ORIGINAL ARTICLE

The experience of using the scale of Functional Independence Measure in individuals undergoing spinal cord injury rehabilitation in Brazil

DC Barbetta¹, LC Cassemiro¹ and MR Assis²**Study Design:** Retrospective cohort.**Objectives:** The aim of this study was to evaluate the correlation between the level and completeness of the injury with Functional Independence Measure (FIM) score and the validity and responsiveness of the FIM in Brazilian individuals with spinal cord injury admitted to rehabilitation.**Setting:** SARAH Network of Rehabilitation Hospitals, Brasília, Brazil.**Methods:** A total of 218 patients with spinal cord injury admitted for rehabilitation in 2006 was included in this study. The validity was assessed as the ability of the FIM to discriminate different levels of disability (cervical, thoracic and lumbar) at admission and the responsiveness was obtained by analyzing admission and discharge data for each of the three injury groups.**Results:** Total FIM score, motor FIM score and each of the 13 items were valid when comparing three groups and comparing groups two by two, except the items 'eating' and 'grooming' among paraplegics, and 'stairs' at cervical and thoracic levels. The scale was not responsive to the five cognitive items, 'stairs' and 'eating', among paraplegics, or 'grooming', 'bathing' and 'dressing upper body' in lumbar level patients. The patient difficulty in performing tasks can vary among populations. Therefore, the continuous evaluation process of psychometric characteristics is important to validate the use of the instrument in different contexts.*Spinal Cord* (2014) **52**, 276–281; doi:10.1038/sc.2013.179; published online 4 February 2014**Keywords:** spinal cord injury; rehabilitation; validation studies

INTRODUCTION

Spinal cord injury (SCI) results in a loss of motor and sensory function as well as autonomic innervation below the level of the injury.¹ As a result, patients suffer limitations in performing daily activities, which causes significant functional impact.

The objective documentation of functional ability after SCI is decisive in interpreting outcomes and evaluating the validity of rehabilitation.² One of the most accepted and widespread instrument is the Functional Independence Measure (FIM), which assesses the activities of self-care, transfers, locomotion, sphincter control and cognition. The total score is obtained by summing the scores of each item ranging from 1 (total dependence) to 7 (complete independence), resulting in a score from 18 to 126.

The validity and responsiveness of FIM in patients with SCI have been studied and show conflicting results^{3–8} except for cognitive evaluation, which has low validity and responsiveness.^{3,5,9} It has been reported that motor score varies by levels of injury, providing information about functional independence. In contrast with the cognitive score, gains in the motor score are frequently appreciable when compared the admission and discharge.^{3,10} In spite of increasing systematically toward the most caudal levels, FIM motor score does not adequately discriminate between adjacent neurological levels.^{11,12} Furthermore, cognitive and locomotion items have presented a marked ceiling effect.¹¹

In Brazil, Riberto *et al.*⁵ found good validity and responsiveness of FIM in outpatients with cervical, thoracic and lumbar spinal cord injuries.⁵ Lawton *et al.*¹³ demonstrated the need for a continuous process of evaluation of psychometric characteristics that are influenced by patient difficulty in performing tasks, which can vary between populations, by training as well as differences in the translations and different versions used.

Hence, the purpose of this study is to evaluate the correlation between the level and completeness of the injury with FIM score and the validity and responsiveness of the FIM scale in subjects with SCI admitted to rehabilitation program in Brazil. Our hypothesis is that the FIM scale is effective and its responsiveness is variable depending on the level of injury (cervical, thoracic and lumbar).

MATERIALS AND METHODS

Materials

We obtained data from the Quality Control Center of the Brasília Unit of SARAH Network of Rehabilitation Hospitals from the electronic register of patients. The data collected concerned gender, age, completeness and level of injury assessed on admission by the doctor using American Spinal Injury Association (ASIA) Impairment Scale (AIS), time of injury, length of stay and functional score collected on admission and at discharge by trained nurses using the FIM. The cord segments affected by spinal cord injury were determined in accordance with the ASIA employing a systematic examination

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of the dermatomes and myotomes. The level of injury was defined as the most caudal segment of the spinal cord with normal sensory and motor function.¹⁴

Participants

Data were collected from 250 subjects with spinal cord injury hospitalized in 2006 for rehabilitation.

