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Clinimetric Properties of the Motor Activity Log for the Assessment of Arm Use in Hemiparetic Patients

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Background and Purpose—The Motor Activity Log (MAL) is a semistructured interview for hemiparetic stroke patients to assess the use of their paretic arm and hand (amount of use [AOU]) and quality of movement [QOM]) during activities of daily living. Scores range from 0 to 5. The following clinimetric properties of the MAL were quantified: internal consistency (Cronbach α), test–retest agreement (Bland and Altman method), cross-sectional construct validity (correlation between AOU and QOM and with the Action Research Arm [ARA] test), longitudinal construct validity (correlation of change on the MAL during the intervention with a global change rating [GCR] and with change on the ARA), and responsiveness (effect size).

Methods—Two baseline measurements 2 weeks apart and 1 follow-up measurement immediately after 2 weeks of intensive exercise therapy either with or without immobilization of the unimpaired arm (forced use) were performed in 56 chronic stroke patients.

Results—Internal consistency was high (AOU: α=0.88; QOM: α=0.91). The limits of agreement were −0.70 to 0.85 and −0.61 to 0.71 for AOU and QOM, respectively. The correlation with the ARA score (Spearman ρ) was 0.63 (AOU and QOM). However, the improvement on the MAL during the intervention was only weakly related to the GCR and to the improvement on the ARA, Spearman ρ was between 0.16 and 0.22. The responsiveness ratio was 1.9 (AOU) and 2.0 (QOM).

Conclusion—The MAL is internally consistent and relatively stable in chronic stroke patients not undergoing an intervention. The cross-sectional construct validity of the MAL is reasonable, but the results raise doubt about its longitudinal construct validity. **(*Stroke*. 2004;35:1410-1414.)**

Key Words: rehabilitation ■ disability evaluation ■ outcome assessment

Constraint-induced movement therapy (CIMT) is a type of treatment for hemiparetic stroke patients, in which patients are strongly encouraged to use the affected arm.[1] The purpose of this treatment is to overcome the "learned nonuse" of the affected arm. Learned nonuse is hypothesized to result from a psychological process in which attempts to use the affected arm during the acute and subacute stages after stroke are "punished" by failure.[2] Overcoming learned nonuse is meant to result in enhanced quantity and quality of the partaking of the affected arm in activities of daily living. The Motor Activity Log (MAL) was developed to measure this improvement.[3] Most researchers investigating the effect of CIMT use additional outcome measures other than the MAL, such as the Wolf Motor Function Test,[4] the Arm Motor Activity Test,[5] the Fugl-Meyer Assessment scale,[6] or the Action Research Arm test,[7] which are all performance measures. The MAL consists of a semi-structured interview for the patient to assess the use of the paretic arm and hand during activities of daily living. Two scores are given for each activity, 1 for the amount of use (AOU) and 1 for the quality of movement (QOM) of the paretic arm. The questions concern activities performed during the past week or, occasionally, the past year.[3] After an initial screening question to verify that the activity at issue has been performed during the time-frame at issue, the patient is asked how much the affected arm participated in this activity. Possible scores range from 0 (never use the affected arm for this activity) to 5 (always use the affected arm for this activity). To measure QOM, the patient is asked how well the affected arm helped during this activity. Possible scores range from 0 (inability to use the affected arm for this activity) to 5 (ability to use the affected arm for this activity just as well as before the stroke).

Since the MAL was first mentioned in a publication,[3] it has been used in a number of studies investigating the effect of CIMT.[8–14] However, no study in which the clinimetric properties of the MAL were investigated has yet been published. Moreover, the number of activities measured and the way the instrument is applied varies between studies. Different publications report on 14,[3] 20,[8] 26,[10] or 30 activities.[11] In some studies, all the questions on the MAL were

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addressed during 1 interview;[10] but in other studies, the MAL was divided into 2 parts, and each part was filled in every other day on alternating days during the treatment.[9] In most studies, all the questions concerned the affected arm and hand, but in 1 study 5 of the 20 items concerned the unaffected arm, which served as a type of control or index for comparison.[14] Apart from the variation in the number of activities and the way in which the interview is performed, the sum score is also calculated differently by various authors. Several authors present the number of activities in which the affected hand participated, either in addition to or instead of the overall sum score of the AOU on all activities that have been performed.[3,11,13] Claims of good internal consistency,[15] test–retest reliability,[11] and inter-rater reliability[16] are not supported by published data, which might enable other researchers to estimate their value.

