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IMPROVING THE SENSITIVITY OF THE BARTHEL INDEX FOR STROKE REHABILITATION*

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Abstract—The Barthel Index is considered to be the best of the ADL measurement scales. However, there are some scales that are more sensitive to small changes in functional independence than the Barthel Index. The sensitivity of the Barthel Index can be improved by expanding the number of categories used to record improvement in each ADL function. Suggested changes to the scoring of the Barthel Index, and guidelines for determining the level of independence are presented. These modifications and guidelines were applied in the assessment of 258 first stroke patients referred for inpatient comprehensive rehabilitation in Brisbane, Australia during 1984 calendar year. The modified scoring of the Barthel Index achieved greater sensitivity and improved reliability than the original version, without causing additional difficulty or affecting the implementation time. The internal consistency reliability coefficient for the modified scoring of the Barthel Index was 0.90, compared to 0.87 for the original scoring.

Functional independence ADL Barthel Index Stroke outcome measure Adaptive recovery scale Stroke rehabilitation

INTRODUCTION

While more than 200 ADL indices exist, many are poorly designed, contribute little to treatment goals and evaluation of outcome, produce results that are often qualitative and ambiguous, are of unknown reliability and validity, and have only localized usage [1–3].

Since improvement in function, effectiveness of intervention, and discharge disposition continue to remain as essential features for assessment indices, it is imperative that measurement tools used have these capacities. In particular, it is desirable that indices to be used be comprehensive, sensitive to change, be suitable for easy statistical manipulation, be of high reliability and validity, and gain widespread use [3, 4].

Four ADL scales, the Katz Index of ADL, the Kenny Self Care Evaluation, PULSES Profile, and the Barthel Index, are regarded as being superior to the rest, and satisfy the criteria above. While the BI is regarded to be supreme [2], the Kenny Self Care Evaluation has greater sensitivity to change than the BI [5]. This paper suggests change to the scoring of the BI to increase its sensitivity to small improvements and recommends its use as a functional independence tool in all impairment entities because of its superiority over all other scales in medical rehabilitation. Our revised version of the BI was standardized on initial and discharge assessments of all 258 first stroke patients with resulting hemiplegia referred for inpatient comprehensive rehabilitation in Brisbane, Australia during the 1984 calendar year.

THE BARTHEL INDEX—ORIGINAL FORMULATION

The Barthel Index [6] measures the individual's performance on 10 ADL functions. It is an empirically derived scale with proven inter observer and test–retest reliability and validity which measures the patient's functional ability

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without family and social functioning distorting the outcome. The BI was found to be reliable and repeatable in skilled and unskilled hands. The Kendall's coefficient of concordance W was highly significant ($p < 0.001$) between all four raters with overall reliability of 0.93 showing a high degree of agreement [7, 8]. The Functional Independence Measure (FIM) developed by the American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation, also uses the BI as its fundamental base. In addition to the BI items, the FIM has communication and social integration items added to it. The FIM tasks have already been tried out in the U.S. However, its inter observer and test–retest reliability, validity and internal consistency are yet to be established using seven points on the scale. The need for such an extended discrimination and the degree of its reliability can only be known as the FIM becomes widely accepted [9].

The values assigned to each item in the BI are based on the amount of physical assistance required to perform the task. The original BI increments are in steps of five points only (Table 1). The items are summed to give a score ranging from 0 to 100. Most items have a maximum of 10 points, scoring 0 for inability to perform the task, 5 points if any assistance is required, and 10 for total independence. The two items that have a maximum of 5 points are scored 0 for both inability, and for any assistance, with 5 points being given for complete independence. The two items that have a maximum of 15 points are scored 0 for inability, 5 or 10 points for assistance and 15 points for full independence.

