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Assessing motor impairment after stroke: a pilot reliability study

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Abstract

Two short tests of motor function, the Motricity Index (MI) and the Trunk Control Test (TCT), were assessed at regular intervals after stroke and compared with a detailed physiotherapy test, the Rivermead Motor Assessment (RMA). The MI and TCT were valid and reliable tests which were usually quicker to perform than the RMA. The TCT was of predictive value when related to eventual walking ability. All three tests appeared to be of equal sensitivity in detecting change.

Motor impairment after stroke is often not adequately described or recorded in medical notes, contrasting with the detailed assessments performed by physiotherapists who have developed many useful but often lengthy tests, some of which can require hours of training before a physiotherapist is competent in their use. The results of these tests are often not easily communicated to other professionals who are rarely familiar with the test procedure. There is a need for short simple validated motor assessments which can be performed repeatedly by doctors and others to monitor clinical progress, to evaluate interventions, and to use in research in rehabilitation medicine. This study was performed to investigate and validate two such tests.

The tests available at present which have been investigated for reliability and validity include the Motor Club Assessment,[1] derived from tests developed at Northwick Park hospital;[2] and the Rivermead Motor Assessment.[3] In practice most doctors use the Medical Research Council (MRC) grades which were initially devised for use with peripheral nerve injuries.[4]

This study investigated the validity and reliability of the Motricity Index[5] which has been used in stroke research,[6] and investigated the validity and reliability of a new test of trunk control.

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Method

Tests

A slightly modified Motricity Index (MI)[5] was developed (and named) in Belgium. The Trunk Control Test (TCT) was derived from the Northwick Park Motor Assessment.[2] The Rivermead Motor Assessment[3] was used to validate these two tests. It is a physiotherapy measure developed in 1979 by Lincoln and Leadbitter using a cumulative model known as the Guttman scale, based on the assumption that stroke patients follow a consistent pattern of recovery. It measures gross motor function, upper limb abilities, lower limb abilities and trunk control.

Twelve female and twenty four male patients were included in the study. The age range of the male patients was 15–77 years (mean 56·1 years) and twelve had right hemiplegia. The age range of the women was 45–69 years (mean 59·9 years) and nine had right hemiplegia. Of the thirty patients, eight had three assessments, eleven had two assessments and seventeen had only one assessment.

The Motricity Index

This test gives a rapid overall indication of a patient's limb impairment.[5] In the original study thirty one movements at proximal, middle and distal joints of arms and legs were measured 11 days, two months, four months and six months after a cerebrovascular accident in 100 consecutive hemiplegic patients admitted to hospital. Using a technique of analysis into principal components (Hotelling's method), the large number of movement studies was reduced to one movement at each joint which represented the general strength of movement at the joint. In the study, MRC grades were used to measure the movement at each joint with the restriction that a grade 2 should be awarded to any incomplete movement. This is explained in detail in the guidelines. The MRC grades were then converted into weighted scores by comparing the difficulty experienced by patients progressing from one MRC grade to the next with the total difficulty experienced in progressing from MRC grade 0 to MRC grade 5. A double entry table was used to permit this calculation.

No guidelines were published in the original study. The following guidelines were used by the doctors assessing patients in this study: the patient should be sitting in a chair or on the edge of the bed, but can be tested lying supine if necessary. In the arm the three movements tested are pinch grip, elbow flexion, and shoulder abduction. In the leg the three movements tested are ankle dorsiflexion, knee extension, and hip flexion.

Pinch grip is assessed by asking the patient to grip a 2·5 cm cube between the thumb and forefinger. The object should be on a flat surface (for example, a book). The tester scores

contraction of any forearm or small hand muscles as follows:

0 No movement.
11 Beginnings of prehension (any movement of finger or thumb).
19 Able to grip the cube, but not hold it against gravity (examiner may need to lift wrist).
22 Able to grip and hold the cube against gravity, but not against a weak pull.
26 Able to grip and hold the cube against a weak pull, but weaker than the other side.
33 Normal pinch grip.