If a measuring instrument is to be used as a primary outcome measure in clinical studies, its internal consistency, reproducibility, and validity must be satisfactory, and its responsiveness must be sufficient to detect changes that are considered to be clinically relevant. From the literature reviewed, there seems to be no consensus about the content of the MAL, how to apply it, or how to calculate a sum score.

In a randomized controlled trial performed in the Netherlands to investigate the effect of forced use (one of the possible approaches in CIMT) in chronic stroke patients,[10] a translated and adapted version of the MAL developed by Taub et al[3] was used as an outcome measure. The aim of the present validation study is to determine the internal consistency, test–retest agreement, cross-sectional and longitudinal construct validity, and responsiveness of this instrument.

Patients and Methods

In the randomized controlled trial reported in detail elsewhere,[10] 66 patients participated. The most relevant inclusion criteria were: (1) a history of a single stroke, at least 1 year previously, resulting in a hemiparesis on the dominant side; (2) Action Research Arm (ARA) test score at intake <51 (maximum score: 57); (3) no severe aphasia (score $>$P50 on the Stichting Afasie Nederland (SAN) test[17]); and (4) Mini Mental State Examination score of ≥ 22.[18] The protocol was approved by the University Medical Center Ethics Committee, and all patients gave written informed consent.

Design

Two baseline measurements were performed, with a 2-week interval before the intervention. The study population was considered to be stable during the period between these 2 measurements because the patients were all in the chronic poststroke phase.[19] The experimental intervention, consisting of immobilization of the unaffected arm by means of a splint and sling, combined with intensive training of the affected arm (6 hours per day, 5 days per week, 2 weeks) was compared with an equally intensive reference intervention of bimanual training.[10] A follow-up measurement took place within 1 week after the 2-week intervention period. Patients in both intervention groups improved, although a differential treatment effect was found.[10] At all 3 measurements, the MAL was filled in and the ARA test was performed. At the end of the intervention period, the patients reported the change in arm and hand function on a global change rating (GCR) scale.

Measurement Instruments

A translated and adapted version of the MAL was used,[3] which contains the 14 original activities, 11 additional activities, and 1 optional activity chosen by the patient. The list of activities and the rating procedure are shown in the Appendix. The purpose of adding activities to the original MAL was to try to make it more responsive. The minimal clinically important difference (MCID) was arbitrarily set at 10% of the range of the scale, ie, 0.5 points.[10]

The ARA test is a performance test in which the ability to perform gross movements and the ability to grasp, move, and release objects differing in size, weight, and shape is tested.[7] The original test consisted of 19 items, rated on a 4-point ordinal scale (0 to 3). By removing 4 items, a hierarchical 1-dimensional scale was constructed.[20] Adding the 15 item scores together yields a sum score that ranges from 0 (none of the movements can be performed) to 45 (all movements are performed without difficulty). The ARA test has been shown to be valid, reliable, and responsive.[21–23]

At the end of the treatment period, the patients filled in a short questionnaire to evaluate their treatment and compliance. One of the questions was a GCR and was phrased, "Compared with 2 weeks ago, the functioning of my arm and hand is. . . ". The response categories were "much worse," "worse," "somewhat worse," "not better, not worse," "somewhat better," "better," and "much better."

