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Functional assessment in spinal cord injury: a comparison of the Modified Barthel Index and the 'adapted' Functional Independence Measure

Elliot Roth Department of Rehabilitation Medicine, Northwestern University Medical School, Rehabilitation Institute of Chicago
Gary Davidoff, John Haughton and **Mary Ardner** Department of Physical Medicine and Rehabilitation, University of Michigan Medical Centre, Ann Arbor, Michigan

The Modified Barthel Index (MBI) and the Functional Independence Measure (FIM) have been used to provide objective measures of functional status and change of spinal cord injured (SCI) patients. To compare rating scores on the MBI and FIM, the functional abilities of 41 SCI patients were rated by one trained nurse-clinician using both scales at admission to initial rehabilitation (ADM), discharge from rehabilitation (DC) and at follow-up (FU) 12 months after rehabilitation. An 'adapted' FIM score was used, and total MBI and FIM scores were divided into self-care and mobility subscores. Comparisons were made between each MBI score and each FIM score at each point in time (ADM, DC, FU) using simple linear regression, which was also used to compare changes in the MBI and FIM scores from ADM to DC and from DC to FU. Excellent correlations ($p<0.0005$) were found between MBI and FIM scores at all points in time and between changes in MBI scores and changes in FIM scores over each time interval.

Introduction

The measurement of functional independence in patients with disabilities has a variety of applications both in patient care and clinical research. The purposes of such an assessment are to provide objective and quantitative measures of patient function; to describe and communicate levels of ability in self-care and mobility skills; to monitor changes in clinical status; to guide management decisions; to evaluate treatment efficacy; to prevent additional disability; to predict prognosis; to plan placement; to estimate care requirements; and to determine compensation.[1–4] Determination of the type and degree of functional disability is widely accepted as an essential component of the comprehensive rehabilitation evaluation and management of patients with physically disabling conditions.[5–7] Recently, the American College of Physicians

Address for correspondence: EJ Roth, Rehabilitation Institute of Chicago, 345 East Superior St, Chicago, Illinois 60611, USA.

recommended routine application of functional assessment ratings for general medical practice, especially for care of the elderly.[2] Such evaluations have been shown to result in a number of benefits, including improved identification of previously unrecognized conditions; enhanced diagnostic and therapeutic outcomes; more accurate prediction of clinical complications or problems; more desirable placement of patients; fewer nursing home discharges; reduced durations of hospitalization; earlier recognition of medication overuse; earlier identification of dementia; and improved patient education.[8–11]

Numerous methods may be employed to determine the ability of an individual to perform functional skills. Most evaluations rely on the use of a standardized functional assessment rating instrument.[4,12–17] Many scales have been developed and utilized, and each rating system has its own unique applications, formats, advantages and disadvantages, as discussed in several recent excellent critical reviews.[1,3,5,7,16,18–20]. Among the many available assessment tools, the Modified Barthel Index (MBI) and the Functional Independence Measure (FIM) are currently of special interest.

The Barthel Index, developed by Mahoney and Barthel[13] and revised by Granger *et al.*,[14] has been used most frequently. When compared with other currently available assessment instruments, it has been considered a superior measure of functional ability because of its established reliability and validity, completeness, sensitivity to change in status, predictive value and clinical relevance.[14,19,21–28] Despite several theoretical and practical problems,[3,18] the MBI is considered the 'best buy' among all currently available scales.[19,21,24,26–28] This scale has been used extensively in series of spinal cord injured (SCI) patients to document their functional capabilities, and to study differences in functional independence across various levels and extents of injury, ages and time intervals.[29–31] These studies have demonstrated its internal consistency, reproducibility, ease of administration and utility when applied to serial assessments over time in this group.

The Functional Independence Measure (FIM) was developed to provide a uniform basis for the evaluation of function in patients with variety of disabilities.[4] The USA regional model systems spinal cord injury care centres, supported by the National Institute on Disability and Rehabilitation Research of the USA Department of Education, has been conducting pilot studies utilizing the FIM as a basis for interval assessment of SCI patients. Preliminary reports[32] indicate good reliability, validity, sensitivity and practicality of the FIM when applied to SCI patients.

