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The Development of an Unidimensional Scale of the Guttman Type for the Assessment of Mobility Disability in Multiple Sclerosis.

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Running Title: Unidimensional Scale for Mobility Disability Assessment in MS

ABSTRACT

Objective: The aim of the study was to develop a valid and reliable unidimensional scale of the Guttman type for the assessment of mobility disability in multiple sclerosis (MS).

Subjects: Sixty-eight subjects with a definite diagnosis of MS participated.They were attending as outpatients at a MS unit at a District General Hospital. Thirty had the primary progressive pattern of disease, and 38 had the relapsing-remitting pattern.

Methods: Formal assessments used for neurological disability were inspected, and 14 test items of gross motor function were extracted and ordered according to two criteria. These were that actions progressed from lying, to sitting, to standing and walking tasks, and that they progressed from broader to narrower bases of support. All subjects carried out all test items which were scored as ‘pass’ or ‘fail’.

Analysis: Data were tested for internal consistency, reliability, inter item correlation, reproducibility and scalability. On the basis of the results, the items were re-ordered in rank, and reduced to eleven tests. The eleven item scale was re-analysed.

Results: Results showed that the scale had an internal consistency of 0.88 (alpha coefficient) and a coefficient of reproducibility (CR) of 0.95 and above for both MS subject groups. The coefficient of scalability (CS) for items was 0.78 for primary progressive subjects and 0.74 for the relapsing-remitting group. Reliability ranged from good (kappa = 0.49) for one item, to perfect for six items.

Conclusion: The scale was demonstrated to be a hierarchical scale of the Guttman type exhibiting homogeneous unidimensionality and good reliability. The high CR indicated that scores may be summed, and the very acceptable levels of CS indicated that the cumulative scores are meaningful within the defined concept of hierarchy used in this study.

INTRODUCTION

The concept of disability focuses on the idea that actions, functions, and behaviours which are thought of as normal, are in some way restricted or reduced. A definition of disability, now widely used is "....any restriction or lack (resulting from an impairment) of ability to perform an activity within the range considered to be normal for a human being." [1]. For some conditions, there is a continuum from the pathology (lesions) to impairment (symptoms and signs) and disability (functional restriction), but in MS this is often not the case. Research using magnetic resonance imaging has demonstrated that there is little consistent relationship between the development of lesions and observed changes in disability [2]. The development of disability should, therefore, be considered as a process which is relatively independent of the development of lesions.

This has not generally been the case, as the most commonly used assessment for “disability” in MS has been the Expanded Disability Status Scale (EDSS) [3], which includes items of both impairment and disability within its single scoring system. In addition, the EDSS regards “disability” almost entirely in terms of walking ability. Several researchers have expressed dissatisfaction with the EDSS as a disability assessment, opining that it is very insensitive to changes in disability and impractical for use in general clinical practice [4 5 6] .

Studies into the disability of MS are limited when available assessments are graded in wide steps, as with the EDSS, and more appropriate and sensitive measures are needed in order to gain more detailed information about the functional outcome of disease progression and the effects of interventions aimed at mitigating physical disability. The aim of this research study was to develop an objective assessment tool, exhibiting the appropriate features of an unidimensional scale of the Guttman type, to fill this apparent gap.

A Guttman Scale consists of individual items ranked in order of difficulty so that all patients pass or fail the items in the same order. Thus, when an assessment of the Guttman type is used, testing can be terminated when an item has been failed. This is because the scale implies that all items above the failed one will also be failed by a statistically significant number of subjects.

In practice, the use of Guttman scaled assessments have added value in that time and effort is saved by both patient and assessor. In the case of MS such a saving is beneficial, as fatigue can be a limiting factor in the performance of motor tasks [32].

In the specific dimension of movement dysfunction, it is the degree of loss of motor control which determines the restrictions of ability for the execution of functional actions. The development of movement dysfunction in MS has not been investigated previously in terms of the biomechanics and the neural control of movement, and it is these theoretical concepts which underlie the unidimensional scale developed in this study.

METHOD

Fourteen test items were chosen in order to assess gross function. The items all conformed to two criteria: firstly, each required trunk control, and secondly, none required isolation of movement at a single body or limb segment.

The majority of the items were taken from the Functional Movement section of the Motor Club Assessment (MCA)[21], as this has been previously demonstrated to have good reliability and validity for the assessment of people with MS [25] although no previous suggestion for hierarchy of test items has been proposed. The selection, therefore, was generally based on items from the MCA that conformed to the criteria. However, these items are not exclusive to the MCA, and also appear in other assessment procedures used for adult neurological patients (Table 1). This provides external evidence that the chosen items are widely considered important for the

assessment of neurological disability by a number of authors who have developed formal assessment tools.

Some test items, when included in various assessments for stroke, require the action to be performed towards affected and unaffected sides of the body. This is not a valid distinction in MS, and such actions were therefore required to be carried out both unilaterally, and bilaterally. The method of assessment for each of the fourteen test items has been published in more detail elsewhere [25].

