Spinal Cord (2011) 49, 838–843

www.nature.com/sc

ORIGINAL ARTICLE

Assessment of unsupported sitting in patients with spinal cord injury

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Study design: Cross-sectional study using a consecutive sample.
Objectives: To modify the Motor Assessment Scale (MAS) item 3 'balanced sitting' and the Sitting Balance Score (SBS) to ensure suitability for patients with spinal cord injury (SCI), and to assess the inter-rater reliability and validity of these instruments.
Setting: Spinal Care Unit, clinical setting.
Methods: Unsupported sitting was tested by three physiotherapists using MAS and SBS in 48 in-patients with SCI. The validity of the scales was tested using neurological level and extent of injury according to the International Standards for Neurological Classification of Spinal Cord Injury, time since injury and the patients' function, as measured by Functional Independence Measure (FIM) item 9–13 and Five Additional Mobility and Locomotor Items (5AML).
Results: The inter-rater reliability was for MAS ($k_w = 0.83$–0.91) and for SBS ($k_w = 0.69$–0.96). The correlation between the balance scales were in relation to; neurological injury level ($r_s = 0.19$–0.51), extent of injury ($r_s = 0.57$–0.68) and the functional tests as measured by FIM items 9–13 ($r_s = 0.13$–0.68, highest for going up and down stairs) and 5AML ($r_s = 0.10$–0.49). The spread of data on the scales was poor.
Conclusion: The inter-rater reliability of MAS and SBS was very good. The validity was little to moderate, probably because the chosen functional tests measured complex functional tasks and not only unsupported sitting. Both tests appear to be feasible in clinical settings, but will need major revisions. These results can therefore be used as a base for constructing new, better tests of unsupported sitting.
Spinal Cord (2011) **49**, 838–843; doi:10.1038/sc.2011.9; published online 1 March 2011

Keywords: agreement; outcome assessment; sitting balance; spinal cord injury; unsupported sitting; validity

Introduction

Many persons with spinal cord injury (SCI) are dependent on wheelchairs and for them, good sitting balance is essential in activities of daily life. However, loss or partial loss of muscle strength and sensory input in the trunk and/or the limbs leads to reduced control of sitting balance.

Balance or postural control can be defined as the ability to control the centre of mass in relation to the base of support[1] and requires complex interactions of musculoskeletal and neural systems. Balance control can be divided into three main elements:[2] the ability to

(1) Maintain a posture (static);
(2) Keep control of balance during voluntary movements (proactive);
(3) Regain control after unforeseen loss of balance (reactive).

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Received 18 May 2010; revised 17 December 2010; accepted 11 January 2011; published online 1 March 2011

To make a good evaluation of the balance control in patients with SCI, it is important to assess all three elements. As balance control is task specific, it is equally important that the assessment is carried out in positions frequently used in daily life.

There are several assessment instruments measuring balance control in different positions, most of them targeted at elderly people or persons with stroke.[3,4] There is, however, no accepted, easy to use, valid and reliable instrument available to describe and evaluate sitting balance control in patients with SCI. The 'Functional Reach Test',[5] a test for proactive balance control by reaching forward in the standing position, is the only known test modified to fit sitting patients with SCI.[6] It has been shown to be reliable, but has not yet been verified for validity. Bolin *et al.*[7] also showed that different patients use different strategies when reaching. Thus, there is a need for better standardization before using this test in clinical settings. As this test only measures the person's ability to reach forward, it does not really reflect the person's ability to reach in other directions, and sit unsupported which is essential in a range of daily activities.

Because of the lack of valid and reliable tests to assess unsupported sitting for patients with SCI, feasible in a clinical setting, the objective of this study was to modify two assessment scales developed for stroke patients to ensure suitability for patients with SCI, and then to assess the inter-rater reliability and validity of these instruments.

Materials and methods

Patients

The population was patients with SCI, classified as American Spinal Injury Association Impairment Scale (AIS) A–D according to the International Standards for Neurological Classification of Spinal Cord Injury,[8] and wheelchair dependent >50% of their time. Participants had to be able to sit unsupported for at least 10 s and able to cooperate. Exclusion criteria were use of an external brace, orthopaedic problems influencing unsupported sitting and pressure ulcers on the buttocks.