The present investigation was designed to compare scores obtained on the MBI and on the FIM in SCI patients at serial assessment intervals.

Methods

Subjects

The study sample consisted of 41 acute traumatic (SCI) patients admitted within 45 days of injury to a regional model systems spinal cord injury care centre for acute management and comprehensive rehabilitation. All patients provided informed consent.

Procedures

Patient data were recorded, including age, gender, education, and level and aetiology of spinal cord injury. The abilities of each patient to perform functional activities were evaluated by one trained nurse-clinician using both the MBI and the FIM at three time periods: admission to initial rehabilitation (ADM), discharge from rehabilitation (DC) and at follow-up (FU) 12 months after rehabilitation discharge. Recording of functional scores was performed by only one evaluator in order to reduce the potential for unreliability of administration of the instrument.

The MBI is a 100-point rating scale of a patient's ability to complete nine self-care (drinking, feeding, dressing upper body, dressing lower body, donning brace, grooming, bathing, bladder continence and bowel continence) and six mobility tasks (chair transfers, toilet transfers, tub transfers, walking 50 yards, stair climbing, and wheelchair propulsion), each of which is assigned a numeric value according to which of the three levels of assistance (independent, assistance, dependent) the patient's performance is rated at.[13,14]

The FIM is a similar rating system of a patient's

Table 1 Items and scoring on the modified Barthel Index and the 'adapted' Functional Independence Measure

Skill	IND		IND/E		SUP		MIN A		MOD A		MAX A		DEP	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Self-care subscore														
Drinking	4	–	4	–	0	–	0	–	0	–	0	–	0	–
Feeding	6	7	6	6	0	5	0	4	0	3	0	2	0	1
Upper dressing	5	7	5	6	3	5	3	4	3	3	0	2	0	1
Lower dressing	7	7	7	6	4	5	4	4	4	3	0	2	0	1
Grooming	5	7	5	6	0	5	0	4	0	3	0	2	0	1
Bathing	6	7	6	6	0	5	0	4	0	3	0	2	0	1
Bladder continence	10	7	10	6	5	5	5	4	5	3	0	2	0	1
Bowel continence	10	7	10	6	5	5	5	4	5	3	0	2	0	1
Perineal care	–	7	–	6	–	5	–	4	–	3	–	2	–	1
Mobility subscore														
Chair transfers	15	7	15	6	7	5	7	4	7	3	0	2	0	1
Toilet transfers	6	7	6	6	3	5	3	4	3	3	0	2	0	1
Tub transfers	1	7	1	6	0	5	0	4	0	3	0	2	0	1
Walk on level	15	7	15	6	10	5	10	4	10	3	0	2	0	1
Stairs	10	7	10	6	5	5	5	4	5	3	0	2	0	1
Wheel	5	7	5	6	0	5	0	4	0	3	0	2	0	1

IND = Independent
IND/E = Independent with equipment
SUP = Independent with supervision
MIN A = Independent with minimal assistance
MOD A = Independent with moderate assistance
MAX A = Independent with maximal assistance
DEP = Dependent
M = Modified Barthel Index[14]
F = Functional Independence Measure[4]
– = Not included on scale

ability to perform self-care, sphincter control, mobility, locomotion, communication, social adjustment and cognition tasks, each of which is rated on a scale between one and seven points, depending on the specific degree of assistance required for each task.[4]

In order to provide congruence between the two scales, an 'adapted' FIM score was used. The FIM subscales reflecting communication, social adjustment and cognition were deleted from analysis, and only the self-care (SC) and mobility (MO) subscales were studied in each of the two scales. It was previously demonstrated that the FIM subscales of communication and social cognition lacked external validity when compared to the results of a comprehensive neuropsychological battery.[33] Subscale scores for self-care and sphincter control on the FIM were combined to create the FIM self-care subscore (which included feeding, grooming, bathing, dressing upper body, dressing lower body and perineal care tasks, while the subscores for mobility and locomotion on the FIM were summed to create the FIM mobility subscore (which included chair transfers, toilet transfers, tub transfers, walking, wheelchair propulsion and stair climbing).

Items on the MBI and the FIM, and their scoring systems, are listed in Table 1.

