

Investigation of a New Motor Assessment Scale for Stroke Patients

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The purpose of this paper is to present and describe a motor assessment scale (MAS) for stroke patients and to report on the investigation of two aspects of its reliability. The MAS is a brief and easily administered assessment of eight areas of motor function and one item related to muscle tone. Each item is scored on a scale from 0 to 6. To check interrater reliability, we videotaped five stroke patients while they were being assessed with the MAS. These scores were used as the criterion ratings. Twenty raters then assessed these patients, and their results were correlated with the criterion ratings. We determined test-retest reliability by assessing on two occasions, separated by a four-week interval, 14 stroke patients whose recovery was considered to be stable and by correlating these scores. The MAS was found to be highly reliable with an average interrater correlation of .95 and an average test-retest correlation of .98.

Key Words: *Cerebrovascular disorders, Evaluation studies, Motor skills.*

The purpose of this paper is to present a motor assessment scale (MAS) designed to measure the progress of stroke patients and the results of a study to investigate the reliability of this scale in terms of interrater and test-retest reliability.

The MAS was developed by the first two authors over many years, after examining forms of assessment published in the literature.¹⁻¹² These assessments failed to meet certain criteria that the authors considered important in clinical practice. Some assessments can be criticized for being too long and, therefore, too time-consuming in clinical practice^{2, 12}; others lack numerical scoring.^{2, 3, 7} Some assessments are based on an assumption that recovery is initially

characterized by stereotyped movements performed within flexor and extensor synergies, which seem to be inconsistent with the pattern of recovery in stroke patients.^{3, 4} Some are based on a developmental sequence inconsistent with recovery in adults.¹¹ The Barthel Index evaluates independence from the care of an attendant and does not include upper-limb function⁹; some assessments are too global.^{5, 6} Pathy's assessment is carried out by a combined group that includes physician, physical therapist, occupational therapist, speech therapist, social worker, nurse, and specialist health visitor.¹⁰ Few have been investigated for reliability.

The MAS was designed to fulfill the following aims:

1. Be brief and easily administered to avoid interfering unduly with treatment time.
2. Have a high degree of interrater reliability.
3. Provide objective results without the use of expensive equipment.
4. Be written in terms that are clear and easily understandable by other health professionals.
5. Produce a change in score only if the patient's performance has changed.
6. Avoid duplicating information about the patient that is recorded elsewhere.

7. Measure relevant everyday motor activities.
8. Measure the patient's best performance.

The score sheet includes eight different items representing eight areas of motor function and one item related to muscle tone on the affected side (Figure). Each item is scored on a seven-point scale from 0 to 6. The motor functions tested are supine to side lying, supine to sitting over the side of the bed, balanced sitting, sitting to standing, walking, upper-arm function, hand movements, and advanced hand activities. The category of General Tonus was included to gain an impression about the presence of excessive or depressed motor activity.

All items except General Tonus are constructed so that Point 6 indicates the optimal motor behavior. In grading General Tonus, Point 4 indicates a consistently normal response; more than four points indicate persistent hypertonus and less than four points indicate various degrees of hypotonus. A comments section is provided for the examiner to add subjective information that may be considered useful and relevant to the assessment.

Criteria for each point on the MAS are provided to assist the examiners in reliably grading the performance of each

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This work was supported in part by a grant from Cumberland College of Health Sciences.

This article was submitted November 23, 1983; was with the authors for revision 17 weeks; and was accepted August 1, 1984.

MOTOR ASSESSMENT SCALE

NAME _____

MOVEMENT SCORING SHEET

DATE

1. SUPINE TO SIDE LYING
2. SUPINE TO SITTING OVER SIDE OF BED
3. BALANCED SITTING
4. SITTING TO STANDING
5. WALKING
6. UPPER-ARM FUNCTION
7. HAND MOVEMENTS
8. ADVANCED HAND ACTIVITIES
9. GENERAL TONUS

	0	1	2	3	4	5	6

COMMENTS (IF APPLICABLE)

Figure. Scoring sheet for MAS.

item. The criteria for each point consists of a description of the activity to be performed followed by an italicized clarification of details to help the examiner (Appendix 1).

The points within each item in the MAS are based on observations made over many years of the progress of a large number of patients. Some points reflect quality of performance directly (Balanced Sitting, Point 6); others require performance within a specified time. The higher points of certain items reflect quality of performance in an indirect manner (Sitting to Standing, Point 6) because it is impossible to perform incorrectly in such a brief period of time. The General Rules list details of equipment, define terms, and give

guidelines for instruction and feedback and for the general milieu in which the scoring is performed (Appendix 2). Total scoring time is approximately 15 minutes.