A total BI score of 0–20 suggests total dependence, 21–60 severe dependence, 61–90 moderate dependence and 91–99 slight dependence. A score of 100 indicates that the patient is independent of assistance from others. The total BI score is generally not as significant or meaningful in treatment as the scores on individual items, since these indicate where the deficiencies are [6, 7]. However, the total discharge score is shown to be related to the type of housing people can live in [10], and provides a suitable measure of total functional independence for evaluating effectiveness of rehabilitation. The BI is therfore used in many outcome studies.

Table 1. Original scoring for the Barthel Index [6]

Items	Unable to perform task	Needs assistance	Fully independent
Personal hygiene	0	0	5
Bathing self	0	0	5
Feeding	0	5	10
Toilet	0	5	10
Stair climbing	0	5	10
Dressing	0	5	10
Bowel control	0	5	10
Bladder control	0	5	10
Ambulation	0	5–10	15
Wheelchair*	0	0	5
Chair/bed transfers	0	5–10	15
Range	0	.....	100

*Score only if unable to walk.

With the BI increment in steps of five points only, the sensitivity of the BI is limited. While total dependence and total independence have polarized scores, classification of patients who require some assistance to perform each task is crude, often being grouped together. The BI therefore is not sensitive to change in the area where assistance is required on many of the items, as it fails to detect the quality and quantity of assistance. A more graduated scale using the same parameters would be more sensitive to small improvements in functional independence while maintaining the other qualities of the BI.

MODIFIED SCORING OF THE BI

Greater sensitivity of the BI is required in scoring those individuals who require assistance of some nature to perform the tasks. While the BI generally comprises a three point scale, i.e. those completely dependent, those who require assistance, and those completely independent, an increase in the number of meaningful categories to differentiate the quantity and quality of assistance required, will increase the sensitivity of the BI. It is important that while the discriminating power of the BI be increased, the total time to administer the BI not be unduly affected, that the task not be made too complex to enable continued implementation by non-specialists, and that the high reliability of the BI be preserved. In the earlier modification [7], introduction of the fourth category was an improvement over the limited discrimination power of the original BI, however it did not provide significantly sharper discrimination. A five point scoring is therefore devised, not only to satisfy the pragmatic requirements above, but also because performance is easily assessed on a five point scale. In the five point scale, those totally dependent, and those fully independent, have the same score as in the original conceptualization. Unlike the original BI, all items in the

Table 2. Modified scoring for the Barthel Index

Items	Code 1 Unable to perform task	2 Attempts task but unsafe	3 Moderate help required	4 Minimal help required	5 Fully independent
Personal hygiene	0	1	3	4	5
Bathing self	0	1	3	4	5
Feeding	0	2	5	8	10
Toilet	0	2	5	8	10
Stair climbing	0	2	5	8	10
Dressing	0	2	5	8	10
Bowel control	0	2	5	8	10
Bladder control	0	2	5	8	10
Ambulation	0	3	8	12	15
Wheelchair*	0	1	3	4	5
Chair/bed transfers	0	3	8	12	15
Range	0				100

*Score only if Ambulation coded "1" and patient trained in wheelchair management.

modified version have an equal number of categories. The score for each category reflects the overall weighting for that item in terms of the total score (Table 2). The equal number of categories facilitates ease and accuracy of coding as the assessor need only record the appropriate category (or code) for each patient. The total BI score can be calculated automatically by computer at a later time.

The modified scoring for the BI follows the same general pattern:

—those unable to perform the task are coded "1" on the evaluation form and contribute 0 to the total Barthel score;
—those greatly dependent and/or unsafe without someone's presence are coded "2";
—those requiring moderate assistance and/or supervision to complete the task are coded "3";
—those requiring minimal assistance and/or supervision are coded "4";
—those fully independent are coded "5". The slowness of an individual in performing a task is not scored less if no human assistance is required for a function.

In the original BI, the score assigned is based on the amount of physical assistance required, and the weighting of that item. In the modified scoring system, the scoring continues to depend on the weighting attached to these items. Table 2 shows how the allocated code is converted to a modified score, which is summed to give a total profile of dependence and independence.