Data Analysis

Three 'static' scores (self-care subscore [SC], mobility subscore [MO] and total score [TO]) were generated for each of the two functional rating scales (the MBI and the FIM) at each of the three time periods (ADM, DC and FU) for each of the 41 patients. MBI scores and subscores were compared to FIM scores and subscores at ADM, DC and FU using simple linear regression analysis. Changes in each of the three scores and subscores ($\triangle$SC, $\triangle$MO and $\triangle$TO) were evaluated and compared between each of the two

Table 2 FIM and MBI scores and subscores at admission, discharge, and follow-up (means ±SEM)

	Admission Mean ± SEM	Range	Discharge Mean ± SEM	Range	Follow-up Mean ± SEM	Range
MBI						
Self-care	15.78±1.97	0–40	41.93±2.06	0–53	44.10±2.13	14–53
Mobility	4.63±1.25	0–37	26.10±1.92	0–47	29.50±2.00	7–47
Total	20.41±2.84	0–70	68.03±3.58	0–100	73.60±3.69	21–100
FIM						
Self-care	23.22±1.82	9–49	47.22±1.89	15–56	48.20±2.16	16–56
Mobility	9.29±0.95	7.30	25.61±1.19	9–35	26.93±1.21	13–35
Total	32.51±2.54	14–73	72.83±2.96	24–90	75.13±3.29	31–91

Table 3 Results of linear regression analysis of static MBI and FIM scores and subscores

	Slope	y-Int.	R^2	*p*
SC				
Admission self-care subscore	1.025	− 8.031	0.890	0.0001
Discharge self-care subscore	1.056	− 7.936	0.939	0.0001
Follow-up self-care subscore	0.953	− 1.826	0.939	0.0001
MO				
Admission mobility subscore	1.156	− 6.105	0.764	0.0001
Discharge mobility subscore	1.343	− 8.198	0.699	0.0001
Follow-up mobility subscore	1.317	− 5.972	0.639	0.0001
TO				
Admission total score	1.054	−13.867	0.889	0.0001
Discharge total score	1.114	−13.005	0.848	0.0001
Follow-up total score	1.023	− 3.232	0.834	0.0001

functional rating scales over each of the two time intervals (ADM–DC and DC–FU) for all patients using linear regression analysis.

Results

The mean (±1 SEM) age of all patients was 30.4±1.7 years. Thirty-five (85%) of the patients were male. The mean educational level was 12.9±0.4 years. Seventeen (41%) patients sustained injuries at the cervical level, 16 (39%) at the thoracic level and the remainder at the lumbosacral levels. Aetiologies of injury, in descending frequency, included: road traffic accidents, 29 (70%); gunshot wounds, 4 (10%); assaults, 4 (10%); falls, 2 (5%); and other causes, 2 (5%).

Mean values and standard errors for MBI and FIM self-care and mobility subscores and total scores at admission, discharge and follow-up are shown in Table 2. There was a trend toward improvement in scores over time, especially between admission to and discharge from rehabilitation.

Each of the three static MBI and FIM scores and subscores at each of the three time periods (ADM, DC, FU) was compared using simple linear regression analysis (Table 3, Figures 1–3). This analysis revealed robust correlations between the MBI and the FIM for all parallel scores and subscores at all three time periods. Between 64% and 94% of the variance in the various FIM scores could be explained by MBI scores, with the most consistent correlations occurring for the three self-care subscore comparisons.

Changes in each of the three MBI scores and subscores (△MBI) and changes in each of the three FIM scores and subscores (△FIM) across