We excluded patients with injury at C4 or above, those with incomplete records, those with SCI more than two levels of difference between sides; medullar syndromes, except conus medulares and cauda equina, and patients with associated cerebral injury (Figure 1).

Individuals with injury at C4 or above were excluded because they have no voluntary muscular contraction and are known to have a floor effect for validity and responsiveness due to their dependence in all daily activities assessed by FIM.

Procedure

The subjects were divided into three groups, cervical (C5–8), thoracic (T1–12) and lumbar levels (L1–5) to compare with the results of Riberto *et al*.⁵ For the purposes of this study, individuals who showed differences in the neurological level between sides were classified with the cranial level of the injury.

The correlation between the level and completeness of the injury and FIM score was assessed and a random value for each level of injury was assigned. The construct validity was assessed by the ability of the FIM scale (total score, motor, cognitive and per item score) to discriminate between different levels of disability according to the level of injury. Responsiveness was evaluated on the FIM scores from admission and discharge for each of the three injury group types.

Statistical analysis

After collection, the data were submitted to statistical analysis using SPSS, version 13.0 for Windows (SPSS Inc, Chicago, IL, USA).

Assessing the distribution of population by gender and completeness of injury involved the chi-square test ($P < 0.05$), whereas analysis of variance ($P < 0.05$) was used for age, time of injury and length of stay plus Tukey's test for multiple comparisons. In this case, $P < 0.01$ was considered statistically significant according to the Bonferroni correction, thereby reducing the possibility of a type I error (finding a difference when it does not exist).

The correlation between the level and completeness of the injury with FIM score was calculated with the Spearman correlation test. Validity was assessed on admission by the Kruskal–Wallis test ($P < 0.05$). The comparison of two groups was made by the Mann–Whitney test with Bonferroni correction ($P < 0.01$). The responsiveness was analyzed using Wilcoxon's signed-rank exact test ($P < 0.01$).

Of the 218 patients in the study, 127 had thoracic injury, 62 had cervical injury and 29 had lumbar injuries. The three groups were similar in terms of gender (mostly men), age of onset and time of injury. Patients with cervical injuries stayed longer in hospital, though significant differences were not observed in the multiple comparison tests. There were differences among

groups regarding completeness of the injury. In the cervical and thoracic areas, most individuals had complete spinal cord injuries, whereas in individuals with lumbar spinal cord injuries there is a predominance of injury in the conus medullaris and cauda equina (Table 1).

RESULTS

Regarding the validity of the FIM scale, we observed a good correlation between the level of injury and the total FIM score, the motor score ($r = 0.64$) and each of the 13 items of motor scores, when evaluated separately which ranged from 0.13 to 0.74. The item 'stairs' showed the lowest correlation index and 'eating' the highest correlation. The cognitive FIM score and assessment of its five items separately showed no correlation with the level of injury. There was no correlation between items evaluated and AIS classification (A, B, C, D).

Differences in total FIM score, in the motor domain and the 13 motor items scored separately were observed when comparing the three groups. In the cognitive dimension, there was no difference between groups except in 'memory'. However, when they performed the multiple comparison tests, we observed no difference in this item (Table 2).

The total FIM score and the motor domain are different among the groups when performing the multiple comparison tests. In this evaluation, the item 'stairs' was not valid when evaluated separately for tetraplegics and individuals with thoracic injury. The same applied with the items 'grooming' and 'bathing' among individuals with thoracic and lumbar injury (Table 2).

Total FIM score and motor score showed to be responsive in their assessment of the three groups. In evaluating the items separately, the item 'stairs' presents no difference in the scores for admission and discharge in the three groups, followed for the items 'eating' among paraplegics and 'grooming' and 'bathing' in individuals with lumbar spinal cord injury (Table 3).

The evaluation of the cognitive domain was shown to be responsive in cervical and thoracic injury. In patients with thoracic injury, the items 'comprehension', 'social interaction' and 'problem solving' were also responsive (Table 3).

