Disability and Rehabilitation, 2005; 27(1/2): 7 – 18

Clinical scales for the assessment of spasticity, associated phenomena, and function: a systematic review of the literature

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Abstract

Purpose: To characterise clinical assessment methods for spasticity and/or its functional consequences in clinical patient populations at risk to suffer from spasticity.

Method: Systematic literature search and manual-based two-step review process of psychometric properties of clinical assessment scales for spasticity and associated phenomena, as well as of functional scales with an association with spasticity. Reviewed psychometric properties included internal consistency, interrater, intrarater as well as retest reliability, construct validity, ecological validity, and responsiveness.

Results: Until May 2003 electronic database searches established a reference pool of 4151 references of which 90 references contributed to the review objectives. An additional 20 references were identified by an informal reference search. Twenty-four clinical scales that assess spasticity and/or related phenomena as well as 10 scales for 'active function' and three scales for 'passive function' with an association with spasticity could be identified. Some evidence signals that a high interrater reliability of the Ashworth and modified Ashworth scales can be achieved, however not in all circumstances. For many scales, reliability data is, however, missing. This is especially true for test retest reliability. Information about construct validity can promote our understanding of what individual scales are likely to assess. Many scales have been able to document changes after therapeutic intervention.

Conclusions: The collated evidence can guide our clinical decision about when to use which scale and can promote evidence-based assessment of spasticity and related clinical phenomena.

Keywords: *Clinical scales, assessment, spasticity, function, mobility, reliability, validity*

Introduction

Reviews of clinical scales for spasticity and associated clinical phenomena and textbook chapters that have been published so far concentrate on the most frequently used scales and some of their psychometric characteristics (e.g. [111 – 113]). The aim of this review was to add information to reviews that are already available and provide comprehensive coverage of both the many clinical scales that may exist and their diverse psychometric properties.

While many scales that intend to assess spasticity concentrate on resistance to passive movement as main construct, spasticity might also lead to other clinically observable phenomena. Therefore, scales that measure associated clinical phenomena in the context of spasticity, i.e. passive range of motion, limb position at rest including postural alignment, tendon reflexes, clonus, spasms, or associated reactions were also included.

It was further sought to identify functional scales which have an association with spasticity. Such associations might be observed with cross-sectional studies. Or, evidence might come from intervention studies when treatment for spasticity leads to changes in function. As there is a debate about the functional significance of spasticity this part of the review would help to identify scales that can be used in clinical practice to document functional aspects linked to spasticity and its treatment.

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ISSN 0963-8288 print/ISSN 1464-5165 online
DOI: 10.1080/09638280400014634

Scales may be constructed of a single item, multiple items, or even multiple subtests. A comprehensive review will seek evidence about psychometric properties at the level of single items, at the level of subtests, and the test. At each level, various properties can be documented, i.e. intra- and interrater reliability, test-retest reliability, construct and ecological validity, and responsiveness [114–116].

Since clinical scales are based on ratings, they are prone to subjectiveness. Intra- and interrater reliability are important characteristics that document the potential of a scale to produce stable results within and across assessors. Test-retest reliability is a prerequisite for scales that are to be used in a follow-up situation. It reflects whether a repeated use of the scale can produce stable test results in clinically stable patients.

Construct validity addresses the question which constructs are measured by the scale and evaluates the relation of a scale to other scales and phenomena. It reflects what the test measures and how it relates to other scales. Ecological validity is the property of a scale that indicates that a test result has some relevance for everyday life situations and reflects not merely a clinical phenomenon. Responsiveness is the ability of a scale to detect changes in a patient's status, e.g. after a therapeutic intervention.

There are further characteristics that are specific to multiple-item tests. Each single item of such tests should be evaluated with regard to its reliability, validity, difficulty, and item-test correlation. Further, internal consistency, the degree to which the items of a test measure a common construct, should be evaluated. For tests with more than one subtest one would like to know the test profile reliability implying the extent to which differences in results of subtests can be regarded as differential information.

For tests with binary coding, the diagnostic accuracy can be characterised by their specificity, sensitivity, and positive and negative predictive value.