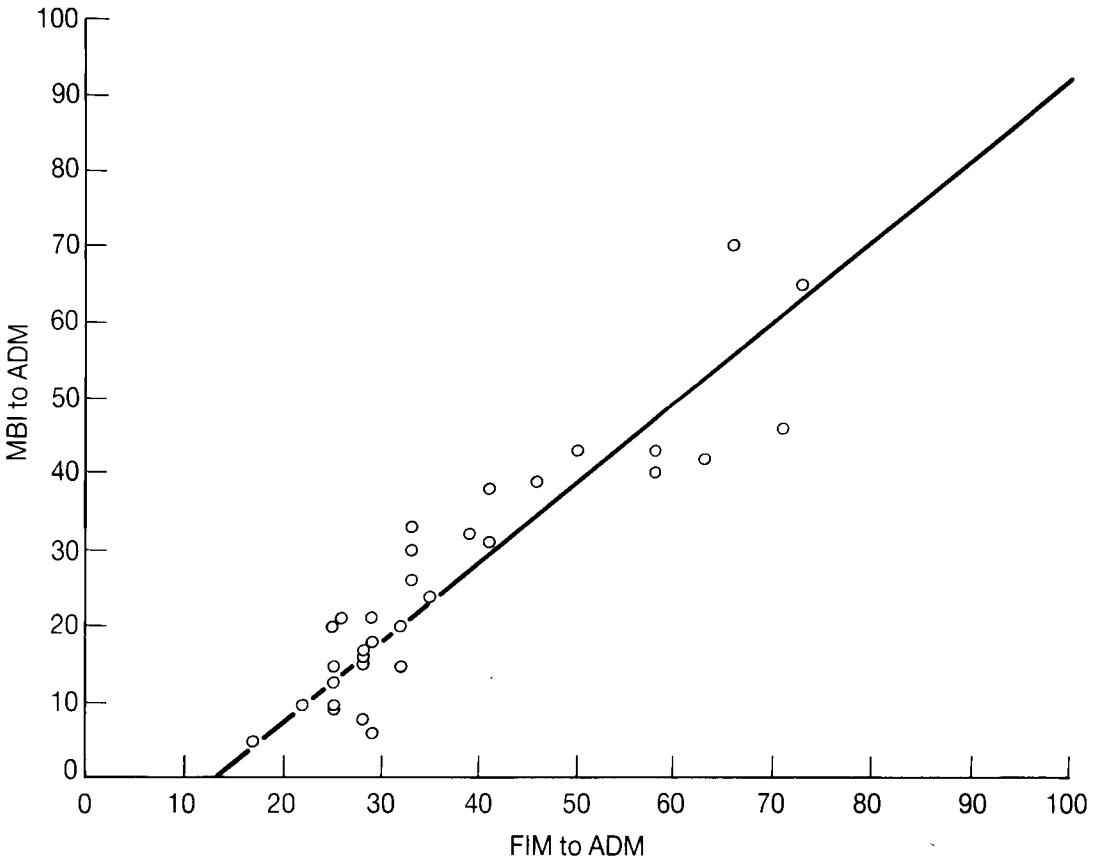

Figure 1 Regression analysis of FIM versus MBI scores: admission total scores ($y = 1.054x - 13.867$, R-squared = 0.889)

each of the two time intervals (ADM–DC and DC–FU) were also compared using simple linear regression analysis. This analysis demonstrated high degrees of correlation between changes in parallel MBI and FIM scores and subscores at all intervals studied. (Table 4). Between 36% and 85% of the variance in FIM score changes could be explained by MBI score changes. Again, the highest degree of correlation was found in changes in the self-care subscores ($\triangle$SC).

Discussion

Rating scales of ability to perform activities of daily living, such as the Modified Barthel Index (MBI) and the Functional Independence Measure (FIM), have been developed to provide objective measures of functional status and change during and after acute and chronic rehabilitation of disabled individuals, including those with spinal cord injury. The Modified Barthel Index is considerably older, its validity more firmly established and its clinical usefulness more clearly demonstrated than the FIM. Because the FIM is a newer instrument, its role in the comprehensive assessment and management of SCI patients has not yet been fully elucidated, although several clinical evaluation trials of the FIM are currently underway.[4,32]

Conceptually, the two scales are alike and are based on similar principles of evaluating the amount of assistance required for specific named daily living tasks. Indeed, the two systems assess

Table 4 Results of linear regression analysis of changes in MBI and FIM scores over time (△MBI and △FIM)

	Slope	y-Int.	R^2	*p*
△SC				
Admission–discharge self-care	0.962	3.048	0.849	0.0001
Discharge–follow-up self-care	0.847	0.774	0.748	0.0001
△MO				
Admission–discharge mobility	1.063	4.222	0.542	0.0001
Discharge–follow-up mobility	1.100	2.251	0.358	0.0005
△TO				
Admission–discharge total	0.966	8.759	0.755	0.0001
Discharge–follow-up total	0.856	3.628	0.645	0.0001