Because we believed the MAS could be a useful evaluation tool, we tested its reliability by investigating the scale's interrater reliability and test-retest reliability.

METHOD

Interrater Reliability

We selected a group of five stroke patients, four women and one man at various stages of recovery. The only criterion for selection was the patient's willingness to consent to participate in the study. An attempt was made, how-

ever, to select five patients who were different from each other in terms of time since stroke and obvious degree of disability, so that the full range of possible scores on the MAS would be represented. The group had three patients with left hemiplegia and two patients with right hemiplegia. None of the patients were dysphasic. The average age was 65 years old (range, 55-78 years). The time from onset of stroke to the time of scoring averaged 14 weeks (range, 6-40 weeks). Hemiplegia was due to cerebrovascular lesion in all five patients.

The last author assessed the five patients, and her scores became the criterion ratings. We videotaped the assessment sessions, but the tapes do not indicate what score was assigned to each item. The timed items have a digital display of elapsed time in one corner of the screen.

A group of 20 volunteers (physical therapists and physical therapy undergraduate students) were involved in the study. The physical therapists were all working in stroke rehabilitation, and several were clinical tutors in the School of Physiotherapy, Cumberland College of Health Sciences. The undergraduates were in their final year of a physical therapy educational program. Each volunteer was instructed in the use of the MAS and provided with a copy of the Criteria for Scoring and General Rules. This instruction was followed by a period of about three weeks to practice using the MAS. A questionnaire completed by each rater revealed that the average number of patients scored during this period was four (range, 1-5). After the practice period, we showed the physical therapists and students the videotapes of the five patients and asked them to use the MAS to score each patient's performance. General Tonus, item 9, was not included because this was considered to be too difficult to score from observation alone.

Videotape was used to avoid the following: 1) the variability of patient performance that may occur if several raters scored the one patient on different occasions and 2) the stressful situation that would occur for patients if each were to be scored by 20 raters.

Test-Retest Reliability

A group of 15 stroke patients, 5 women and 10 men, were selected. The

only criteria for selection were the patients' willingness to consent to participate and the stable nature of their disability. Six patients had left hemiplegia and nine patients had right hemiplegia. The degree of disability varied. The rehabilitation team of the Lottie Stewart Rehabilitation Unit considered each patient's recovery to have reached a plateau. The average age of the patients was 70 years (range, 42–85 years). The time from onset of stroke to the time of the first evaluation for the purposes of this study averaged 55 months (range, 5 months–34 years). Hemiplegia was the result of cerebrovascular lesion in all 15 patients.

The last author scored the patients on two occasions separated by a four-week interval. One male patient with left hemiplegia was unable to participate in the retest procedure because of admission to a hospital. The results have therefore been correlated for 14 patients.

Data Analysis

We tabulated the assessments made of the five patients by the 20 raters. Each rater's scores were compared with the criterion ratings. Two different measures of interrater reliability were computed: 1) percentage agreement and 2) Pearson product-moment correlation coefficients.

The last author's assessments of 14 patients on two occasions were correlated using Pearson product-moment correlation to measure test-retest reliability. One correlation was computed on the eight scores made on each patient on the two occasions.

RESULTS

Interrater Reliability

Table 1 summarizes the percentage agreement obtained between each physical therapist's scores and the criterion ratings for each of the five patients. Table 1 also presents average percentage agreement for each rater across the five patients (row means) and average percentage agreement among the 20 raters for each patient (column means). The overall average of these means was 87 percent agreement. This figure represents the average agreement with the criterion ratings.

Table 1 also lists Pearson correlation coefficients. Each rater's scores for the

TABLE 1
Percentage Agreement and Pearson Correlation Coefficients Between Raters' Scores (N = 20) and the Criterion Rating for Patients Assessed (N = 5)

Rater	Patient					\bar{X}	<i>r</i>
	1	2	3	4	5		
1	88	100	100	88	100	95	.97
2	75	88	88	88	88	85	.92
3	75	100	100	63	100	88	.95
4	75	100	100	63	88	85	.94
5	75	75	88	88	100	85	.95
6	88	100	100	75	100	93	.97
7	100	88	100	88	100	95	.99
8	88	100	75	100	88	90	.97
9	88	100	100	88	100	95	.97
10	88	75	88	75	100	85	.95
11	100	88	75	88	88	88	.97
12	88	50	88	100	75	80	.93
13	88	100	100	75	63	85	.95
14	75	100	100	88	88	90	.94
15	75	88	100	100	88	90	.97
16	75	100	63	88	75	80	.98
17	88	88	100	75	88	88	.98
18	75	100	88	88	75	85	.89
19	88	75	88	63	75	78	.91
20	88	88	88	75	88	85	.96
\bar{X}	84	90	91	83	88	87	.95