It is clear that for (most) clinical ratings scales not all these aspects have been evaluated. Nevertheless, the review intended to be comprehensive in that it wanted to document evidence regarding all these psychometric properties to the extent that they were found in the reviewed literature.

Methods

Selection criteria for references

Only original scientific reports of studies in human beings were reviewed.

Published references of clinical scales have been reviewed:

A if they intend to measure spasticity (and associated clinical phenomena [in the context of spasticity], i.e. resistance to passive movement, passive range of motion, limb position at rest including postural alignment, tendon reflexes, clonus, spasms, or associated reactions), AND/OR

B if they intend to treat spasticity, AND/OR

C if they document associations between spasticity and function.
Evidence of functional consequences of spasticity can be derived from
- (a) either intervention studies that measure the effect of an intervention for spasticity on function,
- (b) or that measure the association between spasticity and function (correlational evidence by cross-sectional study).

These measures do not necessarily assess spasticity (i.e. not the same construct). Nevertheless, knowledge about measures that indicate associations between spasticity and function are important in the context of rehabilitation. The review of clinical scales was restricted to those functional scales with a documented association with a clinical measure of spasticity, or a documented effect of spasticity treatment on function.

(B) and (C.a.) were selected for review if the study was a randomised, controlled trial, because this study type has the best chance to reveal unbiased effects of intervention.

Reference pool for the selection of references

Screening for potential references was based on a reference pool that was established by

(I) An internet literature search with the following algorithm:
- a. Search terms were
  1. Spas*
  2. Hyperton*
  3. Reflex*
  4. Measur* or Assess*
  5. Stroke* or CVA OR multiple sclerosis or MS OR spinal cord injury or SCI OR cerebral palsy or CP

  Combinations
  1. 1, 4 & 5
  2. 2, 4 & 5
  3. 3, 4 & 5
- b. The search included conference proceedings and was done on the following databases Medline, Pubmed, CINAHL,

EMBASE, Web of science, Science direct, and First Search.

(II) Other literature sources that seemed relevant for the review and were available to members of the review team.

Review procedures and strategies

Rationale for the review of individual scales. Most frequently, reviews are structured according to the references. In this review, however, the individual clinical scales were the basic units of the review.

This approach was chosen because (1) the review is concerned with clinical scales for the measurement of spasticity and/or its functional consequences, and (2) the information and evidence regarding these scales might be scattered across various references.

Accordingly, information and evidence was collected for individual scales rather than for individual references.

A considerable body of literature specifically evaluates clinical scales. However, many publications with another focus, e.g. evaluation of intervention, also contain important information about clinical scales for the measurement of spasticity and/or its functional consequences. For some scales such reports may even be the only source of evidence. Therefore, all references containing information about clinical scales for the measurement of spasticity and/or its functional consequences were included in the review process. Only of those aspects of the reference relevant for assessment of spasticity were further analysed.

Two-step approach for the review of individual scales. The review was conducted on the basis of a two step approach. References were selected for the review (step 1), and contributed then to the reviewed information and evidence regarding individual scales (step 2).

Step 1 of the review – selection of references:

The publications of the reference pool were screened for title, abstract, and key words of references to exclude the majority of references that would not contribute to the review of clinical scales of spasticity. Studies obviously not related to spasticity, non-human studies or non-original studies (reviews) were excluded in this phase. All other references were screened for selection on the basis of the full-length version of the publication to avoid exclusion of documents which might contain relevant information (false negative selection).

The selection procedure was carried out by four assessors. To ensure an acceptable interrater agreement (above 90%), the assessors participated in a training at onset of the selection phase, and a double-check procedure was followed for a sample of the references. The training and selection process were manual-based with written instructions specifying the selection criteria and the steps to follow for reading the documents and reporting results.

After interrater training, the first 50 documents of each assessor were double-checked by one of the other assessors, and results were compared. During the further selection procedure, ten percent of the other references were also double-checked. Overall, interrater agreement of step 1 of the review by pairs of two assessors was substantial with a 97.5% agreement rate and a kappa of 0.718.