Statistical Analysis

Although all analyses were performed for the original MAL (14 activities) and for the adapted MAL (26 activities), only the results of the original version are presented here. The internal consistency of the MAL during the first baseline measurement was assessed by means of Cronbach α,[24] at first based on the original data and then also after substitution of missing values for the activities that had not been performed by the patient during the past week with corrected item means.[25,26] For all other analyses, data were complete for 56 subjects. The Bland and Altman method was used to evaluate the test–retest agreement during the baseline period.[27] The upper and lower limits of agreement represent the "error thresholds." Assuming a normal distribution of the differences, only slightly $>$95% of the differences between the 2 measurements per individual in a stable population will be between these limits.[27] The cross-sectional construct validity was assessed by correlation of the first baseline AOU and QOM scores with each other and with the first baseline ARA score. The longitudinal construct validity was assessed by correlation of the change in score during the intervention (both intervention groups) with the change measured by different instruments (ie, change on the ARA and the GCR), and by comparing the change during the intervention with the change in the stable baseline period (responsiveness ratio). The responsiveness ratio was calculated as the ratio of the mean change after the intervention and the standard deviation of the mean change during the baseline period.[28] It can be interpreted as the ability of the instrument to detect a change expressed as an effect size normalized for the variability in a stable population. A greater responsiveness ratio in the 26-item version compared with the 14-item version would justify the use of this extended version.

Results

Of the 66 patients who entered the study, 62 completed the treatment. One week follow-up measurements were obtained from 61 patients.[10] Data on the GCR were missing for 5 cases, because of organizational error. The results presented here are based on the data from 56 patients. The baseline characteristics of these patients are shown in Table 1.

Several patients reported that they had not performed a number of activities on the MAL during the past week. The internal consistency of the MAL, assessed by Cronbach α on the data of the 29 patients who had performed all 14 activities, was 0.88 and 0.91 for the AOU and QOM scales, respectively. After substitution of the missing values for the activities that had not been performed with corrected item means, Cronbach α was 0.87 and 0.90 for the AOU and QOM scales, respectively (n=56).

TABLE 1. Baseline Characteristics of the 56 Chronic Stroke Patients Included in the Study

Median age (interquartile range)	61 (52–66)
Median years since stroke (interquartile range)	3.2 (2.1–5.1)
Females (%)	24 (43)
Diagnosis of hemorrhage (%)	13 (23)
Left-sided hemiparesis (%)	10 (18)
Sensory disorders present (%)	24 (43)
Hemineglect present (%)	5 (9)
Median baseline* ARA† score (interquartile range)	30.0 (18.6–32.9)
Median baseline* MAL AOU‡ score (interquartile range)	1.45 (0.82–2.33)
Median baseline* MAL QOM§ score (interquartile range)	1.21 (0.70–1.70)

*Mean of both baseline measurements per patient.
†ARA, Action Research Arm test, possible range 0–45.
‡MAL AOU, MAL amount of use scale, possible range 0–5.
§MAL QOM, MAL quality of movement scale, possible range 0–5.

The Bland and Altman plots illustrating the test–retest agreement are shown in Figures 1 and 2.

The means and standard deviations of the MAL AOU and QOM scores at the 3 measurement points are shown in Table 2. The mean differences between the 2 baseline measurements did not differ significantly from 0, and the limits of agreement were ≈12% to 15% of the range of the scale. Any difference that is between these limits is likely to be caused by "noise" or measurement error.

Spearman rank correlation coefficient between the AOU and QOM scores at the first baseline measurement was 0.95 ($P<0.001$); between the MAL and the ARA, the Spearman ρ was 0.63 ($P<0.001$) for the AOU and QOM scores. The correlation between the change on the MAL and the change on the ARA during the treatment period was weak and not statistically significant (Spearman $\rho=0.16$ and $P=0.23$ for the AOU scale; $\rho=0.16$ and $P=0.25$ for the QOM scale). Irrespective of the type of treatment they received, virtually all patients expressed a positive opinion about the effects of their treatment, which is evident from their GCR answers. None of the patients chose any of the "worse" categories. Two patients reported that their arm and hand function had not changed, 23 stated that it was "somewhat better," 26 felt that it was "better," and 5 patients considered their arm and hand function to be "much better" than before the intervention. There was a weak and nonsignificant correlation between the change score on the MAL during treatment and the GCR (Spearman $\rho=0.20$ and $P=0.15$ for the AOU scale; Spearman $\rho=0.22$ and $P=0.10$ for the QOM scale). The responsiveness ratio is also shown in Table 2.