Table 1 Epidemiological data

	Cervical (n = 62)	Thoracic (n = 127)	Lumbar (n = 29)	P-value
Male (%)	82.25	78.74	86.20	NS
Age ($\mu \pm$ s.d.) ^a	31 $\pm$ 11.27	30 $\pm$ 10.57	35 $\pm$ 13	NS
Time of injury ($\mu \pm$ s.d.) ^a	1.7 $\pm$ 2.41	2.19 $\pm$ 14.13	1.95 $\pm$ 3.19	NS
Length of hospital stay ($\mu \pm$ s.d.) ^b	5.34 $\pm$ 1.80	4.67 $\pm$ 1.40	4.66 $\pm$ 1.64	0.02
AIS (%)				
A	35.48	81.10	17.24	<0.001
B	30.65	7.08	3.45	
C	20.97	2.36	10.34	
D	12.9	2.36	27.59	
E	—	—	—	
Conus medullaris/cauda equina syndrome	—	7.10	41.38	

Abbreviations: AIS: American Spinal Injury Association (ASIA) Impairment Scale; n, number of subjects; NS, not significant; s.d., standard deviation; μ , average.

^aTime in years.

^bTime in weeks.

Figure 1 Flow chart—excluded patients. n, number of subject; C, cervical.

Table 2 Comparison of FIM score between groups (validity)

Items	Cervical	Thoracic	Lumbar	Cervical vs thoracic vs lumbar	Cervical vs thoracic	Cervical vs lumbar	Thoracic vs lumbar
	score μ (s.d.)			P-value			
<i>Motor</i>	25.56 (17.70)	49.96 (15.70)	68.79 (14.52)	*	*	*	*
Eating	3.37 (2.13)	6.68 (0.73)	7 (0)	*	*	*	0.585
Grooming	2.65 (2.57)	6.55 (1.16)	6.93 (0.26)	*	*	*	0.098
Bathing	1.97 (1.56)	4.18 (1.85)	5.34 (1.19)	*	*	*	*
<i>Dressing</i>							
Upper body	2.37 (1.98)	5.98 (1.70)	6.86 (0.35)	*	*	*	*
Lower body	1.55 (1.47)	2.92 (2.08)	5.03 (2.23)	*	*	*	*
Toileting	1.58 (1.47)	2.90 (2.18)	5.20 (2.14)	*	*	*	*
<i>Management</i>							
Bladder	1.94 (1.97)	2.88 (2.17)	4.34 (2.37)	*	*	*	*
Bowel	1.56 (1.59)	2.34 (2.09)	4.17 (2.46)	*	*	*	*
<i>Transfer</i>							
Bed/chair	1.77 (1.53)	3.21 (1.98)	5.41 (1.72)	*	*	*	*
Toilet	1.76 (1.49)	3.18 (1.94)	5.37 (1.69)	*	*	*	*
Shower	1.79 (1.56)	3.16 (1.93)	5.37 (1.69)	*	*	*	*
Locomotion	2.11 (1.76)	4.66 (1.79)	5.65 (0.66)	*	*	*	*
Stairs	1.15 (0.69)	1.07 (0.63)	2.06 (1.96)	*	0.07	*	*
<i>Cognitive</i>	34.55 (1.73)	34.72 (1.16)	34.82 (0.75)	0.50	0.30	0.36	0.80
Comprehension	7.00 (0.00)	6.96 (0.27)	7 (0)	0.50	0.55	1.00	1.00
Expression	6.95 (0.28)	7 (0)	7 (0)	0.08	0.11	0.56	1.00
Social interaction	6.79 (0.86)	6.87 (0.67)	7 (0)	0.25	0.41	0.17	0.36
Problem solving	6.89 (0.48)	6.88 (0.62)	6.93 (0.37)	0.81	0.68	0.60	0.89
Memory	6.92 (0.45)	7 (0)	6.98 (0.40)	**	0.11	0.59	0.34
Total	60.11 (18.10)	84.68 (15.69)	103.62 (14.74)	*	*	*	*

Abbreviations: FIM, Functional Independence Measure; s.d., standard deviation; μ : average.* $P < 0.01$.** $P < 0.05$.