The participants were included consecutively from a total of 285 in-patients with SCIs admitted to Sunnaas Rehabilitation Hospital in the periods February–June and September–November 2009. The participant's age, body height, time since injury, motor injury level and AIS were recorded.

The sample size for weighted κ was calculated as $2c$,[2] where c is the number of categories. According to the inclusion criteria, we planned not to use score 1 in the Motor Assessment Scale (MAS). This sample size showed that 50 patients were necessary when using five categories in MAS.[9]

Fifty patients were included, two declined to participate leaving 48 (37 men and 11 women) in the study group. Median age was 47 (range 18–69) years and median time since injury was 6 years (range: 3 months–48 years). The distribution of neurological level and AIS is shown in Figure 1. The highest neurological injury level was C5 and the lowest L1. Two patients with two anatomical injury sites were analysed according to the level that clinically dominated balance performance.

Assessment scales

The main criteria for the choice of balance scales were that they should be easy to carry out in a clinical setting, that is, take limited time to perform and need little equipment. After a literature search, two different tests of unsupported sitting were chosen: MAS item 3 'balanced sitting'[10] and Sitting Balance Score (SBS).[11]

MAS consists of six different items. It is a six-point ordinal scale where the scores of each item are ranked in order of difficulty. The patient is scored on the best of three attempts. It assesses static and proactive sitting balance control and takes ~10 min to perform, less if the patient cannot perform all tasks. The reliability has been found to be good[12] and, construct validity has been found to be good for the total score, but variable for individual items in stroke patients.[4] MAS has been translated into Norwegian.[13]

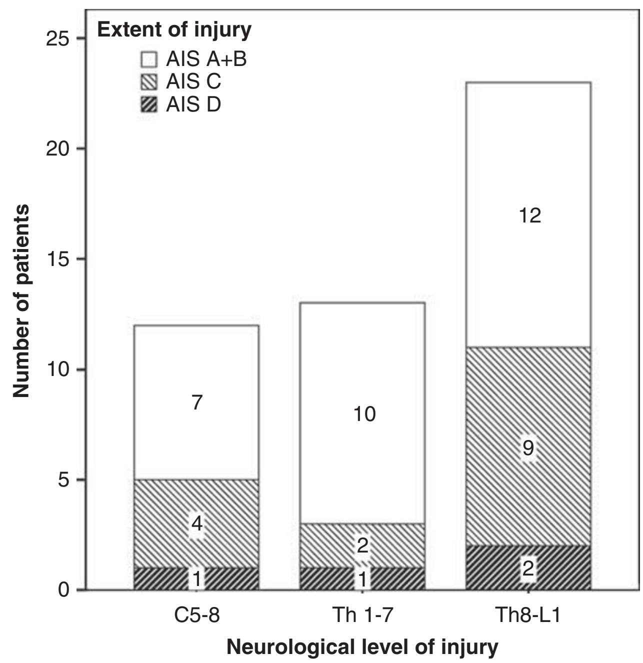

Figure 1 Distribution of neurological level and extent of injury of the patients included in the study. C, cervical; L, lumbar; Th, thoracic.

SBS is a four-point ordinal scale testing static and reactive balance control, originally constructed for stroke rehabilitation prognosis. The test takes <2 min to perform. It has been found to have good reliability in patients with stroke, but has not been tested for validity.[3]

To use these balance scales in patients with SCI, both scales were slightly modified by the physiotherapists in the SCI unit, according to motor impairments seen in this patient group (Box 1, 2).

To assess the validity, we chose to analyse the relationship between the tests of unsupported sitting versus neurological injury level, AIS,[8] time since injury and two functional assessment scales: the Functional Independence Measure (FIM) items 9–12 (bed transfer, toilet transfer, wheelchair mobility and going up and down stairs),[14] and the Five Additional Mobility and Locomotor Items (5AML) (push on ramp, push on flat, bed transfer, negotiate kerbs and vertical transfer).[15] The 5AML is regarded as an extension of FIM and captures functional aspects related to mobility and wheelchair skills.

Procedure

The two scales for unsupported sitting and the test procedure were pilot tested on four persons with SCI with different neurological levels and AIS before the start of the study. All testers were trained in the final testing procedure before patients were enrolled in the study. The 'nudge' to be used in SBS was practiced by nudging a pendulum with a 1-kg sandbag 1 m horizontally with the required force (7–14 Nm or 1 kg) with both right and left hand.

