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ORIGINAL ARTICLE

United States (US) multi-center study to assess the validity and reliability of the Spinal Cord Independence Measure (SCIM III)

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Study design: Multi-center, prospective, cohort study.
Objectives: To assess the validity and reliability of the Spinal Cord Independence Measure (SCIM III) in measuring functional ability in persons with spinal cord injury (SCI).
Setting: Inpatient rehabilitation hospitals in the United States (US).
Methods: Functional ability was measured with the SCIM III during the first week of admittance into inpatient acute rehabilitation and within one week of discharge from the same rehabilitation program. Motor and sensory neurologic impairment was measured with the American Spinal Injury Association Impairment Scale. The Functional Independence Measure (FIM), the default functional measure currently used in most US hospitals, was used as a comparison standard for the SCIM III. Statistical analyses were used to test the validity and reliability of the SCIM III.
Results: Total agreement between raters was above 70% on most SCIM III tasks and all κ-coefficients were statistically significant ($P<0.001$). The coefficients of Pearson correlation between the paired raters were above 0.81 and intraclass correlation coefficients were above 0.81. Cronbach's-α was above 0.7, with the exception of the respiration task. The coefficient of Pearson correlation between the FIM and SCIM III was 0.8 ($P<0.001$). For the respiration and sphincter management subscale, the SCIM III was more responsive to change, than the FIM ($P<0.0001$).
Conclusion: Overall, the SCIM III is a reliable and valid measure of functional change in SCI. However, improved scoring instructions and a few modifications to the scoring categories may reduce variability between raters and enhance clinical utility.
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Keywords: SCIM; FIM; spinal cord injury; functional outcome measure; reliability; validity

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Introduction

In the past two decades, there have been great strides made in understanding the biological changes resulting from spinal cord injury (SCI). The future holds promise for the development of therapies that will promote degrees of repair and recovery of function for people living with SCI. Lessons learned from the past 'failed' SCI clinical trials, however, demonstrate that, in order to accurately evaluate the overall effectiveness of SCI therapies, more functionally relevant outcome measures are needed to measure minimal yet clinically important differences. Specifically, the Spinal Cord Independence Measure (SCIM), has been recommended for further testing and development for use as a measure of functional ability in future SCI clinical trials. A panel of SCI researchers recommended the SCIM as the most suitable among four candidate measures of functional recovery reviewed as a special initiative of the National Institute on Disability and Rehabilitation Research.[1] It was recommended that a large-scale, multi-center, prospective trial be conducted in the US, which would mirror a recently published multi-center international study by the developers of the SCIM.[2,3] Reasons that this study be conducted in the US include: (1) the US healthcare system is very different from the international healthcare systems and poses a challenging environment for introducing a new functional outcome measure to replace the Functional Independence Measure (FIM) and (2) all published studies, at least to that point in time (through 2005), evaluating the validity and reliability of the SCIM had been conducted by the developers of the instrument.

Therefore, the current study was conducted using the SCIM III, the latest version of the SCIM, to test the hypothesis that the SCIM III is a valid and reliable measure of functional ability in persons with SCI. The first aim was to examine the reliability of SCIM III evaluations. The second aim was to examine the validity of the SCIM III as an outcome measure to assess functional ability in persons with SCI. An additional component of the study was to determine whether more detailed training instructions were needed to properly administer the SCIM III.

Materials and methods

Participating sites were selected either because they were part of the Model SCI Systems or the Commission on Accreditation of Rehabilitation Facilities-accredited Spinal Cord System. The University of California at Irvine was the coordinating center for 19 enrolling centers. Institutional Review Board approval was obtained from all sites. We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research. Subject selection was prospective but was not randomized.

Participants

Participants could have any level of SCI, with a traumatic or non-traumatic cause and American Spinal Injury Association Impairment Scale grade A, B, C, or D. They had to be at least 18 years of age and undergoing their initial inpatient rehabilitation stay. Participants were excluded if they had any cognitive impairment or any additional condition, other than SCI and SCI-related secondary conditions, which may have influenced everyday function. All subjects started the study within 1 week after being admitted for their initial inpatient rehabilitation.

