically aimed. These experiments support a revived effort to treat impairment despite the main goal of rehabilitation that has focused on disability reduction. The information from these studies points out a proof of principle that more exercise can alter the motor outcome, at least a particular impairment that had been the target of the exercise programs. The improved outcome results, particularly after robot training, support the rationale for the validation of a new scale that measures motor performance of the upper limb. This scale, called the Motor Status Scale (MSS) (see Appendix), was generated some time ago and built on the valid and reliable foundation of the Fugl-Meyer (FM) scale that has been the cornerstone of motor outcome assessment after stroke. Compared to the FM, the MSS employs a finer grading of isolated movements and evaluates the complete range of motor function of the upper limb. In past experiments, the MSS has demonstrated utility in identifying and quantifying change of motor function of the upper limb in controlled treatment trials.

METHODS

Eighteen consecutive patients with stroke, admitted for acute rehabilitation, gave informed consent to the evaluation of their paralyzed upper extremity with the complete MSS (MSS and complete instruction manual available from the correspon-
Table 1a. The Motor Status Score Results (total for the shoulder and elbow) of 9 Consecutively Evaluated Patients with Stroke

<table>
<thead>
<tr>
<th>Patient</th>
<th>Patient 2</th>
<th>Patient 3</th>
<th>Patient 4</th>
<th>Patient 5</th>
<th>Patient 6</th>
<th>Patient 7</th>
<th>Patient 8</th>
<th>Patient 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Therapist 1</td>
<td>36.8</td>
<td>36</td>
<td>3.6</td>
<td>26.4</td>
<td>9</td>
<td>24</td>
<td>10</td>
<td>31.4</td>
</tr>
<tr>
<td>Therapist 2</td>
<td>36.4</td>
<td>33</td>
<td>2.8</td>
<td>24.4</td>
<td>9</td>
<td>23.2</td>
<td>5.6</td>
<td>32.2</td>
</tr>
<tr>
<td>Therapist 3</td>
<td>36.6</td>
<td>29.6</td>
<td>2.6</td>
<td>25.8</td>
<td>9</td>
<td>24</td>
<td>5.8</td>
<td>32.2</td>
</tr>
<tr>
<td>Therapist 4</td>
<td>36.5</td>
<td>24.6</td>
<td>3.4</td>
<td>26.0</td>
<td>8.6</td>
<td>22.6</td>
<td>7.4</td>
<td>31.8</td>
</tr>
<tr>
<td>Mean</td>
<td>36.6</td>
<td>33.3</td>
<td>3.10</td>
<td>25.6</td>
<td>8.90</td>
<td>23.5</td>
<td>7.20</td>
<td>31.9</td>
</tr>
</tbody>
</table>

| Standard deviation | 0.16 | 2.75 | 0.47 | 0.87 | 0.20 | 0.67 | 2.03 | 0.38 | 0.56 |
| Standard error     | 0.08 | 1.37 | 0.24 | 0.44 | 0.10 | 0.34 | 1.02 | 0.19 | 0.28 |

Table 1b. The Motor Status Score Results (total for the shoulder and elbow) of 3 Consecutively Evaluated Patients with Stroke

<table>
<thead>
<tr>
<th>Patient</th>
<th>Patient 2</th>
<th>Patient 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Therapist 1</td>
<td>32.2</td>
<td>7.6</td>
</tr>
<tr>
<td>Therapist 2</td>
<td>30.2</td>
<td>8.2</td>
</tr>
<tr>
<td>Therapist 3</td>
<td>33.6</td>
<td>11.0</td>
</tr>
<tr>
<td>Mean</td>
<td>32</td>
<td>8.93</td>
</tr>
</tbody>
</table>

| Standard deviation | 0.99 | 1.81 | 0.50 |
| Standard error     | 1.71 | 1.05 | 0.29 |

informed consent to the evaluation with the MSS on consecutive days. Two different therapists performed these measures.

