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Three measures of functional outcome for lower limb amputees: a retrospective review

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Abstract

Outcome measures are becoming increasingly important in health care. Functional outcome measures are of particular importance for lower limb amputees since much of the rehabilitation process is concerned with increasing mobility and personal independence.

The Scottish Physiotherapy Amputee Research Group (SPARG) has used three measures of functional outcome: the Barthel Index, Russek's classification and the Locomotor Index. The review reported here involves 938 patients having a primary amputation at the transtibial or transfemoral level between October 1992 and July 1997. Differences in function due to age and level of amputation are well known clinically and the measures were compared by looking at their ability to detect these differences.

The Barthel Index lacked sensitivity because of ceiling effects and should not be considered as a suitable functional outcome measure for amputee patients. Russek's classification does detect significant differences but requires a large number of patients making it unsuitable for single hospital investigations. The Locomotor Index demonstrates significant differences due to age and amputation level despite fewer patients being assessed by this measure during the period covered by this paper. The range of the Locomotor Index can be extended to cover more active amputees by considering its 'advanced activities' subscale separately.

The Locomotor Index is a promising measure and should be considered by rehabilitation teams looking for a valid, reliable and sensitive functional outcome measure for use with lower limb amputees.

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Introduction

Clinicians involved in the rehabilitation of lower limb amputees increasingly need to use outcome measures to demonstrate that they are providing a clinically effective service. Functional assessment measures are of particular importance for this group of patients since much of the rehabilitation process is associated with improving mobility and personal independence.

Recognising that physiotherapy is a central component of all amputee rehabilitation programmes, the Scottish Physiotherapy Amputee Research Group (SPARG) was established in 1991 to evaluate current physiotherapy practice concerning the management of amputees and to disseminate the results (see *Physiotherapy* 79, p.649). The group comprises every senior physiotherapist in Scotland (population approximately 5.5 million) with a clinical responsibility for amputee patients; at present, 26 physiotherapists fall into this category. In addition, SPARG has members representing the British Association of Chartered Physiotherapists in Amputee Rehabilitation, the British Association of Prosthetists and Orthotists and the David Murray Foundation (a Scottish charitable organisation working with amputees). SPARG also works closely with the Scottish Vascular Audit Group whose membership comprises all consultant vascular surgeons in Scotland and with the Information and Statistics Division at the Scottish Office Department of Health.

One of SPARG's core activities is to conduct

a regular, nationwide audit of the rehabilitation care received by lower limb amputees in Scotland (Condie *et al.*, 1996). The audit is based around a document known as a Discharge Summary Form (DSF) and custom software that allows data collected on the DSFs to be stored and subsequently analysed. The DSF was first used in October 1992 and a DSF is now completed for virtually all lower limb amputees in Scotland. Physiotherapists at ten amputating hospitals use the custom software to enter and analyse their own data. Other hospitals return their DSFs to the SPARG Coordinator where they are dealt with centrally. Analysis for the whole of Scotland is done by merging each hospital's data into a single database.

As part of this audit work, SPARG has attempted to measure the functional abilities of lower limb amputees at the time of discharge from hospital by including a functional assessment section on the DSF. This would provide an additional, standardised outcome by which to compare the rehabilitation programmes in use throughout Scotland. Since 1992, SPARG has used three outcome measures: the Barthel Index (Kullman, 1987; Mahoney and Barthel, 1965), Russek's classification (Kullman, 1987; Russek, 1961) and the 'Locomotor Index' part of the Prosthetic Profile for Amputees (Gauthier-Gagnon and Grisé, 1994; Grisé *et al.*, 1993). None of these measures was used for the whole period covered by this paper (1/10/92 - 31/7/97). The Barthel Index was used between 1/10/92 and 30/9/95, Russek's classification between 1/10/92 and 30/4/97 and the Locomotor Index from 1/10/96 onwards. As is clear from these dates, the functional assessment section of the DSF generally contained two measures. Completing the functional assessment part of the DSF took the physiotherapist less than five minutes.