Procedures

The data collection time points were within the first week of admission to rehabilitation and within the last week before being discharged. Sites were given minimal direction in regard to performing the SCIM III evaluation. They were to follow the instructions on the SCIM III worksheet and to use clinical judgment to solve questions. On the basis of clinical judgment, if a task was deemed unsafe to test, in particular at admission, evaluators were instructed to mark the task as not testable. SCIM III evaluation was performed by direct observation at each time point by two staff members of one of the following professions: nursing, occupational therapy, physical therapy, clinical research, or psychiatry. Both staff members performed the evaluations independently, within 1 week of each other and blind to each other's findings. Specific tasks within self-care and sphincter control, that a rater may not have been able to directly observe during examination, were scored according to information obtained from a staff member observing the subject performing the task during the same week. FIM evaluations were performed upon admission and discharge, according to each site's standard operating procedure for the FIM. Additional information obtained from medical charts include: complete American Spinal Injury Association Impairment Scale grade and motor/sensory scores, gender, year of birth, date of injury onset, injury etiology, date of admission to rehabilitation, date of discharge from rehabilitation, surgical operations from time of injury until discharge from rehabilitation and immobilization devices. Each site was provided with an Excel template file into which all de-identified subject data were entered and electronically transmitted to University of California at Irvine every 3 months during the enrollment period. Data from all sites were pooled for analyses.

Data analyses

All statistical analyses were conducted by a senior statistician at the University of California at Irvine Center for Statistical Consulting. The level of significance was set at 0.05. For comparison purposes, the statistical methods used in the present study were based on those used in the original study to be replicated,[3] rather than using more appropriate non-parametric tests.

Inter-rater reliability was demonstrated by (1) percentage of examinations in which the task scores assigned by the two raters were identical (total agreement), (2) the chance-corrected measure of agreement on tasks (weighted Cohen's-κ), (3) Pearson's coefficients of the correlation between the two raters' scores for each subscale, (4) *t*-tests between the two

Table 1 Demographic and clinical characteristics

N	*Mean age at injury (± s.d.)*	*Male (%)*	*Female (%)*	*Traumatic (%)*	*Non-traumatic (%)*	*Tetraplegia (%)*	*Paraplegia (%)*	*AIS A (%)*	*AIS B (%)*	*AIS C (%)*	*AIS D (%)*
390	45.3 ± 17.9	294 (75.4)	96(24.6)	270 (69.2)	120 (30.8)	187 (47.9)	203 (52.1)	135 (34.6)	54 (13.8)	80 (20.5)	121 (31.0)

Abbreviation: AIS, American Spinal Injury Association Impairment Scale.

Table 2 Percentage of agreement between raters plus weighted κ-values

SCIM III tasks	*Admission*		*Discharge*	
	% Agreement	*κ-Values*	*% Agreement*	*κ-Values*
Feeding	84	0.85	85	0.80
Bathing—upper body	72	0.68	73	0.70
Bathing—lower body	78	0.67	79	0.77
Dressing—upper body	65	0.63	67	0.71
Dressing—lower body	73	0.61	70	0.75
Grooming	78	0.76	80	0.75
Respiration	81	0.73	90	0.70
Bladder—sphincter	72	0.76	72	0.81
Bowel—sphincter	71	0.56	69	0.60
Use of toilet	80	0.65	74	0.79
Mobility in bed	68	0.67	75	0.78
Transfer—bed/wheelchair	86	0.74	86	0.79
Transfer—wheelchair/toilet	85	0.70	84	0.74
Mobility indoors	77	0.73	80	0.81
Mobility moderate distances	77	0.70	78	0.79
Mobility outdoors	75	0.67	76	0.74
Stair management	95	0.71	86	0.79
Transfer—wheelchair/car	93	0.69	83	0.71
Transfer—ground/wheelchair	99	0.59	94	0.67

Abbreviation: SCIM III, Spinal Cord Independence Measure III.
$N = 398$.

raters' mean scores for the each subscale, and (5) the intraclass correlation.

Internal consistency was demonstrated by Cronbach's-α coefficient. Values of Cronbach's-α exceeding 0.7 supported reasonable internal consistency.

Criterion-related validity of the SCIM III was evaluated by Pearson correlation between total FIM and SCIM III scores at admission and discharge. Responsiveness to change was evaluated by McNemar test comparing SCIM III subscales scores with FIM tasks that matched those subscales.

Results

A total of 463 subjects were enrolled in the study and complete data were collected on 390 of those individuals. All subjects were enrolled sequentially at each site. Demographic and clinical data for participants are provided in Table 1.