To determine whether these test instruments provide stable and reliable responses over repeated administrations and among different examiners, we used SPSS 10.1 to calculate the intrarater reliability, test re-test reliability, and the internal consistency reliability of the test items in the MSS. We generated the regression test of the relationship between the FM and the MSS with Statview 5.0.

RESULTS

Tables 1a and 1b, and 2a and 2b show respectively the total MSS score for the shoulder/elbow, and for the wrist, hand, and fingers evaluation for each patient by each therapist, and also show respectively the summary descriptive statistics for each patient on the MSS for shoulder/elbow, and for wrist, hand, and fingers.

Selection of consecutive patients produced considerable variability of upper limb motor function; however, the scoring of the various degrees of motor function was reliable across the examiners. Intraclass correlation coefficients (ICC) were significant for intrarater scores for the shoulder/elbow (for the 4 examiners and 9 patients, ICC = 0.9944, 95% confidence interval [CI] = 0.9842, 0.9986, P <
Table 2a. The Motor Status Score Results (total for the wrist, hand, and fingers) of 9 Consecutively Evaluated Patients with Stroke

<table>
<thead>
<tr>
<th>Therapist</th>
<th>Patient 1</th>
<th>Patient 2</th>
<th>Patient 3</th>
<th>Patient 4</th>
<th>Patient 5</th>
<th>Patient 6</th>
<th>Patient 7</th>
<th>Patient 8</th>
<th>Patient 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Therapist 1</td>
<td>40.0</td>
<td>39</td>
<td>0</td>
<td>6.8</td>
<td>0</td>
<td>5.6</td>
<td>2.4</td>
<td>11.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Therapist 2</td>
<td>39.8</td>
<td>35</td>
<td>0</td>
<td>6.8</td>
<td>0</td>
<td>6.4</td>
<td>2.4</td>
<td>7.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Therapist 3</td>
<td>39.8</td>
<td>36.4</td>
<td>0</td>
<td>6.8</td>
<td>0</td>
<td>5.8</td>
<td>2.4</td>
<td>9.0</td>
<td>5.6</td>
</tr>
<tr>
<td>Therapist 4</td>
<td>39.8</td>
<td>34.4</td>
<td>0</td>
<td>6.8</td>
<td>0</td>
<td>5.8</td>
<td>2.4</td>
<td>7.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Mean</td>
<td>39.85</td>
<td>36.2</td>
<td>0</td>
<td>6.8</td>
<td>0</td>
<td>5.9</td>
<td>2.4</td>
<td>8.8</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Table 2b. The Motor Status Score Results (total for the wrist, hand, and fingers) of 3 Consecutively Evaluated Patients with Stroke

<table>
<thead>
<tr>
<th>Therapist</th>
<th>Patient 1</th>
<th>Patient 2</th>
<th>Patient 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Therapist 1</td>
<td>36.4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Therapist 2</td>
<td>36.4</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Therapist 3</td>
<td>36.4</td>
<td>1.0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3. The Motor Status Score (MSS) Totals for the Shoulder and Elbow (S/E) and for the Wrist, Hand, and Fingers (W/H) for 6 Patients Evaluated by the Same Therapist on Consecutive Days

<table>
<thead>
<tr>
<th>Patient</th>
<th>Evaluation 1</th>
<th>Evaluation 2</th>
<th>Evaluation 1</th>
<th>Evaluation 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSS S/E</td>
<td>36.8</td>
<td>36.6</td>
<td>22.0</td>
<td>22.4</td>
</tr>
<tr>
<td>Therapist 1</td>
<td>23.8</td>
<td>24.2</td>
<td>5.8</td>
<td>5.8</td>
</tr>
<tr>
<td>Patient 3</td>
<td>6.4</td>
<td>8.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Therapist 2</td>
<td>21.8</td>
<td>23.6</td>
<td>10.0</td>
<td>7.6</td>
</tr>
<tr>
<td>Patient 5</td>
<td>39.6</td>
<td>39.4</td>
<td>24.8</td>
<td>26</td>
</tr>
<tr>
<td>Patient 6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

0.0001; for the 3 examiners and 3 patients, ICC = 0.9845, 95% CI = 0.8920, 0.9996, P = 0.0001) and for the wrist/hand (for the 4 examiners and 9 patients, ICC = 0.9949, 95% CI = 0.9851, 0.9987, P < 0.0001; for the 3 examiners and 3 patients, ICC = 0.9997, 95% CI = 0.9977, 1.000, P < 0.0001).