Step 2 of the review – scale characteristics:

Each reference selected for step 2 was further analysed by two assessors. All information related to psychometric characteristics to clinical scales of spasticity was retrieved. The assessors used a list of scale characteristics to look for. The list included a definition of each characteristic to improve and facilitate the analysis.

Scale characteristics/Psychometric properties [114–116]:

- the scale of measurement of the test
- the scale of measurement of individual items
- item characteristics (i.e. objectivity, retest reliability, difficulty, item-test correlation)
- reliability (i.e. internal consistency, interrater and intrarater reliability, test retest reliability)
- validity (i.e. criterion validity, construct validity, predictive validity, ecological validity and responsiveness)
- test profile characteristics (e.g. profile reliability)
- availability of norms
- diagnostic accuracy (i.e. sensitivity, specificity, predictive value of a positive and a negative test)

For functional scales, only (1) issues of construct validity, e.g. their relation to spasticity, and (2) their ability to detect functional changes occurring after antispastic treatment (responsiveness), were addressed.

Correlation coefficients were verbally commented in a standardised way as follows (Table IV):

Results and comments

Electronic searches of references until May 2003 led to a total of 4151 references. Step 1 of the review process identified 90 references with contributions to the review. On the basis of non-electronical searches performed by the raters, another 20 informative references were identified. Thus, 110 references were included in step 2 of the review.

While a detailed description of the review findings would be beyond the scope of this paper, it will present the summary findings for the scales that have been evaluated by the systematic review. Reliability and validity issues will separately be presented for groups of scales with common characteristics.

Firstly, summary results are given for scales that intend to measure spasticity and associated clinical phenomena. Secondly, scales are reviewed that assess function and have a documented association with spasticity.

Scales of spasticity and associated clinical phenomena

A variety of scales have been identified with at least some evidence regarding their psychometric properties: (A) Scales that assess tone (resistance to passive motion), (B) scales that assess range of motion and posture at rest, and (C) scales for other clinical phenomena related to spasticity, e.g. tendon reflexes and spasms (Table I).

Assessment of tone

Eight single-item scales for the assessment of tone and three multiple-item scales that include tone assessment have been identified.

Single-item scales. Single-item ordinal scales for the assessment of tone are the Ashworth scale, the modified Ashworth scale, other ordinal scales, the Tardieu scale and visual analog scales (VAS) (for both self-report and assessment by clinicians). These scales have variable (intra- and) interrater reliability which can be high, but also in some circumstances low (Ashworth scale: [19,38,71]; Modified Ashworth scale: [12,13,15,29,30,35,36,38,94]; other scales: [55,80]; Tardieu scale: [30,99]; VAS: [80]). No clear picture emerged which circumstances (e.g. assessed joint, diagnostic group, examiner's qualification) could account for this variance. For the modified Ashworth scale the evidence might suggest that interrater reliability was higher when the scale was used for less heavy limbs. But other reasons might equally account for the reported variability of reliability estimates.

Given the moderate reliability of VAS for spasticity as assessed by clinicians [80] it is difficult to see what could be gained beyond the more widely used ordinal scales by a clinical scale with (only) seemingly higher resolution. When used as a self-report instrument it might, however, add valuable, i.e. patient-centred, information [93].

Table I. Scales for the assessment of spasticity and associated clinical phenomena.