Box 1 Motor Assessment Scale (MAS) item 3 'balanced sitting'[a]

Score	Original	Modifications (in italics) used in this study
1	Sits with support only	Sits with support only
2	Sits unsupported for 10 s	Sits unsupported for 10 s
3	Sits unsupported with weight well forward and evenly distributed	Sits unsupported with weight well forward and evenly distributed
4	Sits unsupported, turns head and trunk to look behind	Sits unsupported, turns head and trunk to look behind
5	Sits unsupported, reaches forward to touch the floor and returns to the starting position	Sits unsupported, reaches forward to touch the floor and returns to the starting position *without use of arms for support*
6	Sits on stool unsupported, reaches sideways to touch floor	Sits on stool unsupported, reaches sideways to touch floor, *reaching distance from wrist to floor defined to be maximum 20 cm, and returns to starting position*

Starting position: sitting on plinth with 90° flexion in knees and hips, back unsupported, feet on floor.[10]
[a]Scores 1–3 are mainly related to static balance control, while scores 4–6 are mainly related to proactive balance control.

Box 2 Sitting Balance Score (SBS)

Score	Original	Modifications (in italics) used in this study
1 (poor)	Unable to maintain a static position	Unable to maintain a static position
2 (fair)	Able to maintain a static position without difficulty but requiring assistance in all righting tasks	*Able to maintain a static position but requiring assistance in all righting tasks*
3 (good)	Able to maintain a static position without difficulty, but requiring assistance in righting from the hemiplegic side	*Able to maintain a static position, but requiring use of hands for support when nudged*
4 (normal)	Able to perform the testing without any physical assistance	Able to perform the testing without any physical assistance *and without use of hands for support*

Starting position: sitting on a hospital bed (modified: *plinth*), feet on the floor, back unsupported, hands on the lap (modified: *or loose along the side*). If the patient can hold this position without assistance for 15 s, he/she is nudged by physiotherapist anteriorly, posteriorly and laterally (modified: *laterally, posteriorly and anteriorly**) using ~5–10 foot pounds (7–14 Nm) of force.[11]
[a]The order of the nudge was altered, starting with lateral nudge which clinically was expected to be the easiest and ending with the nudging anteriorly, which was expected to be most difficult to perform for the patients.

Inter-rater reliability
Three experienced physiotherapists performed the tests of unsupported sitting. The testing order of the therapists was block randomised and the testers were blinded to each other's results. All three therapists performed the tests one after the other in the same session, lasting ~30 min for each patient.

The patient sat on a plinth with feet firmly placed on the floor, thighs supported on the plinth and back unsupported. To let the patient experience balance control during voluntary movements, MAS was always performed before SBS. The patients were instructed not to give any information to the next therapist concerning the results of the testing already done. If necessary, the patients were allowed to lie down to rest between each test.

Validity
The functional testing was performed by another experienced physiotherapist in a separate session. This therapist was not blinded to the results of the MAS or SBS. Items in the functional testing that were inappropriate or previously not attempted by the patients were not included. The ramps described in 5AML were not available, so this test was modified to fit a ramp in the hospital and, for practical reasons, the patients did not descend the ramp. Only the time used in the ascent was recorded.

Statement of ethics
We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

Data analysis
The statistics were performed in SPSS 15.0 for Windows (Sunnaas Rehabilitation Hospital, Nesoddtangen, Norway). All data were analysed using non-parametric tests. Both balance scales are ordinal scales and hence κ with linear weights (κ_w) with 95% confidence intervals, was used in analysing inter-rater reliability.[16] Interpretation of the weighted κ was done as follows: slight 0.00–0.20, fair 0.21–0.40, moderate 0.41–0.60, substantial 0.61–0.80 and almost perfect 0.81–1.00.[16] Spearman's ρ correlation coefficient (r_s) was used for assessing validity of MAS and SBS scale and was interpreted as follows: little, if any 0.00–0.25, low 0.26–0.49, moderate 0.50–0.69, high 0.70–0.89 and very high 0.90–1.00.[17]

Results

Inter-rater reliability
The inter-rater reliability was almost perfect for MAS ($\kappa_w = 0.83$–0.91) and substantial to almost perfect for SBS ($\kappa_w = 0.69$–0.96) (Table 1). The lower end of all 95% confidence interval was at least moderate and all above $\kappa_w = 0.50$.