For the other five movements a uniform scoring system very similar to the MRC grades as used:

0 No movement.
9 Palpable contraction in muscle, but no movement.
14 Visible movement, but not full range and not against gravity.
19 Full range of movement against gravity but not against resistance.
25 Full movement against resistance, but weaker than the other side.
33 Normal power.

The elbow is tested with the elbow flexed to 90°, forearm horizontal and upper arm vertical. The patient is asked to bend the elbow so that the hand touches the shoulder. The examiner resists with a hand on the wrist, and monitors the *biceps*. If there is no movement, the examiner may hold the elbow out so that the arm is horizontal, and give a score of 14 if movement is then seen.

Shoulder abduction. The elbow is fully flexed and against the chest and the patient asked to abduct the arm. The examiner monitors contraction of the *deltoid* (movement of shoulder girdle does not count—there must be movement of humerus in relation to scapula). A score of 19 is given when the shoulder is abducted to more than 90° beyond the horizontal against gravity but not against resistance.

Ankle dorsiflexion is tested with the foot relaxed in a plantar flexed position. The patient is asked to dorsiflex the foot ("As if standing on your heels."), and the examiner monitors the *tibialis anterior*. A score of 14 is given when there is less than a full range of dorsiflexion.

Knee extension is tested with the foot unsupported, and the knee at 90°. The patient is asked to extend the knee to touch the examiner's hand held level with the knee, and the examiner monitors contraction of the *quadriceps*. A score of 14 is given for less than 50% of full extension (that is, 45° only), and a score of 19 when the knee is fully extended, but easily pushed down.

Hip flexion is tested with the hip bent at 90°. The patient is asked to lift the knee towards the chin, and the examiner checks for the associated (trick) movement of leaning back by placing the hand behind the back and asking the patient not to lean back. The examiner than monitors contraction of *ilio-psoas/rectus femoris (anterior thigh)*. A score of 14 is given for less than a full range of possible flexion (check passive movement), and a score of 19 when the hip is fully flexed, but easily pushed down.

The total "arm score" is the addition of the scores for tests 1–3; the total "leg score" is the addition of score for tests 4–6; and the total "side score" is the addition of the arm and leg scores, divided by two. One point may be added to each limb score so that the top score is 100%.

The Trunk Control Test (TCT)

Trunk control after stroke is an important predictive feature related to the level of eventual recovery.[6] The TCT examines four simple aspects of trunk movement. The patient lies supine on the bed and is asked to roll to the weak side, roll to the strong side, sit up from lying down, and sit in a balanced position on the edge of the bed, with the feet off the ground for a minimum of 30 seconds.

The scoring has arbitrary weights, and is as follows:

0 unable to perform movement without assistance;
12 able to perform movement, but in an abnormal style, for example, pulls on bed clothes, rope or monkey pole, or uses arms to steady self when sitting;
25 able to complete movement normally.

For sitting balance, a patient scores 12 if they need to touch anything with their hands to stay upright, and 0 if they are unable to stay up (by any means) for 30 seconds.

The TCT score is the simple addition of the scores obtained on the four tests.

A summary of the tests and scoring is provided in table 1.

Design

Patients recovering from stroke were assessed at six weeks, 12 weeks and 18 weeks post stroke using the three described tests. They were inpatients at a neuro-rehabilitation unit and were frequently discharged before 18 weeks, in which case they were not recalled for testing. Consequently the number of patients varies from time to time.

Two doctors, one senior (CC) and one junior, who were blind to each others results, performed the MI and the TCT, and recorded their results separately. The junior doctors involved in the study received a copy of the guidelines and were given a demonstration of the tests and scoring. A physiotherapist recorded the Rivermead Motor Assessment on each patient. All assessments were performed within five days of each other on each patient. The times taken to perform the MI and TCT were recorded.

Inter-rater reliability for Motricity Index and Trunk Control Test was measured using the results of the six week assessments on 20 patients. Comparability of the Rivermead Motor Assessment with the Motricity Index and the Trunk Control Test was measured by calculating rank order comparisons using Spearman's rho.