Name of scale	Construct	Structure of scale
A. Assessment of tone		
Ashworth scale	Resistance to passive motion	Ordinal, 1 item
Modified Ashworth Scale (MAS)	Resistance to passive motion	Ordinal, 1 item
Velocity-corrected MAS	Resistance to passive motion	Ordinal, 1 item
Muscle tone scale	Resistance to passive motion	Ordinal, 1 item
Other categorization of tone	Resistance to passive motion	Ordinal, 1 item
Modified Tardieu Scale	Dynamic catch range of motion	Numerical, 1 item
'Spasticité' (Bilan moteur)	Resistance to passive motion	Ordinal, 9 items, SRS
VAS for tone (clinical rater)	Resistance to passive motion	Numerical, 1 item
VAS for tone (patient)	Resistance to passive motion	Numerical, 1 item
Tone assessment scale	Resistance to passive motion Resting posture, associated reactions	Ordinal, 12 items (6 + 3 + 3 items), SRS
Spasticity score (hip adductors)	Resistance to passive motion, spasm frequency	Ordinal, Two-items product
Total spasticity score (ankle)	Resistance to passive motion, tendon jerk, clonus	Ordinal, 3 items, SRS
B. Assessment of ROM and posture		
ROM with goniometer	Range of motion	Numerical, 1 item
ROM – visual estimation	Range of motion	Numerical, 1 item
Maximum inter-knee distance	Range of motion	Numerical, 1 item
Finger curl at rest	Resting posture	Numerical, 1 item
Ankle position at rest	Resting posture	Numerical, 1 item
C. Other clinical phenomena		
Spasm severity scale	Spasm severity	Ordinal, 1 item (self)
Spasm frequency scale(s)	Spasm frequency	Ordinal, 1 item (self)
Spams score	Spasm frequency and severity	Ordinal, 2 items
Tendon reflex scale(s), e.g. NINDS myotatic reflex scale	Tendon reflex	Ordinal, 1 item
Extensor toe sign(s)	Extensor toe sign(s)	Nominal, 6 items
Plantar stimulation response	Plantar stimulation response	Ordinal, 1 item
Clonus score	Clonus	Ordinal, 1 item

Abbreviations: SRS, summated rating scale; VAS, Visual Analog Scale; ROM, range of motion; NINDS, National Institute of Neurological Disorders and Stroke; and self, self-report scale

The combined assessment of modified Ashworth scores and the angular velocity during testing (velocity-corrected Modified Ashworth scale) might improve the test's resolution (11 possible scores) and reliability, but this is then an instrumented test rather than a scale [97].

Retest reliability of the ordinal scales seems to be moderate, but has not been investigated extensively (Ashworth scale: [7,81]; Tardieu scale: [7,30,99]).

The Modified Ashworth scores are moderately correlated with self-rated spasticity lending some support to the use of the ordinal scales for clinical rating of spasticity [92,93].

Neither the Ashworth scores nor the Modified Ashworth scores are closely associated with other signs of the upper motor neuron syndrome (Ashworth scale: [14,21,22,33,44,81]; Modified Ashworth scale: [11]). This supports the notion that the different clinical phenomena have to be assessed separately. The scales have a moderate association with results from reflex-related EMG parameters (Ashworth scale: [23,52,60,61,62,69,110]; Modified Ashworth scale: [5,47,78,91]; other scales: [8,75]). Their association with objective measures of resistance to passive movement is stronger (Ashworth scale: [18,23,25,64,67,68,88,103,104]; Modified Ashworth scale: [31,42,45,56,70,87]). Therefore, these ordinal measures and certainly the Ashworth scale may be regarded as clinical assessment of resistance of passive motion that is in part of reflexiogenic origin. Modified Ashworth scale grades '1', '1+' and '2', however, may not be valid as representing different levels of resistance to passive movement [73,74].

The effects of treatment on muscle tone can be documented with the Ashworth and Modified Ashworth scale. Responsiveness has been shown for upper and lower limbs in various diagnostic groups, i.e. cerebral palsy, stroke, traumatic brain injury, spinal cord injury, and multiple sclerosis (Ashworth scale: [1,21,22,32,37,43,44,49,58,59,63,66–68,77, 89,90,98,100,102,106]; Modified Ashworth scale: [3,4,10,20,39,50,65,79,83,84,96,109]). The Tardieu Scale can detect therapeutically induced changes of spasticity in hip adductors among CP children [7].

Multiple-item scales. The tone assessment scale's resistance to passive movements items (RPM) [6,36] and the items of the subtest 'spasticité' of the 'Bilan moteur' test (BM-S) [85] are reliable tests of resistance to passive movement and explicitly assess spasticity in different muscle groups. This kind of 'summary' information might be considered an advantage in some situations such as the evaluation of antispastic treatment. Methodological questions, however, arise for these ordinal scales: the summary score may not be valid for comparisons, e.g. 1 + 2 does not necessarily equal 3 + 0.