The majority of scores on MAS were 2 and 4 with very few patients scoring 3 as shown in Table 2. On SBS a majority of patients were given score 3. This was anticipated; therefore, the nudges in the different directions were recorded separately. Analysis showed a similar inter-rater reliability when splitting score 3 into those who managed nudges in three directions without arm support and those who did not ($\kappa_w = 0.63$, 0.79 and 0.72).

A few patients were given score 1 on MAS and SBS as at least 10 s independent sitting was an inclusion criteria in this study. However, three patients with cervical lesions were given this score by at least one tester.

Validity
The correlation between MAS and SBS was high for all the testers ($r_s = 0.78$, 0.85 and 0.77). As an example, the scores for one tester are shown in Table 2.

The correlations between neurological levels of injury, when divided into three levels (C5-8, Th1-7 and Th8-L1), and MAS and SBS were mostly low for SBS ($r_s = 0.19–0.37$) and moderate for MAS ($r_s = 0.43–0.51$). For AIS, the correlations with MAS and SBS were moderate to high ($r_s = 0.57–0.68$) (Table 3; Figure 2).

The correlations between time since injury and MAS and SBS were low, if any (MAS: $r_s = 0.14–0.21$) (SBS: $r_s = 0.24–0.26$).

Table 1 Inter-rater reliability (κ coefficients with linear weighting and 95% confidence intervals (CIs)) for the two tests of unsupported sitting, Motor Assessment Scale (MAS) item 3 and Sitting Balance Score (SBS), for testers A, B and C

Testers	*n*[a]	*MAS*		*SBS*	
		κ_w	*95% CI*	κ_w	*95% CI*
A and B	41	0.83	0.72–0.93	0.72	0.56–0.89
A and C	36	0.91	0.84–0.99	0.96	0.89–1.0
B and C	41	0.83	0.73–0.94	0.69	0.52–0.85

[a]Although 48 patients participated, the maximal tested patients of one pair of testers were 41.

Table 2 Cross-tabulation showing the distribution of scores from Motor Assessment Scale (MAS) item 3 and Sitting Balance Score (SBS) from tester A ($n = 47$; $r_s = 0.78$)

		SBS				*Total*
		1	*2*	*3*	*4*	
MAS score	1	2	0	0	0	2
	2	0	1	18	1	20
	3	0	0	4	0	4
	4	0	0	7	3	10
	5	0	0	0	6	6
	6	0	0	0	5	5
	Total	2	1	29	15	47

Both MAS score and SBS showed low to moderate correlations ($r_s = 0.34–0.50$) with the FIM tests of bed transfer, and moderate to high ($r_s = 0.60–0.68$) for going up and down stairs. For the other functional tests the correlation was little to low ($r_s = 0.13–0.49$), among which pushing on ramp showed the best correlation (Table 4).

Discussion

The main findings were that the inter-rater reliability for MAS and SBS was very good, but the validity was little to moderate. Poor spread of data could have influenced results.

The inter-rater reliability was somewhat lower for SBS than for MAS, which might be caused by the nature of the test. The nudge is difficult to standardize regarding the pushing force and the speed to be used. Depending on how the test was performed, one might also question if it really was a true test of reactive balance control. The nudge was applied in the same order, in three subsequent tests. This testing procedure could have contributed to the lower reliability, as the patient might have been able to anticipate the direction of the nudge in the second or third test. A majority of patients were given score 3 on SBS which might indicate low sensitivity of this scale for SCI patients. We believe it could be useful to include a score between score 3 and 4, to better distinguish between different levels of unsupported sitting as the patient in score 3 is allowed to use hand support in all directions, while no hand support is allowed in score 4. Despite the good reliability, the poor spread of data in both scales may indicate a need for further adaptations.

The MAS scores had higher correlations than the SBS with neurological injury level. However, both the MAS score and the SBS had almost equal correlations with the AIS. Other studies have shown similar correlations with other balance tests,[6,18,19] although Lynch *et al.*[6] did not manage to differentiate between high thoracic and cervical lesions. The correlation between MAS score and SBS and neurological injury level might be confounded by low numbers, poor spread on SBS and uneven distribution of both neurological levels and AIS.

Time since injury showed low correlation with both MAS and SBS. This is in contrast to Boswell-Ruys *et al.*[19] who found that their test battery discriminated between patients with acute and chronic (>1 year) SCI. An explanation for this might be an uneven distribution of both neurological levels and AIS in our group.