TABLE 2
Percentages of Raters Agreeing with Criterion Ratings for Eight Scale Items for Five Patients

Scale Item	Patient					\bar{X}
	1	2	3	4	5	
1. Supine to side lying	65	75	75	60	95	74
2. Supine to sitting over side of bed	100	100	100	100	75	95
3. Balanced sitting	100	100	100	100	95	99
4. Sitting to standing	10	80	75	95	80	68
5. Walking	95	85	95	95	60	86
6. Upper-arm function	100	85	85	70	100	88
7. Hand movements	100	85	95	100	95	95
8. Advanced hand activities	100	100	100	40	100	88

five patients (40 scores in all) were correlated with the criterion ratings. The results are presented in the last column of Table 1. The correlations show greater relationship between the rater's scores and the criterion ratings than does the measure of percentage agreement. Percentage agreement is a more stringent measure of consistency because only scores that match exactly on the seven-point scales are considered as agreement. Thus, if rater 1 has scored Walking with a 5 when the criterion is 4, this is a disagreement. The correlation coefficient, however, determines the extent of linear relationship in two sets of scores. Thus, a substantial relationship can be found if the two sets of scores

have general agreement in high and low sections of the scale without complete agreement. Both percentage agreement and correlation coefficients, however, indicate that the MAS can be used reliably by physical therapists after instruction and a short practice period. The average percentage agreement for each patient (column means) shows some variability, but all of the five patients could be assessed reliably. This finding strengthens the claim that the MAS is a reliable instrument.

We investigated the question of whether the amount of practice was related to proficiency in use of the MAS by correlating the number of practice patients and reliability scores (row

means in Tab. 1). This correlation was only .24, indicating that, within the range of one to five (the minimum and maximum number of patients for practice), no significant relationship existed between the number of practice patients and each rater's reliability in matching the criterion ratings. This lack of significance can be interpreted as a positive finding because these results show that high reliability was achieved with only a minimum of practice. The usefulness of the MAS would be increased greatly if extensive training were unnecessary.

Test-Retest Reliability

The test-retest correlations ranged between .87 and 1.00, with an average correlation of .98. Thus, reliability was very satisfactory. The test-retest reliability was somewhat higher than interrater reliability, a common finding in reliability studies. A high test-retest reliability is necessary for the scale to be confidently used to assess a patient's progress. With a reliable scale, a physical therapist has reason to believe that changes in the scores of a particular patient indeed reflect a change in the patient's motor abilities and not just measurement error.

DISCUSSION

Although we found no significant relationship between the number of practice patients and the raters' reliability in the original study, this may not be true for practicing physical therapists in general. They may need to apply the MAS to a larger number of patients to become proficient and accurate in its use. In the past 12 months, the first two authors have led training sessions for both physical therapists and physical therapy undergraduate students (a total of 103) and have compared their reliability with the criterion ratings used in this study. Feedback from this group and their reliability scores suggest that the MAS should be used with at least six patients for an individual to be sufficiently familiar with the criteria to score patients on the videotape with consistent reliability.

We also found it interesting to investigate the various items of the MAS to

APPENDIX 1

Criteria for Scoring

1. Supine to Side Lying onto Intact Side

1. Pulls himself into side lying. (Starting position must be supine lying, not knees flexed. Patient pulls himself into side lying with intact arm, moves affected leg with intact leg.)
2. Moves leg across actively and the lower half of the body follows. (Starting position as above. Arm is left behind.)
3. Arm is lifted across body with other arm. Leg is moved actively and body follows in a block. (Starting position as above.)
4. Moves arm across body actively and the rest of the body follows in a block. (Starting position as above.)
5. Moves arm and leg and rolls to side but overbalances. (Starting position as above. Shoulder protracts and arm flexes forward.)
6. Rolls to side in 3 seconds. (Starting position as above. Must not use hands.)

2. Supine to Sitting over Side of Bed

1. Side lying, lifts head sideways but cannot sit up. (Patient assisted to side lying.)
2. Side lying to sitting over side of bed. (Therapist assists patient with movement. Patient controls head position throughout.)
3. Side lying to sitting over side of bed. (Therapist gives stand-by help [see Appendix 2] by assisting legs over side of bed.)
4. Side lying to sitting over side of bed. (With no stand-by help.)
5. Supine to sitting over side of bed. (With no stand-by help.)
6. Supine to sitting over side of bed within 10 seconds. (With no stand-by help.)