Tests that combine the assessment of different constructs for a specified body region, e.g. the total spasticity score (ankle: tendon reflex, resistance to passive movement and clonus) [34,46] or the spasticity score (hip adductors: resistance to passive movement and spasm frequency) [98], might reflect the intention to have a single outcome score that covers related constructs. While such an approach seems practical and has been shown to be reliable it remains debatable whether this is methodologically attractive.

Assessment of range of motion and posture

Goniometric assessment of range of motion (ROM) has moderately high to high (intra- and) interrater reliability when used with cerebral palsy children [2,29,30,82]. This has also even been shown when ROM was estimated visually in children instead of the usual approach with a goniometer [2]. The ROM scores are associated with (original and modified) Ashworth scores among CP children [100,106,109] and patients with SCI [83] or stroke [92,96]. Assessment of ROM is also sensitive to change after antispastic therapy among CP children and stroke patients [4,92,96,100,106,109] (responsiveness). Thus, ROM assessment can be suggested for status and follow-up assessments of spasticity related reduction of ROM in CP children, SCI patients, and stroke patients. The assessment of specific postures can also be used to monitor effects of antispastic treatment in specific clinical situations. The maximal distance between knees can help to monitor treatment effects on hip adductor spasticity in MS patients [41]. Finger curl at rest [96] and ankle position at rest [83] can reflect antispastic therapeutic effects in hemiparetic patients with severe spasticity.

Assessment of other clinical phenomena related to spasticity

Tendon reflexes. The NINDS myotatic reflex scale has moderate (to substantial) interrater reliability [48]. It has been shown that reflexes vary across muscle groups [81]. Thus, their separate assessment is warranted (as done by clinicians). Reflex rating is sensitive to change after antispastic medication [22,49,86].

Clonus score. Moderate retest reliability has been documented in SCI patients [81].

Plantar stimulation response. Moderate retest reliability has been reported with SCI patients [81] as well as responsiveness after antispastic medication in MS patients [22].

Spasm severity and spasm frequency. Moderate retest reliability has been reported with SCI patients [81]. There was only a low correlation of self-rated spasm severity with Ashworth scores [81]. Spasm frequency was moderately correlated with interference with function in spinal cord injury patients [81]. Thus, the assessment of spasm severity and/or frequency (in addition to assessment of muscle tone) is warranted in spasticity due to spinal cord lesions. The scales are sensitive to change after antispastic therapy in spinal cord injury [77] and MS patients [22,77].

Scales that assess function and have a documented association with spasticity

Function in this context is used to denote a person's ability to perform an activity independently (Tables II and III).

'Active function' relates to the capacity to move the body or its parts actively. 'Active functions' can range from simple active movements at a specified joint to complex movements such as handling objects and gross motor functions such as walking and running, and even complex actions such as dressing, feeding, or climbing stairs.

'Passive function' relates to the ability to integrate a body part in activities passively, e.g. putting an arm through a sleeve or cutting finger nails.

In studies with children with cerebral palsy, the Ashworth Scale and the Modified Ashworth scale score have been associated with quality of arm skills (QUEST) (Ashworth scale: [27]), active ankle motion (Modified Ashworth scale: [50]), gait velocity, stride length and foot contact pattern during gait (Ashworth scale: [28,106]), gross motor functions (GMFM) (Ashworth scale: [23,100]; Modified Ashworth scale: [50]), the Barthel Index and the self-care domain of the Pediatric evaluation of disability inventory (PEDI) (Ashworth scale: [27,53]).

In stroke patients scores of both the Ashworth Scale and the Modified Ashworth scale were documented to be related to some measures of active function, i.e. to the ability to move the arm selectively (Fugl-Meyer test) (Modified Ashworth scale: [17,42]) as well as gait asymmetry and velocity measures (Ashworth scale: [26]; Modified Ashworth scale: [40]). They are also related to 'passive' function, i.e. handling the arm in stroke patients (disability rating scale, carer burden scale) (Modified Ashworth scale: [10]) and the ease of hygiene and catheterisation in MS patients with severe hip adductor spasticity (hygiene score) (Ashworth scale: [98]).

Table II. Scales for the assessment of active function.