Table 3 Spearman's ρ correlation coefficients (r_s) between the tests of unsupported sitting, Motor Assessment Scale (MAS) item 3 and Sitting Balance Score (SBS), and the level and extent of injury (AIS)

	Tester A			*Tester B*			*Tester C*		
	MAS	*SBS*	n	*MAS*	*SBS*	n	*MAS*	*SBS*	n
Neurological level of injury (categories: C5-8, Th1-7, Th8-L1)	0.51**	0.21	47	0.46**	0.37*	42	0.43**	0.19	42
Extent of injury (categories: AIS A and B, AIS C, AIS D)	0.68**	0.67**	47	0.61**	0.57**	42	0.63**	0.66**	42

Abbreviations: AIS, American Spinal Injury Association Impairment Scale; C, cervical; L, lumbar; Th, thoracic.
*$P<0.05$, **$P<0.01$.

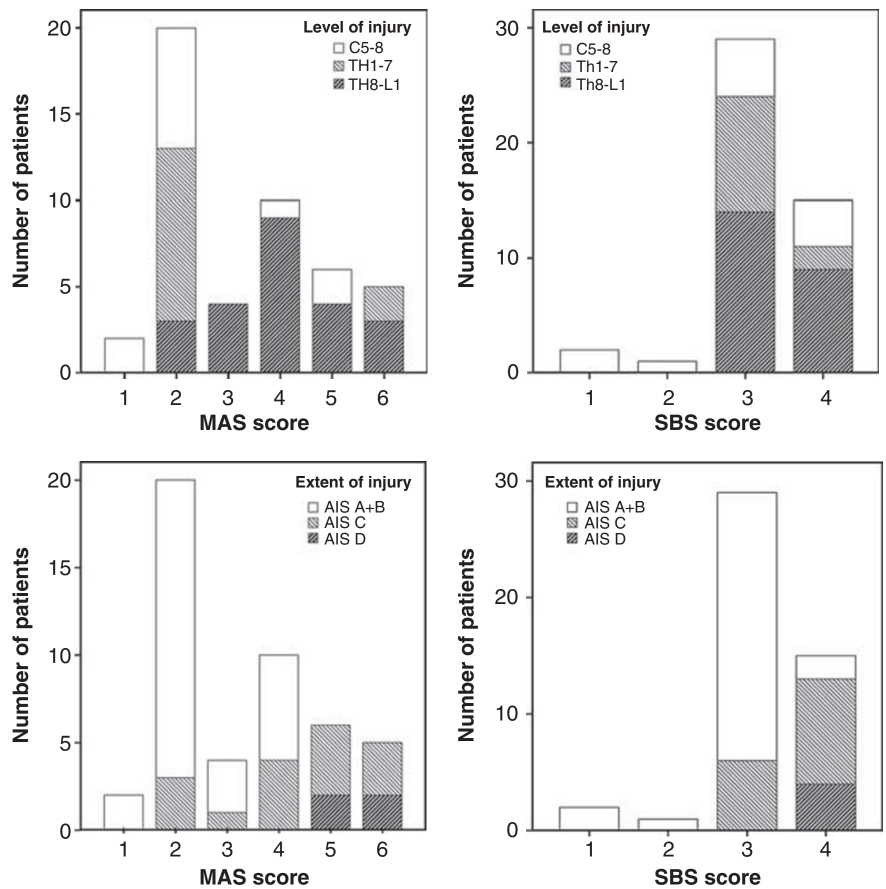

Figure 2 Motor Assessment Scale (MAS) item 3 and Sitting Balance Score (SBS) for tester A in relation to neurological level and extent of injury in 48 patients with SCI. C, cervical; L, lumbar; Th, thoracic.