DISCUSSION

Our results showed a good correlation between FIM scores and the level of injury and validity and responsiveness of total and motor FIM scores in individuals with spinal cord injury as previously noted in the literature.^{3,5,8,11,15,16} However there is no correlation between completeness of the injury and FIM score. The demographic characteristics among the three studied groups were similar, endorsing the validity of FIM for discriminating functional ability in different neurological levels. The differences among groups regarding completeness of the injury are not clinically significant.

Our study has some limitations that should be highlighted. This is a survey based on retrospective registration and, therefore, was subject to the evaluation and information selection bias.

The functional ability of the SCI subject can be predicted by several factors and the neurological level has been identified as the foremost factor. The positive correlation between muscular strength and functional ability provides data about each functional level of injury.⁶⁻⁹ Nevertheless, there are other factors that have equal or greater influence on the ability of the SCI subjects and that were not considered independently by this analysis. In order to better

understand which lesion and individual characteristics could be related to the functional ability, it would be necessary to carry out a logistic regression analysis.

The FIM is an ordinal scale with imperfect interval between scores. Consensus on the appropriated data models applied to this situation has not been reached. Nonparametric methods are available to test the validity and responsiveness of inference from ordinal scales, minimizing the impact of the not equal interval.¹⁷ The nonparametric tests Kruskal–Wallis and Mann–Whitney *U* tests (equivalent to the one-way analysis of variance) are used to compare independent groups. The Wilcoxon signed-rank test is a nonparametric test, equivalent to the dependent *t*-test. It is used to compare two sets of scores that come from the same participants (SPSS, 13.0 for Windows).

The Brazilian version of the FIM was developed only in the 2000. The study that evaluated the psychometrics properties of the FIM in Brazil was developed by Riberto *et al.*⁵ The authors have already appointed the requirement of studies of validity in order to corroborate its use in rehabilitation assessment of Brazilian individuals, as local peculiarities may determine differences in the data provided.^{5,18} That study endorses our findings of convergent validity of Brazilian version of the FIM, having observed lower values

Table 3 Comparison of FIM scores on admission and discharge (responsiveness)