Name of scale	Construct	Type of scale
Grip strength	Grip strength	Numerical, 1 item
Muscle strength grading (MRC)	Muscle strength	Numerical, 1 item
Active ROM	Focal motor function	Numerical, 1 item
Gait analysis	Gait function	Nominal or numerical, single or multiple items
Fugl-Meyer, arm motor score	Selective innervation	Ordinal, 33 items, SRS
QUEST	Arm motor function	Dichotomous and ordinal, 4 domains, 33 items, SRS
GMFM	Motor function (5 subtests)	Ordinal, 88 items, SRS
PEDI, self-care score	Basic ADL competence	Dichotomous, 73 items, SRS
Barthel Index	Basic ADL competence	Ordinal, 10 items, SRS
Interference with function scale	Interference with function	Ordinal, 1 item

Abbreviations: MRC, Medical Research Council; ROM, range of motion; SRS, summated rating scale; QUEST, Quality of upper extremities skills; GMFM, Gross motor function measure; and PEDI, Pediatric Evaluation of Disability Inventory.

Table III. Scales for the assessment of passive function.

Name of scale	Construct	Type of scale
Hygiene score	Ease to clean and catheterise	Ordinal, 1 item
Disability scale	Impact of tone on passive arm function	Ordinal, 8 items, SRS
Carer burden scale	Impact of spasticity on arm care	Ordinal, 4 items, SRS

Abbreviations: SRS, summated rating scale.

Table IV. Verbal descriptors for strength of association and agreement.

Correlation coefficients (r, rho, ICC, alpha) [117]:	
0.00 – 0.39	low
0.40 – 0.59	moderate
0.60 – 0.79	moderately high
0.80 – 1.00	high
Kappa statistics [118]	
0.00 – 0.20	slight agreement
0.21 – 0.40	fair agreement
0.41 – 0.60	moderate agreement
0.61 – 0.80	substantial agreement
0.81 – 1.00	almost perfect agreement

When spasticity is treated with the intention to improve active or passive function the following aspects and scales might be able to detect functional therapeutic effects (responsiveness):

Children with CP. Test of quality of arm skills (QUEST) [27], active ankle motion [50, 106, 109], foot contact pattern during gait [109], gait velocity and stride length [9,106], and gross motor functions (GMFM) [50,100,109] as well as the the self-care domain of the Pediatric Evaluation of Disability Inventory (PEDI) [27].

Stroke and MS patients. 'Active' function in terms of muscle strength grading in proximal leg muscles (MS patients) [89], active ankle motion [20] and time needed to ambulate 25 feet [43] (hemiparetic patients). 'Passive' function, i.e. handling the arm in stroke patients (disability rating scale, carer burden scale) [10,39] and the ease of hygiene and catheterisation in MS patients with severe hip adductor spasticity (hygiene score) [98].

Discussion

Synopsis of the key findings

A wide range of scales for spasticity and related clinical phenomena as well as some scales for function that have a documented association with spasticity could be identified by this review (compare Tables I–III). Many of these are single item scales that assess muscle tone/resistance to passive movement or range of motion and can be used in various circumstances, i.e. different joints and diseases causing spasticity. Some scales are related to specific body parts such as the fingers, hip (adductors) or the ankle (flexors). Other scales intend to measure changes of muscle tone throughout the body and to give summary information, e.g. the tone assessment scale and the subtest 'spasticité' of the 'Bilan moteur' test. Phenomena related to spasticity such as spasms, tendon reflexes, clonus, and extensor toe signs can also be assessed with clinical scales. Functional scales whose test results are associated with spasticity are measures of grip strength, active joint motion, the Fugl-Meyer arm motor test (selective arm innervation), the QUEST (quality of upper extremity skills), the GMFM (Gross Motor Function Measure), gait velocity and the foot contact pattern during walking, the Barthel Index, the self-care domain of the PEDI (Pediatric Evaluation of Disability Inventory), and the interference with function scale. Further, some scales assess to what extent handling and care of specific body parts that are affected by spasticity is possible, e.g. the disability scale and carer burden scale as well as the hygiene score.