The Barthel Index was originally developed as a means of assessing the level of independence in patients with neuromuscular or musculoskeletal disorders. It consists of ten items, each of which is rated in terms of whether the patient is able to perform a particular task independently (see Appendix, Table A1). Scores for the ten items are summed to give an overall score out of 100. The validity of the Barthel Index is well documented (Shah and Cooper, 1993) and the Index has also been found to be reliable (Collin *et al.*, 1988). Although not developed for amputees, some authors (Kullman, 1987; Goldberg, 1984) have used the Barthel Index with this group of patients and found it to be a useful indicator of functional abilities and rehabilitation outcome. Further, the Barthel Index is widely used and the Royal College of Physicians (1992) and others (Wade and Collin, 1988; Shah and Cooper, 1993) recommend its use as a 'gold standard' for measuring rehabilitation outcomes. For these reasons, and because some SPARG members had used Barthel with elderly (non-amputee) patients, SPARG chose the Barthel Index as one of its functional outcome measures in 1992.

The Russek's classification, unlike the Barthel Index, was developed for use with lower limb amputees. It is a six-point scale (see Appendix, Table A2) used to assess a patient's functional abilities when using his/her prosthesis. A score of six is awarded when the prosthesis provides full restoration of function and a score of one means that the prosthesis offers no advantage to the patient. In addition to the basic six-point scale, Kullman (1987) used the positive and negative factors concerning the patient, the stump and the prosthesis listed by Russek (1961) in his original publication. The number of positive and negative factors was used to correlate walking ability (as measured by the six-point scale) with prognosis prior to receiving the prosthesis. Russek found, for example, that the presence of one negative factor usually decreased walking ability by one point on the scale. SPARG, however, was not concerned *per se* with prognosis at admission, but in assessing in a simple way functional abilities at discharge and so used only the six-point scale. Altner *et al.* (1980), for example, used Russek's classification in this way to assess the pre- and post-amputation functional abilities of blind lower limb amputees.

To the best of the authors' knowledge, there is no published work concerning the validity and reliability of Russek's classification. However, Kullman (1987) considered Russek's classification, to be a useful method of evaluating an amputee's walking abilities and, because of this, SPARG considered it worthwhile to try this measure with amputee patients in Scotland.

The Locomotor Index is part of a more detailed assessment measure known as the Prosthetic Profile for Amputees (PPA)

developed by Gauthier-Gagnon and colleagues at the University of Montreal (Gauthier-Gagnon and Grisé, 1994; Grisé *et al.*, 1993). The Locomotor Index is a self-standing 14 point measure with each item on the scale scored from zero to three according to the patient's degree of independence in performing a given activity (see Appendix, Table A3). This scoring system gives a minimum score of zero and a maximum score of 42. The index can be divided into two seven-point subscales covering basic and advanced activities. Gauthier-Gagnon *et al.* (1993) found these subscales to be clinically useful with the advanced subscale discriminating between the least and most able amputees (Gauthier-Gagnon, 1995, personal communication). The authors of the PPA have demonstrated that the measure has face and construct validity and strong test-retest agreements show the measure also to be reliable (Gauthier-Gagnon and Grisé, 1994; Grisé *et al.*, 1993).

SPARG now uses only the Locomotor Index. The aim of this paper is to review its experiences of these three measures and to explain why SPARG would now recommend the Locomotor Index as the only one of these measures that should be considered an appropriate measure of functional outcome for lower limb amputees.

Methodology

Data collected on amputees who had an amputation between 1/10/92 and 30/7/97 were reviewed. The patient group considered in this paper comprises a subgroup of 938 unilateral amputees who had an amputation at either the transtibial (74%) or transfemoral (26%) level, were fitted with a prosthesis and had their functional abilities assessed using at least one of the Barthel Index, Russek's classification or the Locomotor Index. There were 573 men and 346 women. The sex of the remaining 19 patients was not recorded but these patients are included in the analysis since patients were not subdivided by sex. The mean age was 67 with a standard deviation of 15 years; 78% of patients were 60 or over. The dominant aetiology was peripheral vascular disease which accounted for 87% of patients, increasing to 92% for patients over 40. A third of patients with peripheral vascular disease were also recorded as being diabetic. The remaining amputations resulted from trauma (5%), tumours (2%), congenital deformities (1%) and various other causes including infection (5%).