3. Balanced Sitting

1. Sits only with support. (Therapist should assist patient into sitting.)
2. Sits unsupported for 10 seconds. (Without holding on, knees and feet together, feet can be supported on floor.)
3. Sits unsupported with weight well forward and evenly distributed. (Weight should be well forward at the hips, head and thoracic spine extended, weight evenly distributed on both sides.)
4. Sits unsupported, turns head and trunk to look behind. (Feet supported and together on floor. Do not allow legs to abduct or feet to move. Have hands resting on thighs, do not allow hands to move onto plinth.)
5. Sits unsupported, reaches forward to touch floor, and returns to starting position. (Feet supported on floor. Do not allow patient to hold on. Do not allow legs and feet to move, support affected arm if necessary. Hand must touch floor at least 10 cm [4 in] in front of feet.)
6. Sits on stool unsupported, reaches sideways to touch floor, and returns to starting position. (Feet supported on floor. Do not allow patient to hold on. Do not allow legs and feet to move, support affected arm if necessary. Patient must reach sideways not forward.)

4. Sitting to Standing

1. Gets to standing with help from therapist. (Any method.)
2. Gets to standing with stand-by help. (Weight unevenly distributed, uses hands for support.)
3. Gets to standing. (Do not allow uneven weight distribution or help from hands.)
4. Gets to standing and stands for 5 seconds with hips and knees extended. (Do not allow uneven weight distribution.)
5. Sitting to standing to sitting with no stand-by help. (Do not allow uneven weight distribution. Full extension of hips and knees.)
6. Sitting to standing to sitting with no stand-by help three times in 10 seconds. (Do not allow uneven weight distribution.)

5. Walking

1. Stands on affected leg and steps forward with other leg. (Weight-bearing hip must be extended. Therapist may give stand-by help.)
2. Walks with stand-by help from one person.
3. Walks 3 m (10 ft) alone or uses any aid but no stand-by help.
4. Walks 5 m (16 ft) with no aid in 15 seconds.
5. Walks 10 m (33 ft) with no aid, turns around, picks up a small sandbag from floor, and walks back in 25 seconds. (May use either hand.)

determine whether any one was more reliable or less reliable than the others. Table 2 has been compiled for this purpose. Table 2 presents the percentage of raters who agree with the criterion ratings for each of the eight items and five

patients. Note that item 3 (Balanced Sitting) of the MAS had the highest degree of consistency and that item 4 (Sitting to Standing) had the lowest. This low score was attributable to poor results with one patient. Some raters com-

Appendix 1 Criteria for Scoring—continued

6. Walks up and down four steps with or without an aid but without holding on to the rail three times in 35 seconds.

6. Upper-Arm Function

1. Lying, protract shoulder girdle with arm in elevation. (Therapist places arm in position and supports it with elbow in extension.)
2. Lying, hold extended arm in elevation for 2 seconds. (Physical therapist should place arm in position and patient must maintain position with some external rotation. Elbow must be held within 20° of full extension.)
3. Flexion and extension of elbow to take palm to forehead with arm as in 2. (Therapist may assist supination of forearm.)
4. Sitting, hold extended arm in forward flexion at 90 degrees to body for 2 seconds. (Therapist should place arm in position and patient must maintain position with some external rotation and elbow extension. Do not allow excess shoulder elevation.)
5. Sitting, patient lifts arm to above position, holds it there for 10 seconds, and then lowers it. (Patient must maintain position with some external rotation. Do not allow pronation.)
6. Standing, hand against wall. Maintain arm position while turning body toward wall. (Have arm abducted to 90° with palm flat against the wall.)

7. Hand Movements

1. Sitting, extension of wrist. (Therapist should have patient sitting at a table with forearm resting on the table. Therapist places cylindrical object in palm of patient's hand. Patient is asked to lift object off the table by extending the wrist. Do not allow elbow flexion.)
2. Sitting, radial deviation of wrist. (Therapist should place forearm in midpronation-supination, ie, resting on ulnar side, thumb in line with forearm and wrist in extension, fingers around a cylindrical object. Patient is asked to lift hand off table. Do not allow elbow flexion or pronation.)
3. Sitting, elbow into side, pronation and supination. (Elbow unsupported and at a right angle. Three-quarter range is acceptable.)
4. Reach forward, pick up large ball of 14-cm (5-in) diameter with both hands and put it down. (Ball should be on table so far in front of patient that he has to extend arms fully to reach it. Shoulders must be protracted, elbows extended, wrist neutral or extended. Palms should be kept in contact with the ball.)
5. Pick up a polystyrene cup from table and put it on table across other side of body. (Do not allow alteration in shape of cup.)
6. Continuous opposition of thumb and each finger more than 14 times in 10 seconds. (Each finger in turn taps the thumb, starting with index finger. Do not allow thumb to slide from one finger to the other, or to go backwards.)