Table 4 Spearman's ρ correlation coefficients (r_s) and significance level for the correlation between Motor Assessment Scale (MAS) item 3 and Sitting Balance Score (SBS) versus the functional tests FIM, items 10, 12, 13, 14 and 5AML

	Tester A			*Tester B*			*Tester C*		
	MAS	*SBS*	*n*	*MAS*	*SBS*	*n*	*MAS*	*SBS*	*n*
FIM item 9 'bed transfer'	0.42**	0.42**	46	0.42**	0.34*	41	0.49**	0.50**	41
FIM item 10 'toilet transfer '	0.17	0.13	37	0.20	0.15	32	0.27	0.19	32
FIM item 12 'mobility wheelchair/walking'	−0.18	−0.21	46	−0.18	−0.20	41	−0.19	−0.22	41
FIM item 13 'going up and down stairs'	0.68**	0.68**	46	0.67**	0.60**	41	0.65**	0.63**	41
5AML item 1 'bed mobility'	0.23	0.26	44	0.15	0.25	39	0.20	0.27	40
5AML item 2 'vertical transfer'	0.32	0.30	26	0.34	0.35	25	0.30	0.36	23
5AML item 3 'push on the flat'	0.27	0.10	40	0.22	0.16	37	0.29	0.10	36
5AML item 3 'push on the flat' in seconds	−0.33*	−0.14	38	−0.26	−0.16	35	−0.42*	−0.20	33
5AML item 4 'push on the ramp' in seconds	−0.42**	−0.23	38	−0.33	−0.27	35	−0.49**	−0.28	34
5AML item 5 'negotiate kerbs'	0.36*	0.16	39	0.18	0.10	36	0.37*	0.18	35

Abbreviations: FIM, Functional Independence Measure; 5AML, Five Additional Mobility and Locomotor Items.
*$P<0.05$, **$P<0.01$.

The validity was found to be variable, and overall not so good, probably due to the fact that the chosen functional tests measured complex functional tasks involving other motor functions besides balance control. The best correlations were obtained for transfer to and from a bed and going up and down stairs. Bed transfer involves moving the upper body over the base of support, thus can be regarded as a task demanding balance control. Going up and down stairs was only possible for patients with remaining gait function and, therefore, patients with higher scores on this item had more intact muscles in the lower body. Some of the functional tasks were not applicable for all of the patients, so fewer patients completed these tests, resulting in less reliable scores. Upper body dressing, the T-shirt test, which has shown to have a good correlation with sitting balance,[18,19] might have been a better test of unsupported sitting than the functional tasks used in this study. We could also have used the modified Functional Reach Test to study it's relationship with MAS and SBS. The Functional Reach Test has in a recent study shown high correlation with centre of pressure excursion.[20] However, considering overstraining the patients with many tests, we chose not to do this.

Patients unable to sit without support for at least 10 s were of practical reasons, excluded from this study. Despite this criterion, three patients were given score 1 on MAS and SBS. Therefore, our statistical calculations of the weighted κ coefficients were made with six categories instead of the planned five categories causing a somewhat lower power for MAS. Although score 1 in MAS and SBS was regarded an exclusion criteria in this study, we still consider them relevant to record for those patients who are unable to sit without support.

Both MAS and SBS were regarded quick and easy to perform by the testers. However, some difficulties in the scoring were detected. The starting position, sitting unsupported as required in both tests, might be difficult to judge, at least with the hands on the lap position as in SBS. Compensation for lack of balance control using a light pressure of hands on the thighs was discouraged. Thus, the patient was asked to hold the arms along the side of the body whenever the therapist was uncertain whether the patient's hands were relaxed. MAS score 3 was difficult to judge for the testers. To score at this level the patient should be able to sit unsupported with the weight well forward and evenly distributed, which is difficult for patients with paralysed muscles in the trunk. This resulted in few patients scoring 3 as they were not able to tilt their pelvis forwards, although, they might have been able to rotate their upper body, as required in score 4. The score 3, therefore, seems less suited for patients with SCI, as it might not fit with the hierarchical structure of the scale for this patient group.

Patients with preserved muscle function in lower limbs might have used lower limb muscles to recover balance. As this reflects the patient's function, this was not considered a problem as long as the feet were kept stationary during the testing.

Conclusions

Two instruments to assess unsupported sitting, the MAS item 3 'balanced sitting' and the SBS, were adapted for patients with SCI. The inter-rater reliability was very good, but the validity was found to be variable. Poor spread of data might have influenced the results. However, both tests appear to be feasible in a clinical setting. As both scales will need major revisions and therefore probably no longer can be considered only modifications of original scales, the results of this study can be used as a base for constructing new and better tests of unsupported sitting in patients with SCI.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

We acknowledge financial support from Oslo University College, Faculty of Health Sciences. We thank the patients, students and the physiotherapists on the spinal unit at Sunnaas Rehabilitation Hospital for their participation in and contribution to this study.

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