Table 3 depicts the results of 2 different examiners evaluating 3 patients each on consecutive days. These test-retest measures for the shoulder/elbow (Pearson correlation coefficient = 0.99, P < 0.004) and for the wrist/hand (Pearson correlation coefficient = 0.99, P < 0.004) were significant.

A test of the internal consistency reliability of the MSS scale items revealed a significant Cronbach alpha = 0.9851, 95% CI = 0.9700, 0.9949, and P < 0.0001.

Figure 1 shows the correlation between the FM score and the MSS score for the upper extremity in the 12 patients who had had evaluations by different examiners. The mean MSS score for each patient was used in this calculation. The correlation was significant (Y = 3.5 + 0.81 X, r² = 0.96, P < 0.0001).

DISCUSSION

As new poststroke rehabilitation treatments focus on specific impairment, there will be a need for validation of appropriate subjective scales that test whether the new treatments are useful, at least until objective measures for motor impairment outcome

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are adequately defined. The results of the MSS for shoulder/elbow and for wrist/hand have significant interrater reliability, and significant internal consistency reliability. Furthermore, the MSS correlates significantly with the standard FM scale and supports the criterion validity of the MSS. These data are consistent with past experience using the MSS s/e scale.6,8,11,12,15-18

The MSS for the upper limb was developed to provide a continuum of measurements that range between impairment scales that isolate individual muscle power and disability scales that focus on function. Restoration of function is the universally preferred goal, and novel training techniques have led to improved recovery.1,9 A more complete characterization of that recovery requires the assessment of isolated movements that form the basis of complex, composite movements. Compared to the FM, the 6-point gradation of the MSS permits finer scoring and includes the evaluation of more movements. For example, the MSS scored isolated shoulder internal and external rotation, scapular protraction, retraction, and elevation; additionally it scored the complex composite movement of reaching away from the body. Evaluating each isolated movement will define motor recovery and the response to treatment more accurately. In sum, the MSS comprises a new measurement scale of functional movements that, combined with motor power and disability measures, will expand our understanding of stroke recovery.

ACKNOWLEDGMENTS

The Burke Medical Research Institute, the NIH (HD-37397), and the Langeloth Foundation supported this work.

APPENDIX.
Upper Extremity Motor Status Assessment

| Patient name: | ____________________________ |
| Scored by:    | ____________________________ |
| Date:         | ____________________________ |

MOVEMENT SCALE—SHOULDER/ELBOW

0  =  no volitional movement or no contraction
1− = contraction or patient initiating first few degrees of movement
1  =  performs partly/incomplete or uncontrolled motion
1+ = lacking last few degrees of motion
2− = completes full range, decreased control or timing
2  =  performs faultlessly (complete, controlled motion)

Place and hold (shoulder: 1B, 2B, 3B, 4B, 5B; elbow: 2B-0 or 1)

MOVEMENT SCALE—WRIST, HAND, AND FINGER

0  =  no volitional movement or contraction
1  =  performs partial movement
2  =  performs complete movement faultlessly
APPENDIX Continued

SEATED ACTIVE RANGE OF MOTION (CHECK WHEELCHAIR POSITIONING)