SCIM III reliability

Inter-rater reliability was evaluated by percent agreement between raters and weighted Cohen's κ-coefficients (Table 2). At admission, total agreement between raters ranged between 65–99%; in 17 of 19 tasks total agreement was above 70%, but only in 8 of 19 tasks was total agreement above 80%. The κ-coefficients ranged from 0.56 to 0.85 and were statistically significant for all tasks ($P<0.001$). There was slightly less variability at discharge, with total agreement between raters ranging between 67–94%. The κ-coefficients ranged from 0.60–0.81 and were statistically significant for all tasks ($P<0.001$).

Pearson correlation coefficients of the paired raters for SCIM III subscales were above 0.81 for admission and above 0.89 for discharge ($P<0.001$). For total SCIM III scores, the Pearson correlation coefficient was 0.91 for admission and 0.96 for discharge ($P<0.001$), and the mean differences between the paired raters scores were all statistically non-different (Table 3). Intraclass correlations at admission were above 0.81 for all SCIM III subscales and was 0.91 for the total SCIM III score (Table 4). At discharge, intraclass correlations were higher, above 0.89 for all SCIM III subscales and 0.95 for the total SCIM III score.

Internal consistency was evaluated by Cronbach's-α coefficients (Table 5). Cronbach's-α values for the overall SCIM III scale were above 0.85 for both the first and second raters at admission and discharge. Cronbach's-α decreased or remained the same when any of the subscales was eliminated. The Cronbach's-α coefficients, at admission and discharge, of the self-care subscale was higher than 0.93 and elimination of any of the items decreased the α-coefficient of the subscale. The Cronbach's-α coefficient of the respiration and sphincter management subscale was below 0.7 at admission and just above 0.7 at discharge. Removal of the respiration task increased the subscales' α-coefficient, but removal of any of the other items decreased the subscales' α-coefficient. The Cronbach's-α coefficient of the mobility in room and toilet subscale was above 0.85 for both admission and discharge evaluations, and only elimination of mobility in bed at admission increased the α-coefficient for the mobility in room and toilet subscale. Elimination of any of the other items in the subscale decreased the α-coefficient. The Cronbach's-α coefficient of the mobility indoors and outdoors subscale was above 0.89 for both admission and discharge evaluations, and only at discharge did elimination of transfer from wheelchair to car or transfer from ground to wheelchair increase the α-coefficient for the subscale. Elimination of any of the other items in the subscale decreased the α-coefficient.

SCIM III validity

The Pearson correlation coefficients for the FIM and the SCIM III first rater or the SCIM III second rater were both 0.80 ($P<0.001$). Further evidence of the validity of the SCIM III to measure change between admission and discharge was demonstrated with McNemar's test (Table 6). For all

Table 3 Pearson correlation and paired *t*-test between raters

SCIM subscales	*Admission*						*Discharge*					
	Mean	*s.d.*	r	*P	t	**P	Mean	*s.d.*	r	*P	t	**P
Self-care—rater 1	7.2	5.3	0.88	<0.0001	0.66	0.51	11.4	5.6	0.92	<0.0001	−0.26	0.79
Self-care—rater 2	7.2	5.5					11.4	5.7				
Respiration and Sphincter—rater 1	15.8	8.8	0.86	<0.0001	−0.22	0.83	25.5	10.1	0.89	<0.0001	−0.86	0.39
Respiration and Sphincter—rater 2	15.9	8.8					15.3	10.2				
Mobility in the Room—rater 1	3	3	0.81	<0.0001	−0.17	0.87	5.8	3.7	0.89	<0.0001	1.14	0.25
Mobility in the Room—rater 2	3	2.9					5.9	3.5				
Mobility indoors/outdoors—rater 1	3.7	4	0.82	<0.0001	1.75	0.08	7.8	5.8	0.93	<0.0001	0.89	0.38
Mobility indoors/outdoors—rater 2	3.5	3.4					7.9	5.9				
SCIM total—rater 1	29.8	17.7	0.91	<0.0001	0.61	0.54	50.6	21.7	0.96	<0.0001	−0.11	0.91
SCIM total—rater 2	29.6	16.9					50.5	22.1				

Abbreviations: SCIM III, Spinal Cord Independence Measure III; r, correlation value; *t*, paired *t*-test value.
N = 389.
**P*, significance level of r; ***P*, significance level of *t*.