The analyses of the adapted MAL containing 26 activities (data not shown) showed remarkably similar results. Becaue the aim of adding activities was to improve the responsiveness of the instrument, the responsiveness ratio was the most interesting parameter. This was 1.7 and 2.0 for the AOU and QOM, respectively.

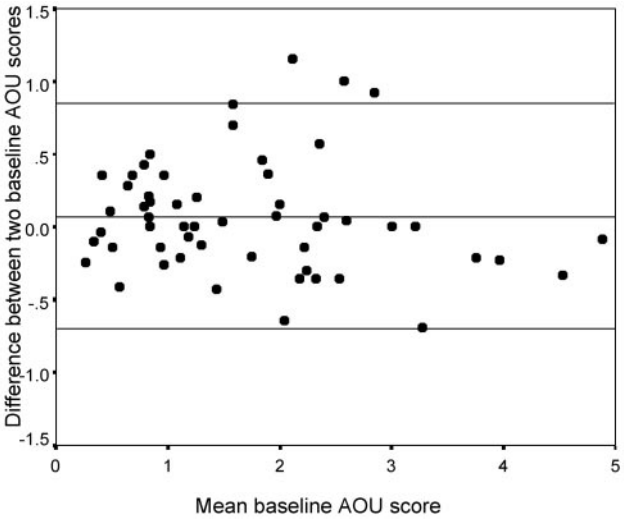

Figure 1. Scatter-plot of the difference between the 2 baseline MAL AOU scores and the mean baseline score per individual. The horizontal lines indicate the mean difference (middle) and the upper and lower limits of agreement.

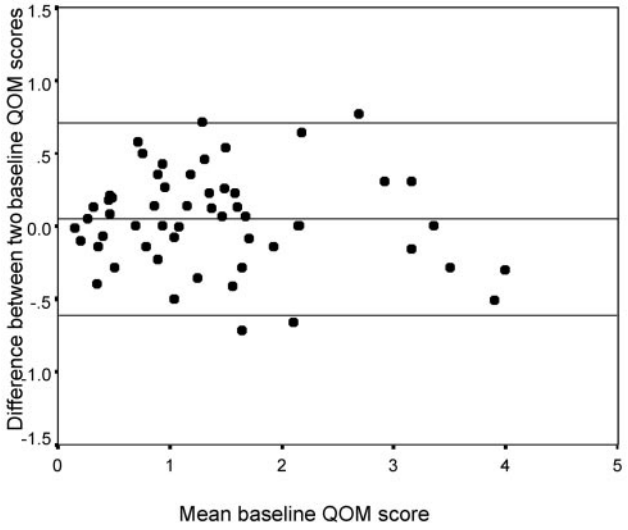

Figure 2. Scatter-plot of the difference between the 2 baseline MAL QOM scores and the mean baseline score per individual. The horizontal lines indicate the mean difference (middle) and the upper and lower limits of agreement.

TABLE 2. Means and Standard Deviations (SD) of MAL Amount of Use (AOU) and Quality of Movement (QOM) Scores at 3 Subsequent Measurement Points and of Differences Between these Measurements. Limits of Agreement, Responsiveness Ratios (n=56)

	MAL AOU		MAL QOM	
	Mean	SD	Mean	SD
Baseline 1	1.66	1.12	1.37	1.00
Change during baseline	0.07	0.39	0.05	0.33
Baseline 2	1.73	1.07	1.42	0.96
Change during intervention	0.76	0.62	0.66	0.62
Follow-up	2.48	1.15	2.08	1.04
Limits of agreement*	−0.70 to 0.85		−0.61 to 0.71	
Responsiveness ratio†	1.9		2.0	

*Mean difference baseline ±2 SD difference baseline.
†Responsiveness ratio = (mean change during intervention) divided by (standard deviation of change baseline).