Items	Cervical			Thoracic			Lumbar		
	Admission μ (s.d.)	Discharge μ (s.d.)	P-value	Admission μ (s.d.)	Discharge μ (s.d.)	P-value	Admission μ (s.d.)	Discharge μ (s.d.)	P-value
<i>Motor</i>	25.56 (17.70)	39.26 (20.63)	*	49.96 (15.70)	69.92 (11.41)	*	68.79 (14.52)	80.65 (6.08)	*
Eating	3.37 (2.13)	5.34 (1.26)	*	6.68 (0.73)	6.94 (0.47)	0.12	7 (0)	7 (0)	1.00
Grooming	2.65 (2.57)	4.79 (1.80)	*	6.55 (1.16)	6.87 (0.65)	*	6.93 (0.26)	6.96 (0.19)	1.00
Bathing	1.97 (1.56)	3.03 (1.81)	*	4.18 (1.85)	5.79 (1.55)	*	5.34 (1.19)	6.65 (0.55)	0.50
<i>Dressing</i>									
Upper body	2.37 (1.98)	3.76 (2.16)	*	5.98 (1.70)	6.60 (0.96)	*	6.86 (0.35)	6.93 (0.26)	*
Lower body	1.55 (1.47)	2.02 (1.83)	*	2.92 (2.08)	4.76 (1.86)	*	5.03 (2.23)	6.41 (0.98)	*
Toileting	1.58 (1.47)	2.26 (1.97)	*	2.90 (2.18)	4.93 (1.82)	*	5.20 (2.14)	6.48 (0.94)	*
<i>Management</i>									
Bladder	1.94 (1.97)	2.94 (2.35)	*	2.88 (2.17)	5.77 (1)	*	4.34 (2.37)	6.06 (1.09)	*
Bowel	1.56 (1.59)	2.42 (2.23)	*	2.34 (2.09)	5.48 (1.53)	*	4.17 (2.46)	6.10 (1.08)	*
<i>Transfer</i>									
Bed/chair	1.77 (1.53)	2.48 (2.05)	*	3.21 (1.98)	5.27 (1.33)	*	5.41 (1.72)	6.48 (0.50)	*
Toilet	1.76 (1.49)	2.48 (2.06)	*	3.18 (1.94)	5.22 (1.34)	*	5.37 (1.69)	6.44 (0.50)	*
Shower	1.79 (1.56)	2.48 (2.06)	*	3.16 (1.93)	5.20 (1.38)	*	5.37 (1.69)	6.44 (0.50)	*
Locomotion	2.11 (1.76)	3.98 (2.04)	*	4.66 (1.79)	5.79 (0.94)	*	5.65 (0.66)	6.06 (0.25)	*
Stairs	1.15 (0.69)	1.27 (1.03)	0.50	1.07 (0.63)	1.23 (1.06)	0.63	2.06 (1.96)	2.58 (2.26)	0.06
<i>Cognitive</i>	34.55 (1.73)	34.98 (0.13)	*	34.72 (1.16)	34.99 (0.08)	*	34.82 (0.75)	34.96 (0.18)	1.00
Comprehension	7.00 (0.00)	7 (0)	1.00	6.96 (0.27)	7 (0)	0.05	7 (0)	7 (0)	1.00
Expression	6.95 (0.28)	7 (0)	0.50	7 (0)	7 (0)	1.00	7 (0)	7 (0)	1.00
Social interaction	6.79 (0.86)	7 (0)	0.06	6.87 (0.67)	7 (0)	*	7 (0)	7 (0)	1.00
Problem solving	6.89 (0.48)	6.98 (0.13)	0.25	6.88 (0.62)	6.99 (0.08)	*	6.93 (0.37)	7 (0)	1.00
Memory	6.92 (0.45)	7 (0)	0.50	7 (0)	7 (0)	1.00	6.98 (0.40)	6.96 (0.18)	1.00
Total	60.11 (18.10)	74.24 (20.65)	*	84.68 (15.69)	104.92 (11.41)	*	103.62 (14.74)	115.62 (6.06)	*

Abbreviations: FIM, functional independence measure; s.d., standard deviation; μ , average.* $P < 0.05$.

of functional independence in patients with higher motor impairment.

The patients studied here were similar to the sample evaluated by Riberto *et al.*,⁵ except regarding time of injury, which the average in our sample was more than 1 year (vs 9.7 ± 13.6 months) and the inclusion of non-traumatic spinal cord injury in the study by Riberto *et al.*⁵

Like the studies by Davidoff *et al.*⁹ and Riberto *et al.*,⁵ the cognitive domain evaluation showed a ceiling effect, that is more than 90% of subjects attained score 7. These results illustrate low validity of the cognitive domain for our study sample, as patients with associated cerebral injury are excluded. However, unlike most studies, some items of cognitive domain showed differences between admission and discharge in cervical and thoracic injury. This is likely due to the fact that some patients have extreme results related to the diagnosis of depression, suggesting that these differences are not clinically significant.

The results in the items 'eating' and 'grooming' in paraplegics were expected because of the preserved muscle strength in their upper limbs. In view of this, the difference between thoracic and lumbar levels in 'dressing upper limbs' would not be expected. However, the long stay in bed before admission, the medical orientation of

restricted mobilization in the postoperative period and the use of orthotics for immobilization of the spine limit the mobility and consequently can reduce independence.

The literature shows no difference in the 'stairs' item, between groups due to the floor effect (score 1), that is, complete dependence for climbing stairs.^{4,5,11,19} In this study, the difference may be because 63% of subjects had incomplete spinal cord injury (AIS D) or conus medulares/cauda equina syndrome and used the walking as a form of locomotion and were therefore independent up and down the stairs.