Table 4 Intraclass correlations (ICC) on SCIM III subscales

Category	*Admission*		*Discharge*	
	ICC	*95% CI*	*ICC*	*95% CI*
Self-care subscale	0.88	0.85–0.92	0.92	0.89–0.95
Respiration and sphincter subscale	0.86	0.82–0.90	0.89	0.86–0.92
Mobility in room and toilet subscale	0.81	0.77–0.85	0.89	0.86–0.92
Mobility indoors and outdoors subscale	0.81	0.77–0.85	0.93	0.90–0.96
SCIM III total	0.91	0.88–0.94	0.95	0.93–0.97

Abbreviations: SCIM III, Spinal Cord Independence Measure III; CI, confidence interval.
N = 389.

subscales, the SCIM III was in agreement with the FIM in responding to functional change ($P<0.0001$). For the respiration and sphincter management subscale, the SCIM III was more responsive to change than the FIM ($P<0.0001$). There was also agreement between raters, further demonstrating reliability.

Discussion

This study was a successful replication of the Itzkovich *et al*. study.[3] We have demonstrated, independent of the SCIM developers, that in a large heterogeneous population, the SCIM III is a valid and reliable measure of functional recovery for SCI. However, there are some aspects that should be addressed to improve its clinical utility and internal consistency.

In regard to inter-rater reliability, our study revealed a greater degree of variability between raters than reported by Itzkovich *et al*.[3] Their percent agreement between raters ranged from 75–96% and there was agreement above 80% for 13 of the 19 tasks, whereas the percent agreement between our raters ranged from 65–99% and was agreement above 80% for only 8 of the tasks. We attribute this greater variability between raters to insufficient scoring instructions provided on the worksheet.

The greatest number of questions from raters across all of the sites had to do with the interpretation and broadness of 'requires partial assistance', which is applicable to the majority of the tasks in the SCIM III. According to current instructions, an individual who requires maximum assistance would score the same as an individual who requires hands off assistance/supervision, yet would be significantly different in terms of independence. That is something that is a critically important component of functional recovery and should be weighted accordingly in the outcome measure. One suggestion would be to split anything with 'requires partial assistance' into multiple categories, such as 'requires 50% or more assistance', 'requires 50% or less assistance' and 'requires supervision or device only'. This would apply across all of the subscales. The suggested category of 'requires 50% or more assistance' would represent categories 1–2 of the FIM. The suggested category of 'requires 50% or less assistance' would represent categories 3–4 of the FIM. The suggested category of 'requires supervision or device only' would represent categories 5–6 of the FIM. The addition of graded degrees of assistance will be important when trying to capture minimally clinically important differences in clinical trials. These are the kinds of differences that have been missed in past clinical trials and will be missed in current clinical trials, utilizing the American Spinal Injury Association Impairment Scale as the primary endpoint. Choosing categories of assistance that clinical personnel are already familiar with should limit any negative effects on inter-rater reliability. Obviously, that would need to be evaluated in a future clinical study. A list of frequently asked questions and comments throughout the study is included in the Supplementary Material.

Further clarification needs to be provided regarding situations, when it is not deemed safe to have an individual attempt to perform a task. Currently, there are no instructions on the SCIM III worksheet addressing this situation. This is particularly important when using the SCIM III in the acute setting, that is, upon admission to rehabilitation. The number of tasks deemed unsafe at admission is dependent upon the degree of injury, which is complicated by the high

Table 5 Internal consistency (Cronbach's coefficient α) within SCIM III subscales

	Admission α-values		*Discharge α-values*	
	Rater 1	*Rater 2*	*Rater 1*	*Rater 2*
Self-care subscale	0.945	0.950	0.930	0.930
α if item deleted				
Feeding	0.939	0.942	0.914	0.919
Bathing—upper body	0.928	0.930	0.911	0.916
Bathing—lower body	0.933	0.936	0.912	0.913
Dressing—upper body	0.933	0.936	0.908	0.913
Dressing—lower body	0.938	0.938	0.916	0.919
Grooming	0.939	0.937	0.909	0.916
Respiration and sphincter management subscale	0.617	0.615	0.740	0.730
α if item deleted				
Respiration	0.679	0.687	0.798	0.788
Bladder—sphincter	0.461	0.425	0.619	0.565
Bowel—sphincter	0.498	0.511	0.675	0.683
Use of toilet	0.519	0.518	0.622	0.598
Mobility in room and toilet subscale	0.868	0.960	0.900	0.850
α if item deleted				
Mobility in bed	0.963	0.959	0.890	0.784
Transfer—bed/wheelchair	0.706	0.712	0.840	0.822
Transfer—wheelchair/toilet	0.742	0.743	0.849	0.771
Mobility indoors and outdoors subscale	0.949	0.950	0.890	0.900
α if item deleted				
Mobility indoors	0.942	0.943	0.846	0.854
Mobility moderate distances	0.941	0.940	0.849	0.851
Mobility outdoors	0.942	0.942	0.863	0.866
Stair management	0.934	0.935	0.866	0.878
Transfer—wheelchair/car	0.937	0.937	0.904	0.897
Transfer—ground/wheelchair	0.944	0.940	0.912	0.915
SCIM III Total	0.850	0.850	0.890	0.880
α if item deleted				
Self-care	0.796	0.788	0.862	0.847
Respiration and sphincter management	0.851	0.851	0.846	0.831
Mobility in room and toilet	0.772	0.770	0.814	0.809
Mobility indoors and outdoors	0.818	0.804	0.899	0.881