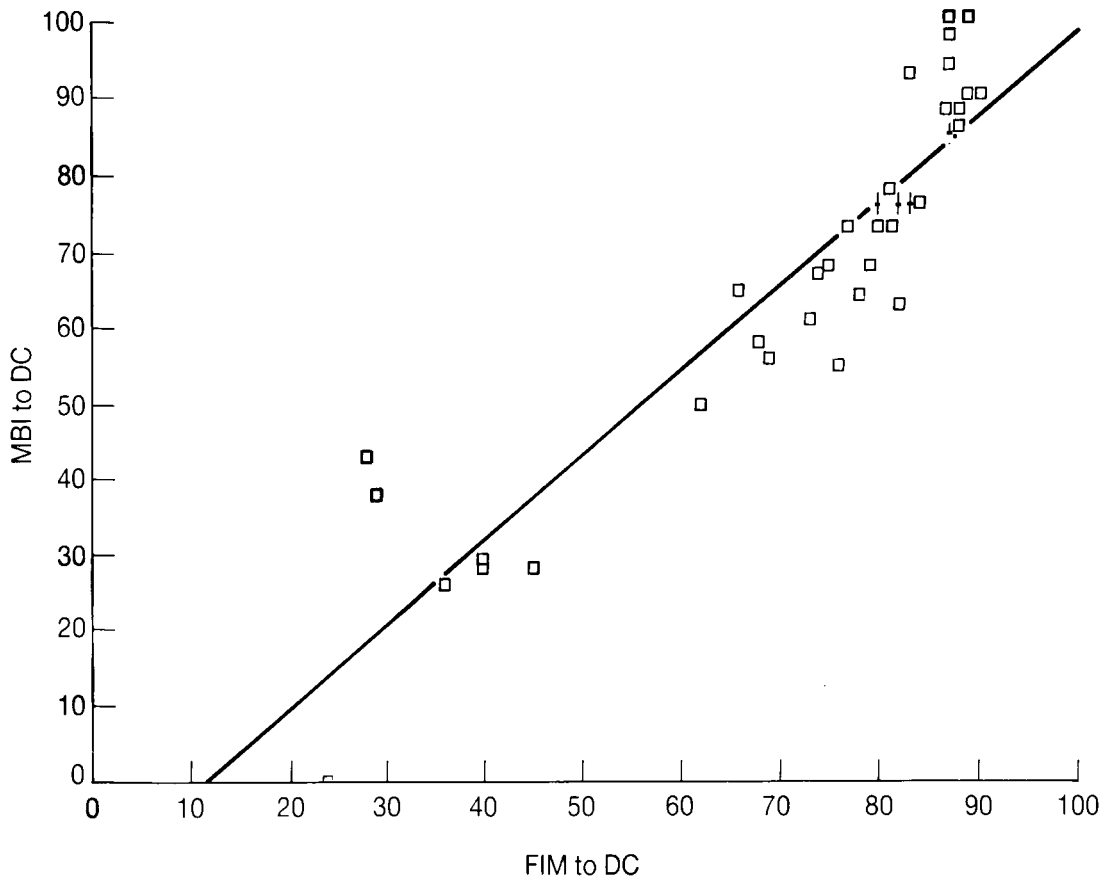

Figure 2 Regression analysis of FIM versus MBI scores: discharge total scores ($y = 1.114x - 13.005$, R-squared = 0.848)