Discussion

Contrary to what is suggested in the literature, the standard MAL does not exist. As described in the introduction, different questions are posed to patients in different ways by different authors who present their findings on the MAL. However, considering the good internal consistency, the choice of activities included in the interview may not be of crucial importance. This is supported by the similarity of the results presented here for the original version containing 14 activities and the adapted version containing 26 activities.

The test–retest agreement shows that the MAL was relatively stable in this population of chronic stroke patients, but it also shows that changes must be >12% to 15% of the range of the scale to exceed the measurement error. This means that the reproducibility of this instrument is insufficient to detect a change of 10% of the range of the scale, which was proposed as the MCID. This renders the MAL less suitable for use in clinical practice but poses no large problem for use in clinical research.

A more serious problem is to decide what a change on the MAL implies, even if it exceeds the limits of agreement. One would expect a positive correlation between improvement on the MAL and improvement on the ARA test, indicating that patients whose dexterity improves make more use of the affected arm and hand. Although there is a reasonable cross-sectional correlation, indicating more hand-use in patients with better dexterity at baseline, the changes on both measures are virtually unrelated. How can this lack of correlation be explained? Obviously, the ARA and the MAL measure different constructs, with the ARA being a performance test and the MAL providing a subjective rating of the use of the affected arm and hand in daily life. Nevertheless, considering the correlation between the baseline scores on both measures, the lack of correlation in the change scores is surprising. A similar problem is posed by the lack of correlation between the change on the MAL and the GCR. Apparently, patients who consider their arm function to be improved (as reflected by their GCR) do not notice that they use their arm and hand more in daily life, and vice versa. Both the GCR and the MAL are concerned with the patient's opinion of "how well the affected arm works." However, a certain amount of social desirability may be reflected in the GCR, because virtually all patients stated that their arm function was at least somewhat better. Contrary to the MAL interview, which was performed by an investigator who was blinded to the allocation of the intervention, the GCR questions were answered in the presence of the physiotherapist who supervised the treatment. This may have enhanced the risk of socially desirable answers. Apart from that, it is not surprising that patients in this study, who have invested so much time and effort in trying to improve, estimate their improvement very positively immediately after this period of intensive training. The general positive attitude of patients at the end of the treatment may have led to unduly optimistic ratings at this time. Although the validity of a retrospective assessment such as the GCR can be questioned,[29] the virtually absent longitudinal correlations with the ARA and the GCR leave us with considerable doubt about the longitudinal construct validity of the MAL. The best way to obtain valid information about the use of the affected arm and hand in daily life would obviously be to observe the patient in the home environment or by using activity-monitoring devices.[30,31] The responsiveness ratios of 1.9 and 2.0, which can be interpreted as an effect size, indicate a considerable change during the treatment period, compared with the baseline period. However, as stated before, it is not clear what this change actually implies, because it is not related to the change in comparable outcome measures.

In conclusion, the MAL is internally consistent, relatively stable in a population of chronic stroke patients, and its reproducibility is sufficient to detect an individual change of at least 12% to 15% of the range of the scale. Although the cross-sectional correlation with the ARA is reasonably good and the responsiveness ratio shows a considerable effect size in chronic patients undergoing intensive training of the affected arm and hand, there are reasons to doubt the longitudinal construct validity of the instrument. Therefore, use of the MAL as a primary outcome measure in clinical trials is not recommended.