Clinical and research implications

This systematic review documents an array of clinical assessment scales of spasticity and related clinical phenomena as well as functional clinical scales with a documented association with spasticity. The state-of-the-art review in terms of available instruments, their psychometric properties, as well as their successful application in intervention studies with spasticity treatment provides clinicians and researchers alike with extensive clinically useful information. Knowing which scales are available and which construct they measure can guide clinicians and researches towards selection of the appropriate scales for her or his own purposes. Because the review used a standardised comprehensive review methodology the scales' psychometric properties can more easily be compared across scales.

The review does, however, equally highlight the restricted methodological knowledge about these scales: Scales for the assessment of spasticity and related clinical phenomena that are actually in use have not been evaluated to a sufficient extent.

For many scales, reliability data are missing. This holds especially true for test retest reliability. This, however, would be highly relevant information for scales that are to be used in follow-up situations.

Reliability studies of the Ashworth and modified Ashworth scales signal that a high interrater reliability can be achieved, but is not achieved in all conditions. Factors influencing variability of reliability ought to be investigated. The lack of standard guidelines for positioning and performance as well as scoring does certainly contribute to the variability of results. Thus, the review found that it is important to consider the method of application of the test as well as the test itself. Hence, a standardised protocol for the use of the Ashworth scale for all major limb movements and its use as a summated rating scale is under development and will be tested in a forthcoming reliability and validity study. Such a process can lead to the development of a more reliable assessment tool and a standardised test protocol.

The definition of spasticity can have a major impact on the validity of any test. The introductory paper in this issue proposed that the term spasticity should be used to describe the entire range of signs and symptoms collectively described as the positive features of the upper motor neuron syndrome. More specifically, the SPASM group defined spasticity as '*disordered sensori-motor control, resulting from an upper motor neurone lesion, presenting as intermittent or sustained involuntary activation of muscles*' [119]. We then used the construct validity information that could be deduced from the reviewed literature to learn about the constructs that are assessed by individual scales (see Tables 1–3). Many scales do not measure spasticity, but constructs that are influenced by both spasticity, i.e. involuntary hyperactivity of skeletal muscle and other constructs such as non-neural components of resistance to passive motion.

While information about construct validity could be derived from various sources an explicit and extensive evaluative approach has rarely been performed for the reviewed scales. The evidence that has been reported is mainly based on univariate analyses. A more explicit, complex and multivariate approach to construct validity of these scales would be warranted. This could provide a clearer picture about the constructs measured by individual scales, their interrelationship as well as their relevance for function.

For tests with multiple items a thorough and comprehensive analysis of items and subtests and thus a methodologically robust construction of the tests is not readily evident. A more comprehensive construction and evaluation of multiple-items scales could, however, improve the knowledge about these scales and clarify the interpretation of test results and test profile differences.

Limitations of the review

The review intended to be comprehensive in terms of coverage of original references, reviewed scales and psychometric characteristics. It is, however, likely that not all relevant references could be traced even though extensive electronic database searches had been performed. Additional, more focussed reviews might provide more in depth information for individual scales or aspects.

Conclusions

The psychometric evidence about clinical scales for the assessment of spasticity and related phenomena as well as function has extensively been reviewed. This evidence can guide our clinical decision about when to use which scales and can promote evidence-based assessment of spasticity and related clinical phenomena. On the other hand, the highlighted limitations of the present evidence can guide the further development of clinical scales and help to improve the state-of-the-art in this area.

Since the review documented very complex and detailed information about many scales, its content could hardly be comprehensively written up in a single paper. For cross-comparisons, it is, however, worthwhile to keep the information bundled. Consequently, this paper can only orient the reader about the review. The reader is therefore encouraged to refer to the more comprehensive review documentation that will be provided in a book chapter format (for reference see SPASM website: www.spasmproject.org).

Acknowledgments

The project was supported within the European thematic network ‘SPASM’ (Support Programme for Assembly of database for Spasticity Measurement) (Proposal No QLTR-2000-00818). Manuscript preparation has been supported within the ‘Kompetenznetz Schlaganfall’ (competence net ‘stroke’) by the BMBF (German Federal Minister for Education and Research). The authors are indebted to Julie Hind, University of Newcastle upon Tyne, for performing the extensive electronic database searches.

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