The discrepancies observed in comparison with other studies may be due to differences in the stratification of the sample taken in the studies ranging between two groups (paraplegics and tetraplegics),¹⁹ three groups (cervical, thoracic and lumbar) and more than four groups based on key muscles^{3,11} or completeness of injury.¹⁰ Dodds *et al.*¹⁰ examined 777 spinal cord injury subjects assessed by Uniform Data System and reported significant differences in FIM scores between different levels of impairment severity. FIM scores decrease with increasing spinal cord injury severity: incomplete paraplegia > complete paraplegia > incomplete quadriplegia > complete quadriplegia.

Factors such as time of injury, criteria used to classify the injury, type of patient care (outpatient or inpatient rehabilitation) and time

of evaluation for the responsiveness may be important in comparing results from other studies, such as Riberto *et al.*⁵ Our study differs to the results of Middleton *et al.*,^{11,19} who showed poor validity and responsiveness to mobility and locomotion items. This difference is possible because patients with AIS D were excluded in the Australian studies, which had a small sample size. In the study by Middleton *et al.*^{11,19}, subjects were assessed in manual rather than motorized wheelchair. However, FIM states that the patients should be assessed in their most common mode of locomotion. In our country, the patients have difficulty in acquiring motorized wheelchairs and this evaluation is provided under the 'locomotion' item of the FIM scale. Hence, in our country, most patients with serious tetraplegia who lack this feature can suffer a significant reduction in their functional score.

Stineman *et al.*⁴ found that the 'stairs' item showed a floor effect most prominently in those patients with spinal cord injury, and the items 'eating', 'grooming' and the five cognitive items presented a score higher at admission. In spite of this, the article does not discriminate the level and completeness of lesion. The authors enrolled 1831 patient with traumatic spinal cord whose data were provided by Uniform Data Sistem for Medical Rehabilitation.⁴

To improve the 'mobility' and 'locomotion' subscales, some authors have proposed to add more items that better assess these specific disabilities or create separate subscales.^{10,19}

The findings reinforce the theory by Lawton *et al.*,¹³ which points out the different socio-cultural factors as determinants of functional independence, reaffirming the need to evaluate the psychometric properties of each instrument in different contexts.

Another point that draws our attention is how the tests were carried out. A study that compared questioning and observational ratings found out that patients could do more than they frequently reported. The observational rating exceeded questioning one, but the results demonstrated a very strong correlation between both means. However, the observational rating is more time consuming and requires a proper environment and is more laborious.²⁰ In the present study, the questioning ratings were used, which could underestimate the ability of individuals to perform the motor FIM tasks.

It is important to highlight that FIM has been used as a generic assesment tool and it is known to be a measure of a burden of care rather than functional ability for SCI population.^{8,9,21,22}

Generic measures are designed to assess functional status regardless of impairment or disability. Specific condition measures are designed to be sensitive to the specific impairment or disability of interest.²³

To accurately evaluate the functional ability of SCI subjects, more functionally relevant and SCI-specific measures are needed in order to better discriminate functional differences between adjacent neurological levels. The International Spinal Cord Injury Society (<http://www.iscos.org.uk>) has indicated the Spinal Cord Independence Measure, which has been extensively validated.²² This measure tool does not have a Portuguese version available yet. The cross-cultural adaptation for use of the Spinal Cord Independence Measure in Brazil requires a unique methodology to reach equivalence between original source and target languages. It is recognized that the tool must not only be translated, but also adapted culturally in order to maintain the content validity of instrument, following the FIM validation steps.

CONCLUSION

For patients with SCI, the total and motor FIM scores were valid and responsive, confirming its appropriateness in the broad use of this instrument. We observed a good correlation between the level of

injury and the total FIM score, motor score and each of the 13 items of motor scores and no correlation with the AIS classification.

Despite some differences in the cognitive assessment, over 90% of individuals presented the ceiling effect. This finding is similar to previous studies which the authors advise against the use of either this item or other items isolated in spinal cord injury populations.

Variations in the sampling of individuals and the range of reevaluation contribute to different results suggesting that the psychometric properties of rating scales are in a continuous building process and consolidate the assessment of different populations.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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