The five categories represent a ranking of the amount of assistance required in functional independence in each task. While the concept of the amount of assistance required is easy, precise evaluation of functional independence in each task is difficult to operationalize. Therefore, as with the original BI, some instruction in evaluation of function for assessors is necessary. The detailed guidelines in the Appendix are not meant to be exhaustive or prescriptive, but indicate a plausible classification of levels of functional independence. After initial familiarization, ranking should be possible without reference to the guidelines.

EFFECTIVENESS OF THE BI MODIFICATIONS

In order to compare the differences between the original and modified scoring of the BI, data from a prospective stroke rehabilitation study of all 258 surviving first stroke patients in all hospitals in Brisbane who were referred for inpatient comprehensive rehabilitation during 1984 [11], was used. In addition to the principal investigator, three occupational therapy graduates served as assessors. All assessors attended one, one-hour clinic demonstration after reviewing the modified scoring. Since the inception of the BI, a number of studies have examined the test–retest and inter observer reliability [7, 8, 10]. However, its internal consistency has never been the subject of scrutiny. In this study therefore, the internal consistency was examined both for the original and modified scoring systems at commencement of rehabilitation and on discharge.

The suggested modifications improved the sensitivity of the Barthel Index (Table 3). However, despite the weighting of each item remain-

Table 3. Barthel scores at commencement of rehabilitation

Items	Original scoring		Modified scoring		Original mean	Modified mean
Personal hygiene	0	82	0	11	($n = 258$)	
			1	14		
			3	30	0.91***	3.03
			4	27		
	5	18	5	18		
Bathing self	0	95	0	33		
			1	31		
			3	21	0.23***	1.59
			4	10		
	5	5	5	5		
Feeding	0	5	0	5		
			2	10		
	5	78	5	30	5.62***	6.43
			8	37		
	10	17	10	17		
Toilet	0	20	0	20		
			2	23		
	5	69	5	29	4.51NS	4.34
			8	17		
	10	11	10	11		
Stair climbing	0	78	0	78		
			2	10		
	5	19	5	3	1.28NS	1.19
			8	7		
	10	3	10	3		
Dressing	0	40	0	40		
			2	29		
	5	53	5	17	3.37***	2.74
			8	8		
	10	7	10	7		
Bowel control	0	5	0	5		
			2	2		
	5	21	5	8	8.45***	8.70
			8	11		
	10	74	10	74		
Bladder control	0	19	0	19		
			2	3		
	5	25	5	13	6.86**	7.01
			8	8		
	10	56	10	56		
Ambulation	0	59	0	59		
	5	18	3	18		
			8	8	3.47***	3.12
	10	16	12	8		
	15	6	15	6		
Chair/bed transfers	0	26	0	26		
	5	20	3	20	6.96***	6.33
			8	27		
	10	43	12	16		
	15	11	15	11		

**$p < 0.01$; ***$p < 0.001$.

ing the same as in the original B1, the means for each item (Table 3), and for the scale as a whole (Table 4), have generally been increased. This is not regarded to be of much consequence, but provides an estimate of the potential error in the original BI.

The high content reliability of the original BI [12] is maintained, and even increased, with a Cronbach's coefficient alpha of internal consistency of 0.90 being recorded for the modified scoring at the commencement of rehabilitation (Table 4). A high alpha of 0.87 was recorded by the original scored version of the BI. At discharge, α values of 0.93 and 0.92 respectively, were recorded. Other measures of reliability, such as the mean correlation, and the minimum and maximum correlations within the correlation matrix of the items in the scale, show the

Table 4. Comparison of original and modified BI scoring at admission and discharge for stroke rehabilitation

	Mean	SD ($n = 258$)	Alpha*	Mean corr.	Min corr.	Max corr.
Initial score						
Modified scoring	44.50	24.51	0.9004	0.5385	0.1476	0.8361
Original scoring	41.67	21.74	0.8673	0.4287	0.1221	0.7781
Discharge score						
Modified scoring	78.12	26.34	0.9276	0.6665	0.2830	0.9012
Original scoring	73.88	26.08	0.9238	0.5697	0.2584	0.8375

*Cronbach's coefficient alpha of internal reliability.

modified scoring to be preferable over the original scoring.