Abbreviation: SCIM III, Spinal Cord Independence Measure III.
$N = 389$.

degree of variability across lesions. This problem must be addressed with more detailed guidelines.

Similar to the results presented by Itzkovich *et al.*,[3] our Cronbach's-α values for the overall SCIM III scale were above 0.85 for both the first and second raters at admission and discharge. One significant component regarding the internal consistency of the SCIM III is the respiration task of the respiration and sphincter management subscale. On the basis of Cronbach's-α values, the respiration task is not contributing to the subscale in either the admission or discharge setting. The majority of participants score either a 0 or 10. The developers should consider revising this task or removing it. Tasks that are more sensitive to change, such as airflow or clearing secretions may be better suited to include as measures of function. Smaller problems were noted regarding the mobility in bed task, transfer from wheelchair to car task, and the transfer from ground to wheelchair task. However, creating multiple categories for partial assistance, as mentioned above, may address those problems.

Our results indicate that the SCIM III is responsive to functional change when compared with the FIM, indicating that the two measures share common components in their underlying construct. The SCIM is more responsive to changes in respiration and sphincter management than the FIM, despite the limitations discussed regarding respiration. This difference is of significant clinical importance, because recovery of function in those tasks is of high priority to the SCI population, particularly sphincter management.[4] The FIM is known to be a measure of burden of care rather than functional recovery for the SCI population[1] and floor/ceiling effects have been described.[5,6] A recent study evaluating the sensitivity of the SCIM III to measure functional change noted some floor/ceiling effects dependent upon injury level, in particular, with the respiration task and some mobility tasks.[7] Perhaps the results and recommendations from that study and the current study can be used to improve the SCIM to the point of becoming the new standard for measuring functional recovery.

Table 6 McNemar's test measuring responsiveness to functional change, between admission and discharge, of the FIM and the SCIM III subscales

Changes identified by FIM	*Changes identified by SCIM III*					
	Rater 1			*Rater 2*		
	No	*Yes*	*Total*	*No*	*Yes*	*Total*
Self-care						
No	11	6	17	12	5	17
Yes	37	335	372	30	342	372
Total	48	341	389	42	347	389
		$S=22.35$; $P<0.0001$			$S=17.86$; $P<0.0001$	
Respiration and sphincter management						
No	28	106	134	24	110	134
Yes	9	246	255	13	242	255
Total	37	352	389	37	352	389
		$S=81.8$; $P<0.0001$			$S=76.5$; $P<0.0001$	
Mobility in room and toilet						
No	27	7	34	26	8	34
Yes	76	279	355	80	275	355
Total	103	286	389	106	286	389
		$S=57.36$; $P<0.0001$			$S=58.91$; $P<0.0001$	
Mobility indoors and outdoors						
No	5	12	17	7	10	17
Yes	46	326	372	48	324	372
Total	51	338	389	55	334	389
		$S=19.93$; $P<0.0001$			$S=13.68$; $P<0.0001$	

Abbreviations: FIM, Functional Independence Measure; S, χ^2-value; SCIM III, Spinal Cord Independence Measure III.

Conclusions and recommendations

Overall, the SCIM III is a valid and reliable measure of functional recovery for persons with SCI. However, we recommend the development of more detailed scoring instructions. This will reduce variability in interpretation of scoring the tasks and will also likely increase the clinical utility of the instrument, especially in a hospital setting where time is limited. In particular, improving the instructions may facilitate the ability to score the SCIM III using a team-based approach, which will help reduce the amount of time spent scoring the tasks and facilitate ease of use. With these improvements, we feel that the SCIM would be a very important and powerful tool to use as a primary endpoint to capture functional change in future clinical trials evaluating interventions for SCI.

Conflict of interest

The authors declare no conflict of interest.

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Supplementary Information accompanies the paper on the Spinal Cord website (http://www.nature.com/sc)