The 14 test items were arranged in a rank order similar to the neurodevelopmental sequence of motor control [9 10]. The rank order had regard for two features of the sequence of actions. Firstly, the activities progressed from lying, to sitting, to standing and walking tasks, and secondly, the actions progressed from broader to narrower bases of support.

In all 68 people with a definite diagnosis of MS consented to participate and were assessed. Thirty had the primary progressive pattern of MS and 38 had the relapsing-remitting pattern. They were attending a MS Clinical and Research Unit at a District General Hospital having been referred for assessment and advice for their MS. Patients carried out all 14 test items three times at yearly intervals. They either passed (score = 1), or failed (score = 0) each item, thus data were encoded in binary form at the time of collection. Inter-observer reliability was tested between two observers, with experience in carrying out the 14 item assessment, on 20 of the MS patients with stable disease.

Testing was carried out according to the published protocol [25]. All assessments were carried out in a physiotherapy gymnasium using a consistent test environment. The walking tests were carried out using the same outdoor route (cement surfaced) marked at 20 and 50 metres. Patients were tested for walking once with those progressing past 20 metres walking onwards to attempt 50 metres.

ANALYSIS

Inter observer reliability was determined using weighted kappa. The correlation between each scale item on the remaining items in the scale was based on linear multiple correlation to estimate the lower bound of reliability (or $lamda_6$) for items[26], and on inter item correlation co-efficients to determine relationships between items. Internal consistency was estimated using Cronbach's co-efficient alpha[27]. Co-efficients of Reproducibility and Scalability were calculated using published methods[29]. Analyses were carried out using SPSS - X release 3.1 for VAX/VMS.

RESULTS

The lower bound of reliability [26] based on linear multiple correlation for the 14 items was 0.95 indicating high correlation between each item in the scale on the remaining items.

For the inter observer reliability estimation, there were 12 disagreements in scoring out of the 280 paired observations. The greatest number of disagreements was for the test of unilateral lower limb stance (item 14) which had four disagreements (weighted kappa = 0.49; 'moderate'). Item 4 had three disagreements (kappa =0.70), items 3 and 13 each had 2 disagreements (kappa = 0.79 and 0.62 respectively; 'good'), while item 2 had only one disagreement (kappa = 0.85; 'very good').

The co-efficient alpha (internal consistency) for the total data was 0.90. A high alpha indicated that there was at least one homogeneous dimension underlying the scores, and that items correlate with one another. A minimum acceptable alpha of 0.70 has been suggested for group data [28]. Thus, the indication was that the selected items essentially measured the same construct, and that the construct itself was homogeneous.

Co-efficients of Reproducibilty and Scalability

A Guttman Scale [29] is one in which a cumulative scale is demonstrated to consist of a hierarchy of items which are homogeneous and relate to one concept. The Co-

efficient of Reproducibility (CR) quantifies the deviation of a scale from perfection[29]. However, as perfection is rarely achieved, an overall CR of 0.90 has been reported as indicating the existence of a valid, cumulative, and unidimensional Guttman Scale [30]. The CR calculated for the primary progressive and the relapsing-remitting patient groups, were 0.93 and 0.95 respectively (Table 2).

The CR is considered insufficient on its own for indicating a valid scale [31]. It has been shown that a large number of subjects who saturate the scale at the top or the bottom (extreme individuals) could produce a high CR. A similar outcome could be produced if several of the scale items were passed or failed by the majority of subjects (extreme items). Determination of the Co-efficient of Scalability (CS) [31] makes it impossible to erroneously attribute a high scalability to a set of tests in a sample containing many extreme items or many extreme individuals. CS is always lower than CR, but a level of acceptance for CS has been suggested at between 0.60 and 0.65 [31]. The CS for the two patient groups, by items and by subjects, indicated that an acceptable level of scalability was exhibited to proceed (Table 2).

In order to determine if the individual items in the scale were ranked in the most appropriate hierarchy, the frequency profile for scale errors by item (that is, the sum of the frequency of the non-modal group) was inspected for each group of patients. The frequency of scale errors indicated that in both patient groups two test items (2 and 1) had more scale errors than items placed above, indicating that they were inappropriately placed in the hierarchy of items.

The items were re-ordered so that 2 and 1 rose in the rank by three places to lie after item 6 and before item 5. The CS and CR were then recalculated. The results showed that the re-ordered scale items produced higher CS and CR than the original rank order (Table 3).

In order to determine if all 14 test items were required, inter-item correlation coefficients (ICC) were determined using the total data. Highly significant correlations were found between standing unsupported for 60 seconds and for 30 seconds (ICC

= 0.92), bed to chair and chair to bed transfers (ICC = 0.96), and between rolling from supine to side lying in both directions and in one direction (ICC = 0.95). This indicated that of each pair, only one item needs to be tested in the scale. The 14 item re-ordered scale was therefore collapsed to 11 items. The final 11 item scale is shown in Table 4.

Using the final form of the 11 item scale, the internal consistency was determined to be 0.88 (alpha coefficient). This indicated that the elimination of three items had not affected the construct validity, and that the scale continued to exhibit a homogeneous unidimensionality.