Appendix

Activities in the Dutch 26-Item Motor Activity Log

For each activity the first question is:

Did you perform this activity during the past week? If the answer is "No," the score is "Not applicable." If the answer is "Yes," the next questions are:

How much did your affected arm participate in this activity? (AOU scale) Possible scores range from 0 (never/not at all) to 5 (always/during all the time); and

How well did your affected arm help during this activity? (QOM scale) Possible scores range from 0 (inability to use the

Activities in Original Version (Taub 1993)	Additional Activities in Dutch Version (Van der Lee 1999)
Steady oneself while standing*	Pour coffee/tea
Put arm through sleeve of clothing	Peel fruit or potatoes
Carry an object in hand from place to place	Dial a number on the phone
Eat with knife and fork†	Open/close a window
Comb hair	Open an envelope
Pick up cup by handle	Take money out of a wallet/purse
Handcraft/card playing/hobbies‡	Undo buttons on clothing
Hold a book, journal or magazine/turn pages for reading§	Do up buttons on clothing
Use towel to dry face or other part of the body	Undo a zip
Pick up glass	Do up a zip
Pick up tooth-brush and brush teeth	Cut nails
Shaving/make-up	Other optional activity
Use key to open door	
Letter writing/typing	

*Original version: steady myself while standing.
†Original version: Pick up fork or spoon and use for eating.
‡Original version: Handcraft/card playing.
§Original version: Hold a book for reading.

affected arm for this activity) to 5 (ability to use the affected arm just as well as before the stroke).

Sum scores are calculated for the amount of use and quality of movement scales separately. To calculate the sum score, the sum of the activity scores is divided by the number of activities performed.