**Shoulder**

1. A. Shoulder flexion to 90°, elbow 0°, forearm neutral
   - *Deltoid, Rotator Cuff*
   - Movement

2. A. Shoulder abduction to 90°, elbow 0°, forearm pronated
   - *Deltoid, Rotator Cuff*
   - Movement

3. A. Shoulder flex 90°–150°, elbow 0°
   - *Deltoid, Rotator Cuff*
   - Movement

4. A. Touch top of head
   - *Deltoid, Rotator Cuff, Biceps Brachii, Triceps Brachii*
   - Movement

5. A. Touch small of back
   - *Subscapularis, Pectoralis Major, Latissimus Dorsi, Teres Major, Deltoid, Upper Trapezius*
   - Movement

6. Scapular elevation
   - *Upper Trapezius, Levator Scapulae*

7. Protraction/retraction of the scapula arm supported on table or lap
   - *Serratus Anterior, Rhomboids Major, Minor, Middle Trapezius*

8. A. Shoulder flex 0°–30°, elbow starts at 90°
   - *Deltoid, Supraspinatus*
   - Movement

9. A. Shoulder 0°, elbow 90°, shoulder internal rotation to abdomen
   - *Subscapularis, Pectoralis Major, Latissimus Dorsi, Teres Major*
   - Movement

10. A. Touch opposite knee
    - *Pectoralis Major, Triceps Brachii, Pronator Group*

**Elbow/Forearm**

1. A. Forearm pronation from midposition shoulder 0°, elbow 90°
   - *Pronator Group*
   - Movement

2. A. Elbow 0°, fully flex
   - *Biceps Brachii, Brachialis, Brachioradialis*
   - Movement

3. Full elbow flexion, extend to 0° (gravity eliminated or against gravity)
   - *Triceps Brachii*
   - Movement

4. Touch opposite shoulder
   - *Deltoid, Rotator Cuff, Pectoralis Major, Biceps*

(Continued)
APPENDIX Continued

**Wrist**
1. Wrist extension with shoulder 0°, elbow 90°, forearm pronated  
   *Extensor Carpi Radialis Longus, Brevis, Extensor Carpi Ulnaris*
2. Wrist flex with shoulder 0°, elbow 90°, forearm supinated  
   *Flexor Carpi Radialis, Flexor Carpi Ulnaris*
3. Wrist circumduction shoulder 0°, elbow 90°, forearm pronated  
   *Extensor Carpi, Radialis, Ulnaris, Flexor Carpi Radialis, Ulnaris*

**Hand**
1. Fingers—mass flexion (fingers to palm)  
   *Flexor Digitorum Superficialis, Profundus, Flexor Digiti Minimi*
2. Fingers—mass extension  
   *Extensor Digitorum, Extensor Indicis, Extensor Digiti Minimi*
3. Hook grasp  
   *Flexor Digitorum Superficialis, Profundus*
4. Intrinsic plus position  
   *Interossei Volar, Dorsal*
5. Thumb adduction  
   *Adductor Pollicis Longus, Abductor Pollicis Brevis*
6. Thumb adduction  
   *Adductor Pollicis*
7. Opposition to base of digit  
   *Opponens Pollicis*
8. A. Opposition to digit 2 (tip pinch)  
7. B. Opposition to digit 3 (tip pinch)  
7. C. Opposition to digit 4 (tip pinch)  
7. **D. Opposition to digit 5 (tip pinch)**  
   *Opponens Pollicis, Flexor Digitorum Superficialis, Profundus, Flexor Pollicis Longus, Interossei*
9. A. Opposition to digit 2 (pad pinch)  
   B. Opposition to digit 3 (pad pinch)  
   C. Opposition to digit 4 (pad pinch)  
   D. Opposition to digit 5 (pad pinch)  
   *Opponens Pollicis, Flexor Pollicis Brevis, Abductor Pollicis Brevis, Flexor Digitorum Superficialis, Profundus, Interossei, Opponens Digitii Minimi*
10. Controlled grasp with soda can grasp, place 2–4 inches away, release  
11. Pincer grasp with pen (sign name, date, or 3 vertical lines)  
12. Lateral pinch with key

**Total movement scale**
REFERENCES