The sensitivity of each test (RMA, 3 components; MI, arm and leg; TCT, total) to change was assessed by looking at paired assessments, six weeks apart, and checking whether they recorded change in the same

Table 1

NAME	
DATE OF ASSESSMENT	DATE OF ADMISSION
DATE OF EVENT	DATE OF BIRTH
DIAGNOSIS	

MOTRICITY INDEX

ARM	RIGHT MRC	RIGHT MOT	LEFT MRC	LEFT MOT
1 Pinch grip				
2 Elbow flexion (from 90°)				
3 Shoulder abduction				
LEG				
4 Ankle dorsiflexion				
5 Knee extension				
6 Hip flexion				
ARM SCORE [1 + 2 + 3] + 1				
LEG SCORE [4 + 5 + 6] + 1				
SIDE SCORE [Arm and leg] / 2				

SCORING

MRC GRADES	MOTRICITY SCORES		
	MRC	Test 1	Test 2–6
0 No movement	0	0	0
1 Palpable flicker	1	11	9
2 Movement without gravity	2	19	14
3 Movement against gravity	3	22	19
4 Movement against resistence	4	26	25
5 Normal	5	33	33

TRUNK CONTROL ASSESSMENT

TESTS (On bed)		SCORING
1 Rolling to weak side		0 – Unable to 12 – Able to do with non-muscular help 25 – Normal
2 Rolling to strong side		
3 Balance in sitting position		
4 Sitting up from lying down		

TRUNK SCORE [1 + 2 + 3 + 4] =

direction or not. The quantity of change was not compared.

Results at six weeks were compared with walking ability at 18 weeks to determine the predictive value of each test. Walking independently was defined as the ability to walk 10 metres without assistance.

Results

It took less than five minutes each to perform the MI and TCT. The paired medical assessments of the MI and TCT were strongly correlated and neither assessor's results showed any significant bias (table 2).

Table 3 summarises the results of the ranked correlations between MI arm and RMA arm scores, between MI leg and RMA leg scores, and between TCT and RMA gross function (GF) scores. The results showed strong correlations between the Rivermead Motor Assessment and the two short tests of motor function. There was a smaller number of assessments performed at 18 weeks which explains the two lower p values.

A scatterplot (fig 1) was constructed as an alternative method of showing the correlation between the RMA and the Motricity Index. This shows an excellent correlation for milder levels of motor impairment but reveals some rank sharing on the RMA for more severe levels of motor impairment which could be regarded as a floor effect.

Inspection of paired observations revealed that in 23 out of 29 there was agreement between all three tests in the direction of change recorded. In the remaining six there was no consistent pattern of disagreement.

Nineteen of the 27 patients seen at six weeks after stroke were not walking independently. Poor performance on all three tests at six weeks was associated with failure to walk by 18 weeks (fig 2). However, the TCT allowed the most clear cut distinction, with scores of 50 or more

Table 2 Interrater reliability of Motricity Index and Trunk Control Test (n = 20)

	Observer 1 Mean (SD)	*Observer 2 Mean (SD)*	*Spearman rho*
MI arm	30 (36)	31 (39)	0·88 ($p < 0·001$)
MI leg	53 (20)	55 (22)	0·87 ($p < 0·001$)
MI side	41 (26)	43 (28)	0·88 ($p < 0·001$)
TCT	66 (28)	63 (23)	0·76 ($p < 0·001$)

Table 3 Rank order comparisons (Rho) of MI/TCT scores and RMA scores

Weeks post-stroke	*RMA arm v MI arm*	*RMA leg v MI leg*	*RMA GF v TCT*
6 (n = 27)	0·76**	0·81**	0·70**
12 (n = 25)	0·73**	0·81**	0·72**
18 (n = 14)	0·74*	0·75*	0·79**

**= $p < 0.001$; *= $p < 0.01$.

being associated with recovery of walking whereas patients scoring under 40 failed to do so. There were only two patients scoring 41–49.