CR is never lowered, and almost always raised by combining categories, whereas CS may be lowered, raised, or remain unchanged [31]. For the eleven item scale the final CR was 0.95 and above for both patient groups, and CS for items was 0.78 for primary progressive, and 0.74 for relapsing-remitting patient groups. CS for subjects were unchanged (0.78 and 0.67 respectively).

DISCUSSION

The scale developed in this study was shown to be a hierarchical scale of the Guttman type [29]. In addition, this Guttman type assessment has predictive value, indicating which activity is more likely to be lost through disease progression in MS, and which activity is most likely to be regained through rehabilitation.

In comparing the rank order of the final eleven item MS scale with the classical neurodevelopmental sequence of motor control, one distinct difference was noticeable. The motor function of rolling was featured much higher in the MS scale than in the neurodevelopmental hierarchy. In the latter, rolling is an earlier developmental milestone than sitting, whereas in the MS scale sitting is an easier activity than rolling.

A similar finding has been reported in stroke patients during recovery when rolling is achieved later than unsupported sitting [33]. The MS disability scale and the stroke

recovery scale [33] both indicate that rolling is a more difficult motor task than unsupported sitting for these adult neurological patients. It raises questions as to why this is the case, and what mechanisms of the neural control of movement are necessary for successful completion of rolling. Further research in this area is needed to investigate this issue.

The MS disability scale developed in this study has several advantages over other scales used to assess the condition. It has a single construct with a high alpha co-efficient (i.e. the scale is unidimensional), and each test item is actually carried out, not reported, by patients. When one item is failed the scale predicts the failure of all other test items ranked as more difficult, as it has a very acceptable CS for items. The scale can determine that patients who fail more items are more severely affected than those who fail less, and thus individuals can be ranked as there is a very acceptable CS for subjects. The CR is high indicating that the scores of individuals, or study populations can be summed (i.e. the scale is cumulative). Therefore, it exhibits all the features of a Guttman type scale, at above the required levels on formal psychometric analytical tests.

The concept of hierarchy which states that patients should fail motor tasks in an identifiable order, is upheld by these results, and this unidimensional cumulative scale is put forward as a more reliable way of determining functional disability in MS.

This valid and reliable tool can be used for assessing and monitoring changes in disability in patients with both relapsing-remitting and primary progressive MS. It is most appropriate for use with MS patients who have mild, moderate, to severe functional disability, but is probably not appropriate for use with the most able bodied and very severely disabled patients where the tool may exhibit “ceiling” (saturation at the top end) and “floor” (saturation at the bottom end) effects. Further research and use of the tool with different groups of MS patients will reveal its clinical utility in due course.

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Table 1 The 14 test items and the other assessments which incorporate each

ITEM No.	TEST	ASSESSMENT REFERENCE
14.	Stand on L. and R. lower limbs with no upper limb support (5 secs each)	21, 34, 35, 36
13.	50 metres unaided walk	13 (walk =40 m),
12.	Transfer from the floor up to standing with no upper limb aid.	21, 34,
11.	Transfer from standing down to the floor with no upper limb aid.	21
10.	Transfer from unsupported sitting to standing with no upper limb aid.	13, 21, 33, 37, 38
9.	50 m aided walk	39
8.	20 m aided walk	3, 21 (walk=15m), 40
7.	Stand no support (60 sec)	none
6.	Stand no support (30 sec)	21, 41
5.	Transfer from bed to chair without upper limb aid	21, 33, 42, 43, 44, 45
4.	Transfer from chair to bed without upper limb aid.	21, 42
3.	Sit no support (60 sec)	21, 33 (time=2 min), 37, 46
2.	Roll from supine to L. and then to R. side lying.	13, 21, 33, 37, 46
1.	Roll from supine lying to one side.	13, 21, 33, 37, 46

Table 2 Co-efficients of Scalability (CS) and Reproducibility (CR): 14 test items at Stage 1

Patient Group	CS Items	CS Subjects	CR
Primary progressive (N = 30)	0.68	0.71	0.93
Relapsing-remitting (N = 38)	0.71	0.62	0.95

Table 3. Co-efficients of Scalability (CS) and Reproducibilty (CR): 14 test items at Stage 2

Patient Group	CS Items	CS Subjects	CR
Primary progressive (N = 30)	0.76	0.78	0.95
Relapsing-remitting (N = 38)	0.74	0.67	0.96

Table 4. A Unidimensional Scale for the Assessment of Motor Disability in Multiple Sclerosis Patients

11. Unsupported unilateral stance (L. and R. 5 seconds each).

10. Unaided 50 metre walk.

9. Rise from the floor to stand without upper limb aid.

8. Get down to the floor from standing without upper limb aid.

7. Rise from unsupported sitting to standing without upper limb assistance.

6. Walk 50 metres using aid.

5. Walk 20 metres using aid.

4. Unsupported standing for 30 seconds.

3. Roll from supine to side lying in both directions.

2. Transfer from bed to chair without assistance.

1. Unsupported sitting for 60 seconds.

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