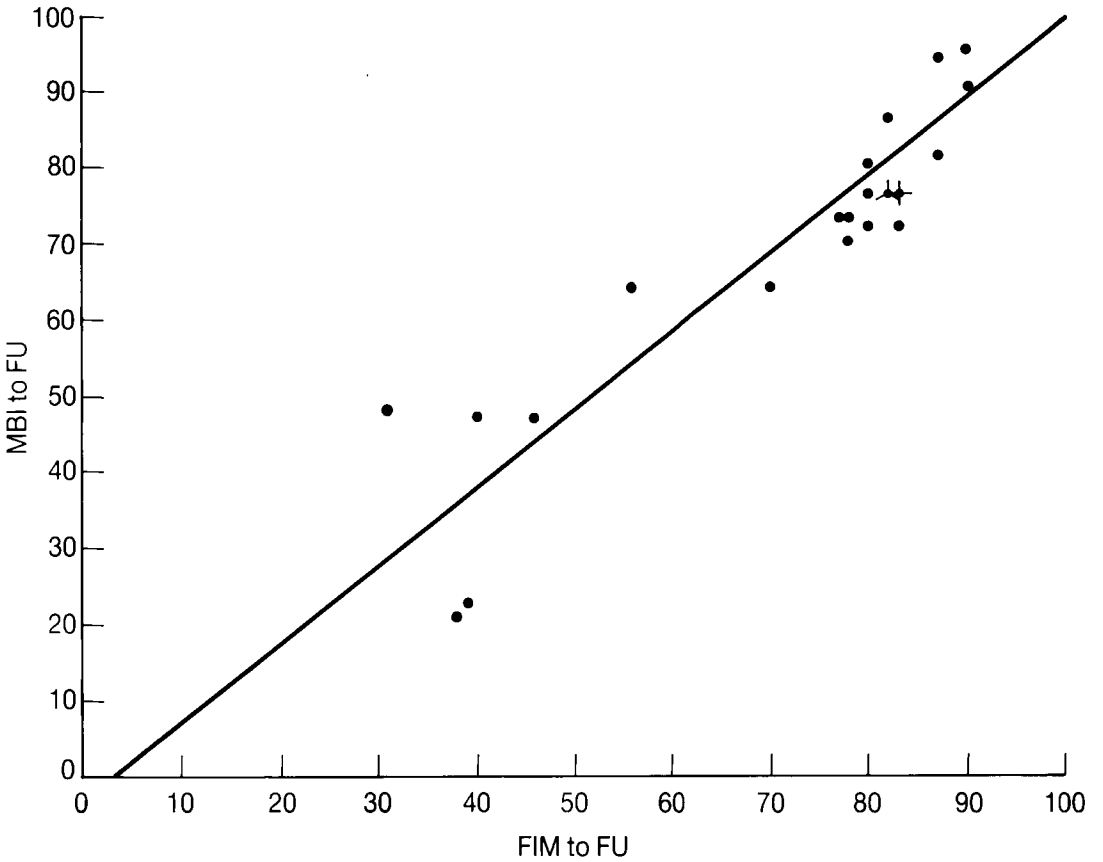

Figure 3 Regression analysis of FIM versus MBI scores: follow-up total scores ($y = 1.023x - 3.232$, R-squared = 0.834)

nearly identical physical skills encompassing personal care and mobility aspects of functioning. It is therefore not completely surprising that scores on the two instruments were found to be as closely correlated as they were.

However, although these two assessment tools evaluate similar entities, they do so in different ways. At present both the rating and weighting systems of the two instruments are not alike. The FIM allows an individual to be rated on many more levels of assistance, which is especially important to fully evaluate those patients who require amounts of assistance or care in the 'middle' ranges. However, there is no indication on the FIM of the relative 'importance' of each task compared to the other skills. A recent report[34] has suggested that the development and implementation of a weighting system for the FIM may be useful, but no such format exists as yet. On the other hand, the MBI has only three levels on which a patient may be rated for a specific task, thereby appearing to limit its sensitivity to small changes in functional status. However, there is a very clear and relatively intricate weighting system used for the MBI, by which the scores reflect the burden of care placed upon others as a result of the patient's particular level of functional disability.

Given these differences in the construction of these two rating systems, it is particularly striking that the analysis in this study yielded a high degree of correlation between the two scales. It is noteworthy that these robust statistical associations occurred for all scores and subscores,

at all points in time (ADM, DC and FU) and across both time intervals (ADM–DC and DC–FU).

A previous longitudinal study[35] found that the Barthel Index and the FIM were very highly correlated with each other across several serial assessments for patients with stroke. The present investigation is the first to examine such a comparison for SCI patients.

The MBI and FIM scores and subscores for SCI patients were found to be highly correlated with each other across time. Because these two systems differ in their scoring format, but were found to yield scores which vary in a parallel fashion, selection of a specific rating system for a particular clinical or research application should be based on factors other than those studied in this investigation.

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