It must be realized that the careful documentation of life function skills using the modified scoring discussed here, reflects the patient's ability in self care during medical rehabilitation. While the BI has also been used to obtain detailed information regarding the patient's ability to perform ADL in the home, caution should be exercised in interpretation. The performance on these tasks in his/her own home may not equate with his/her recorded ability in the rehabilitation centre, primarily due to the influence of factors in the home, and the community environment, e.g. doorway widths, wheelchair access, attitudes of the patient and the caregivers and their relationship. The importance of these and other factors cannot be over emphasized. In addition to self care independence, the patient's individual needs for long term care and his/her overall functioning in the home, social and community environment, may require the addition of further specific items from the item banks provided by Fortinsky *et al.* [13] and Yerxa *et al.* [14].

CONCLUSION

While there may be a desire to develop and use objective measures which satisfy individual needs of a hospital, centre or a particular professional group, Dombovy *et al.*, [2], Jongbloed [3], and Greshan [4] stress that the use of inadequate ADL measures should not be tolerated, and editors and their reviewers must demand that outcome scales have established and proven reliability and validity.

The BI has been selected as being the best of the ADL scales, and has widespread use. The modification to the scoring of the BI as suggested in this paper further improves the sensitivity of the BI, thus enhancing its appeal. The modified scoring does not cause any additional difficulty, does not increase the implementation time for trained assessors, improves the internal consistency, and provides better discrimination of functional ability. Its usefulness to stroke has been presented in this paper; its performance with other impairment categories remains to be investigated.

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APPENDIX

New Guidelines for the BI Functions

Personal hygiene

1. The patient is unable to attend to personal hygiene, and is dependent in all aspects.
2. Assistance is required in all steps of personal hygiene.
3. Some assistance is required in one or more steps of personal hygiene.
4. Patient is able to conduct his/her own personal hygiene but requires minimal assistance before and/or after the operation.
5. The patient can wash his/her hands and face, comb hair, clean teeth and shave. A male patient may use any kind of razor but must insert the blade, or plug in the razor without help, as well as retrieve it from the drawer or cabinet. A female patient must apply her own make-up, if used, but need not braid or style her hair.

Bathing self

1. Total dependence in bathing self.
2. Assistance is required in all aspects of bathing.
3. Assistance is required with either transfer to shower/bath or with washing or drying; including inability to complete a task because of condition or disease etc.
4. Supervision is required for safety in adjusting the water temperature, or in the transfer.
5. The patient may use a bath tub, a shower, or take a complete sponge bath. The patient must be able to do all the steps of whichever method is employed without another person being present.

Feeding

1. Dependent in all aspects and needs to be fed.
2. Can manipulate an eating device, usually a spoon, but someone must provide active assistance during the meal.
3. Able to feed self with supervision. Assistance is required with associated tasks such as putting milk/sugar into tea, salt, pepper, spreading butter, turning a plate or other "set-up" activities.
4. Independence in feeding with prepared tray except may be cut meat, open milk carton, jar lid etc. Presence of another person is not required.
5. The patient can feed self from a tray or table when someone puts the food within reach. The patient must put on an assistive device if needed, cut the food, and if desired, use salt and pepper, spread butter, etc.

On and off the toilet

1. Fully dependent in toileting.
2. Assistance required in all aspects of toileting.
3. Assistance may be required with management of clothing, transferring, or washing hands.
4. Supervision may be required for safety with normal toilet. A commode may be used at night but assistance is required for emptying and cleaning.
5. The patient is able to get on and off the toilet, fasten and unfasten clothes, prevent soiling of clothes and use toilet paper without help. If necessary, the patient may use a bed pan or commode, or urinal at night, but must be able to empty it, and clean it.