Discussion

In this study two simple tests of motor impairment have been shown to be short and reliable when used by different observers, and to correlate highly with a longer and more detailed assessment of motor impairment performed by physiotherapists. The RMA takes up to 40 minutes to complete.[3] The MI and the TCT, when used by doctors given the guidelines shown in the Methods section and one demonstration, have therefore been shown to be valid and reliable tests of motor loss after stroke. However, only a relatively small number of patients were studied, and thus some of the conclusions need further confirmation.

All the tests used appear to detect change equally after stroke, but further studies are needed to delineate the relative sensitivity of the various tests. One problem in the analysis of arm results was the number of arms which failed to recover at all, which is a common feature in stroke patients.[7]

Predictive validity was confirmed in this small group. As expected the TCT score was predictive of eventual outcome, confirming previous studies which found sitting balance to be important. In this study, scoring 50 or more on the Trunk Control Test at six weeks was predictive of recovery of walking ability by 18 weeks. The other two tests also had predictive validity but were ambiguous over a wider score range.

There can be little doubt that the Motricity Index and Trunk Control Test are valid measures of motor impairment after stroke. Previous studies have shown close correlations between MI scores and survival,[6] the presence of dysphagia,[8] the level of arm function,[9] walking ability[6] and Barthel ADL index scores.[6] This study shows close correlation with another measure of motor loss, the RMA, and confirms the predictive validity of the TCT.

There are several advantages of the MI and the TCT when assessing motor loss after stroke. The tests are short, easily applied on the ward, do not require any special training, are easily communicated and can be incorporated into normal neurological examination procedures especially as they are based on the MRC system of grading motor power. They may be as sensitive to gross change as the more detailed RMA, though this needs further study because the RMA looks at the type (quality) of movement.

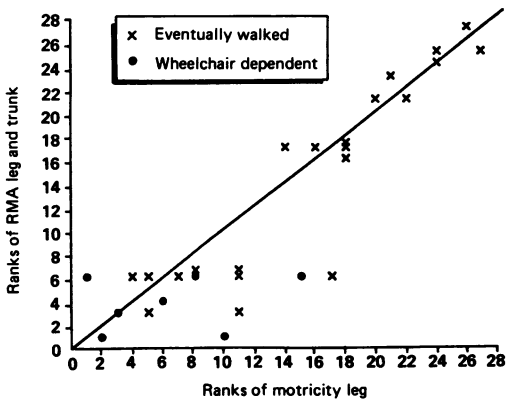

Figure 1 Scatterplot of RMA leg and trunk scores against MI scores.

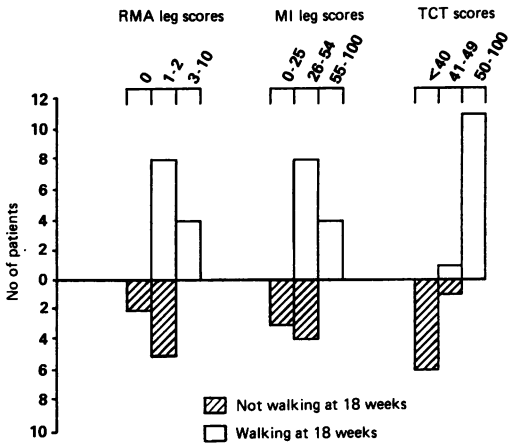

Figure 2 Histogram of mobility at 18 weeks according to motor scores at six weeks.

There are limitations to the MI and the TCT. They are not useful in planning physiotherapy treatment as they give no information on quality of performance. They are probably not sensitive to minor changes, although in this study the much longer RMA did not seem any more sensitive. Measuring power directly may offer a good quick and more sensitive measure.[10] The MI and TCT do not take into account other associated phenomena such as spasticity, sensory loss or apraxia. Other assessments do include spasticity[11] but this may be a disadvantage because it complicates interpretation. Specific measures of spasticity are available if required.[12]

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