References

1. Taub E, Uswatte G, Pidikiti RD. Constraint-induced movement therapy: a new family of techniques with broad application to physical rehabilitation–a clinical review. *J Rehabil Res Dev.* 1999;36:237–251.
2. Taub E. Somatosensory deafferentation research with monkeys: Implications for rehabilitation medicine. In: Ince LP, ed. *Behavioral psychology in rehabilitation medicine: clinical applications.* Baltimore, Md: Williams and Wilkins; 1980:371.
3. Taub E, Miller NE, Novack TA, Cook EW 3rd, Fleming WC, Nepomuceno CS, Connell JS, Crago JE. Technique to improve chronic motor deficit after stroke. *Arch Phys Med Rehabil.* 1993;74:347–354.
4. Wolf SL, Catlin PA, Ellis M, Archer AL, Morgan, Piacentino A. Assessing Wolf motor function test as outcome measure for research in patients after stroke. *Stroke.* 2001;32:1635–1639.
5. Kopp B, Kunkel A, Flor H, Platz T, Rose U, Mauritz KH, Gresser K, McCulloch KL, Taub E. The Arm Motor Ability Test: reliability, validity, and sensitivity to change of an instrument for assessing disabilities in activities of daily living. *Arch Phys Med Rehabil.* 1997;78:615–620.
6. Fugl-Meyer AR, Jaasko, L, Leyman I, Olsson S, Steglind S. The post-stroke hemiplegic patient. 1. A method for evaluation of physical performance. *Scand J Rehab Med.* 1975;7:13–31.
7. Lyle RC. A performance test for assessment of upper limb function in physical rehabilitation treatment and research. *Intl J Rehabil Res.* 1981;4: 483–492.
8. Liepert J, Miltner WHR, Bauder H, Sommer M, Dettmers C, Taub E, Weiller C. Motor cortex plasticity during constraint-induced movement therapy in stroke patients. *Neurosci Letters.* 1998;250:5–8.
9. Miltner WHR, Bauder H, Sommer M, Dettmers C, Taub E. Effects of constraint-induced movement therapy on patients with chronic motor deficits after stroke: a replication. *Stroke.* 1999;30:586–592.
10. van der Lee JH, Wagenaar RC, Lankhorst GJ, Vogelaar TW, Devillé WL, Bouter LM. Forced use of the upper extremity in chronic stroke patients: results from a single-blind randomized clinical trial. *Stroke.* 1999;30: 2369–2375.
11. Blanton S, Wolf SL. An application of upper-extremity constraint-induced movement therapy in a patient with subacute stroke. *Phys Ther.* 1999;79: 847–853.
12. Liepert J, Bauder H, Wolfgang HR, Miltner WH, Taub E, Weiller C. Treatment-induced cortical reorganization after stroke in humans. *Stroke.* 2000;31:1210–1216.
13. Page SJ, Sisto SA, Levine P, Johnston MV, Hughes M. Modified constraint induced therapy: a randomized feasibility and efficacy study. *J Rehabil Res Dev.* 2001;38:583–590.
14. Sterr A, Elbert T, Berthold I, Kolbel S, Rockstroh B, Taub E. Longer versus shorter daily constraint-induced movement therapy of chronic hemiparesis: an exploratory study. *Arch Phys Med Rehabil.* 2002;83: 1374–1377.
15. Taub E, Uswatte G. Constraint-induced movement therapy and massed practice [Letter to the Editor]. *Stroke.* 2000;31:986–988.
16. Uswatte G, Taub E. Constraint-induced movement therapy: new approaches to outcome measurement in rehabilitation. In: Stuss DT, Winocur G, Robertson IH, eds. *Cognitive Neurorehabilitation.* Cambridge, UK: Cambridge University Press; 1999:215–229.
17. Deelman BG, Koning-Haanstra M, Liebrand WBG, van de Burg W. *Handleiding van de SAN test.* Lisse, The Netherlands: Swets en Zeitlinger; 1987. In Dutch.
18. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state." A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res.* 1975;12:189–198.
19. Nakayama H, Jørgensen HS, Raaschou HO, Olsen TS. Recovery of upper extremity function in stroke patients: the Copenhagen stroke study. *Arch Phys Med Rehabil.* 1994;75:394–398.
20. van der Lee JH, Roorda LD, Beckerman H, Lankhorst GJ, Bouter LM. Improving the Action Research Arm test: a unidimensional hierarchical scale. *Clin Rehabil.* 2002;16:646–653.
21. De Weerdt W, Harrison MA. Measuring recovery of arm-hand function in stroke patients: a comparison of the Brunnstrom-Fugl-Meyer test and the Action Research Arm test. *Physiotherapy Canada.* 1985;37:65–70.
22. van der Lee JH, de Groot V, Beckerman H, Wagenaar RC, Lankhorst GJ, Bouter LM. The intra- and inter-rater reliability of the Action Research Arm test: a practical test of upper extremity function in patients with stroke. *Arch Phys Med Rehabil.* 2001;82:14–19.
23. van der Lee JH, Beckerman H, Lankhorst GJ, Bouter LM. The responsiveness of the Action Research Arm test and the Fugl-Meyer Assessment scale in chronic stroke patients. *J Rehab Med.* 2001;33:110–113.
24. Streiner DL, Norman GR. *Health Measurement Scales: A Practical Guide to Their Development and Use.* 2nd ed. Oxford, UK: Oxford University Press; 1995.
25. Huisman JME. *Item Nonresponse: Occurrence, Causes and Imputation of Missing Answers to Test Items.* Leiden, The Netherlands: DSWO Press, Leiden University; 1999.
26. Huisman M. Imputation of missing item responses: some simple techniques. *Quality and Quantity.* 2000;34:331–351.
27. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet.* 1986;1:307–310.
28. Guyatt GH, Walter S, Norman G. Measuring change over time: assessing the usefulness of evaluative instruments. *J Chron Dis.* 1987;40:171–178.
29. Norman GR, Stratford PW, Regehr G. Methodological problems in the retrospective computation of responsiveness to change: the lesson of Cronbach. *J Clin Epidemiol.* 1997;50:869–879.
30. Uswatte G, Miltner WH, Foo B, Varma M, Moran S, Taub E. Objective measurement of functional upper-extremity movement using accelerometer recordings transformed with a threshold filter. *Stroke.* 2000;31:662–667.
31. Schasfoort FC, Bussmann JB, Stam HJ. Ambulatory measurement of upper limb usage and mobility-related activities during normal daily life with an upper limb-activity monitor: a feasibility study. *Med Biol Eng Comput.* 2002;40:173–182.