Stairs

1. The patient is unable to climb stairs.
2. Assistance is required in all aspects of stairclimbing, including assistance with walking aids.
3. The patient is able to ascend/descend but is unable to carry walking aids, and needs supervision and assistance.
4. Generally no assistance is required. At times supervision is required for safety due to morning stiffness, shortness of breath etc.
5. The patient is able to go up and down a flight of stairs safely without help or supervision. The patient is able to use hand rails, cane, or crutches when needed and is able to carry these devices as he/she ascends or descends.

Dressing

1. The patient is dependent in all aspects of dressing and is unable to participate in the activity.
2. The patient is able to participate to some degree, but is dependent in all aspects of dressing.
3. Assistance is needed in putting on, and/or removing any clothing.
4. Only minimal assistance is required with fastening clothing, such as buttons, zips, bra, shoes etc.
5. The patient is able to put on, remove, and fasten clothing, tie shoelaces, or put on, fasten, remove corset, braces, as prescribed.

Bowels

1. The patient is bowel incontinent.
2. The patient needs help to assume appropriate position, and with bowel movement facilitatory techniques.
3. The patient can assume appropriate position, but cannot use facilitatory techniques, or clean self without assistance and has frequent accidents. Assistance is required with incontinence aids such as pads etc.
4. The patient may require supervision with the use of suppository or enema and has occasional accidents.
5. The patient can control bowels and has no accidents, can use suppository, or take an enema when necessary.

Bladder

1. The patient is dependent in bladder management, is incontinent, or has indwelling catheter.
2. The patient is incontinent but is able to assist with the application of an internal or external device.
3. The patient is generally dry by day, but not at night, and needs some assistance with the devices.
4. The patient is generally dry by day and night, but may have an occasional accident, or need minimal assistance with internal or external devices.
5. The patient is able to control bladder day and night, and/or is independent with internal or external devices.

Chair/bed transfers

1. Unable to participate in a transfer. Two attendants are required to transfer the patient with or without a mechanical device.
2. Able to participate but maximum assistance of one other person is required in all aspects of the transfer.
3. The transfer requires the assistance of one other person. Assistance may be required in any aspect of the transfer.
4. The presence of another person is required either as a confidence measure, or to provide supervision for safety.

5. The patient can safely approach the bed in a wheelchair, lock the brakes, lift the footrests, move safely to bed, lie down, come to a sitting position on the side of the bed, change the position of the wheelchair, transfer back into it safely. The patient must be independent in all phases of this activity.

Ambulation

1. Dependent in ambulation.
2. Constant presence of one or more assistants is required during ambulation.
3. Assistance is required with reaching aids and/or their manipulation. One person is required to offer assistance.
4. The patient is independent in ambulation but unable to walk 50 yards/metres without help, or supervision is needed for confidence or safety in hazardous situations.
5. The patient must be able to wear braces if required, lock and unlock these braces, assume standing position, sit down, and place the necessary aids into position for use. The patient must be able to use crutches, canes, or a walkerette, and walk 50 metres/yards without help or supervision.

Wheelchair management (alternative to Ambulation)

Only use this item if the patient is rated "1" for Ambulation, and then only if the patient has been trained in wheelchair management.

1. Dependent in wheelchair ambulation.
2. Patient can propel self short distances on flat surface, but assistance is required for all other steps of wheelchair management.
3. Presence of one person is necessary and constant assistance is required to manipulate chair to table, bed etc.
4. The patient can propel self for a reasonable duration over regularly encountered terrain. Minimal assistance may still be required in "tight corners".
5. To propel wheelchair independently, the patient must be able to go around corners, turn around, manoeuvre the chair to a table, bed, toilet, etc. The patient must be able to push a chair at least 50 metres/yards.