8. Advanced Hand Activities

1. Picking up the top of a pen and putting it down again. (Patient stretches arm forward, picks up pen top, releases it on table close to body.)
2. Picking up one jellybean from a cup and placing it in another cup. (Teacup contains eight jellybeans. Both cups must be at arms' length. Left hand takes jellybean from cup on right and releases it in cup on left.)
3. Drawing horizontal lines to stop at a vertical line 10 times in 20 seconds. (At least five lines must touch and stop at the vertical line.)
4. Holding a pencil, making rapid consecutive dots on a sheet of paper. (Patient must do at least 2 dots a second for 5 seconds. Patient picks pencil up and positions it without assistance. Patient must hold pen as for writing. Patient must make a dot not a stroke.)
5. Taking a dessert spoon of liquid to the mouth. (Do not allow head to lower towards spoon. Do not allow liquid to spill.)
6. Holding a comb and combing hair at back of head.

9. General Tonus

1. Flaccid, limp, no resistance when body parts are handled.
 2. Some response felt as body parts are moved.
 3. Variable, sometimes flaccid, sometimes good tone, sometimes hypertonic.
 4. Consistently normal response.
 5. Hypertonic 50 percent of the time.
 6. Hypertonic at all times.
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mented that they had difficulty observing this patient's distribution of weight when she stood up. A major reason for this was the position of either the camera or the examiner at the crucial stage in the testing of this item for this patient.

Experience with the MAS, both during this study and subsequently, indicates that certain minor changes may make it a more useful measurement tool. For example, Point 5 in Balanced Sitting requires clarification of height of

the stool in relation to knee-joint angle.

We have found the MAS to be useful for providing feedback to the patient on his progress, and it can be used to motivate him toward recovery. Two questionnaires are being designed to investigate whether progress measured by the MAS relates to the physical therapist's and patient's subjective impressions of progress.

CONCLUSION

We have developed this MAS for stroke patients and investigated it for reliability. This scale has been found to be highly reliable and its validity and usefulness in measuring the progress of patients in physical therapy should be investigated. Because the reliability of each individual rater is considered an essential factor in the use of this scale, we recommend that physical therapists intending to use the MAS should become familiar with the criteria for scoring by testing at least six patients before formally using it in clinical practice.

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APPENDIX 2
General Rules for Administering the MAS

1. The test should preferably be carried out in a quiet private room or curtained-off area.
 2. The test should be carried out when patient is maximally alert. For example, not when he is under the influence of hypnotic or sedative drugs. Record should be made if patient is under the influence of one of these drugs.
 3. Patient should be dressed in suitable street clothes with sleeves rolled up and without shoes and socks. Items 1 to 3 inclusive may be scored if necessary with patient in his night clothes.
 4. Each item is recorded on a scale of 0 to 6.
 5. All items are to be performed independently by the patient unless otherwise stated. "Stand-by help" means that the physical therapist stands by and may steady the patient but must not actively assist.
 6. Items 1 to 8 are recorded according to the patient's responses to specific instructions. General Tonus, item 9, is scored from continuous observations and handling throughout the assessment.
 7. Patient should be scored on his best performance. Repeat three times unless other specific instructions are stated.
 8. Because the scale is designed to score patient's best performance, the physical therapist should give general encouragement but should not give specific feedback on whether response is correct or incorrect. Sensitivity to the patient is necessary to enable him to produce his best performance.
 9. Instructions should be repeated and demonstrations given to patient if necessary.
 10. The order of administration of items 1 to 9 can be varied according to convenience.
 11. If patient becomes emotionally labile at any stage during scoring, the physical therapist should wait 15 seconds before attempting the following procedures:
 - (1) ask the patient to close his mouth and take a deep breath;
 - (2) hold patient's jaw closed and ask the patient to stop crying.If patient is unable to control behavior, the examiner should cease testing him, and rescore this item and any other items unscored at a more suitable time.
 12. If performance is scored differently on left and right side, the physical therapist may indicate this with a L in one box and R in another box.
 13. The patient should be informed when he is being timed.
 14. You will need the following equipment: a low wide plinth, a stopwatch, a polystyrene cup, eight jellybeans, two teacups, a rubber ball approximately 14-cm (5-in) diameter, a stool, a comb, a top of a pen, a table, a dessert spoon and water, a pen, a prepared sheet for drawing lines, and a cylindrical object such as a jar.
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