A total of 546 patients were assessed using the Barthel Index, 772 using Russek's classification and 195 using the Locomotor Index. The different numbers of patients assessed using the three measures simply reflects the different time periods for which the measures were in use. Basic details of patients assessed using each of the three measures are given in Table 1. Many patients appear twice in Table 1 because Russek's classification was used, at different times, together with the Barthel Index and the Locomotor Index. Of the 546 Barthel Index patients, 514 were also assessed using Russek's classification while 61 of the Locomotor Index patients were also assessed using Russek's classification.

The three measures are compared here using two *a priori* predictions. Firstly, younger amputees should score significantly higher than older amputees and, secondly, transtibial amputees should score significantly higher than transfemoral amputees. The consensus view of SPARG is that a measure demonstrating both of these results is a better measure than one that does not.

Results

Summaries of median scores on the Barthel Index, Russek's classification and Locomotor Index are given in Tables 2-4. The Mann-

Table 1. Basic details of patients assessed using the Barthel Index, Russek's classification and the Locomotor Index. PVD = peripheral vascular disease.

Patients assessed using:	Barthel Index	Russek's	Locomotor Index
Number of patients	546	772	195
% PVD	56	57	58
% diabetic + PVD	32	31	27
% transtibial	71	72	85
% male	64	62	66
Average age	66	67	67

Table 2. Median Barthel Index scores achieved by transtibial (TT) and transfemoral (TF) amputees. Amputees have been compared by level (TT v TF) and by age (e.g. TT≤40 v TT>40). CI = confidence interval.

	median	95% CI	n
TT	95	90 - 95	387
TF	95	90 - 100	159
TT v TF	p = 0.35		
Score by age: TT			
≤40	100	100 - 100	24
>40	95	90 - 95	360
TT≤40 v TT>40	p < 0.007		
Score by age: TF			
≤40	100	95 - 100	11
>40	95	95 - 100	146
TF≤40 v TF>40	p = 0.21		

Table 3. Median Russek's classification scores achieved by transtibial (TT) and transfemoral (TF) amputees. Amputees have been compared by level (TT v TF) and by age (eg. TT≤40 v TT>40). CI = confidence interval.

	median	95% CI	n
TT	4	4 - 4	554
TF	3	3 - 3	218
TT v TF	p < 0.001		
Score by age: TT			
≤40	5	5 - 5	35
>40	4	3 - 4	519
TT≤40 v TT>40	p < 0.001		
Score by age: TF			
≤40	5	4 - 5	17
>40	3	3 - 3	201
TF≤40 v TF>40	p < 0.001		

Table 4. Median Locomotor Index scores achieved by transtibial (TT) and transfemoral (TF) amputees. Amputees have been compared by level (TT v TF) and by age (TT≤40 v TT>40). There were too few young transfemoral amputees for a meaningful comparison of median scores for the two age groups. CI = confidence interval.

	median	95% CI	n
TT	34	31 - 35	166
TF	24	17 - 28	29
TT v TF	p = 0.002		
Score by age: TT			
≤40	42	40 - 42	13
>40	33	28 - 34	152
TT≤40 v TT>40	p < 0.001		

Whitney test has been used for significance testing as all three measures are ordinal making parametric tests inappropriate. Only the Barthel Index does not show a significant difference in median score between transtibial and transfemoral amputees. Younger (40 years old was chosen as the cutoff) transtibial amputees score significantly higher ($p < 0.001$) than older amputees for all three measures. Russek's classification also demonstrates a significant difference ($p < 0.001$) in median score due to age for transfemoral amputees. Unfortunately, there were too few (four) transfemoral amputees below the age of 40 assessed using the Locomotor Index and a meaningful comparison of median scores for the two age groups was not possible.

Table 5 compares median scores achieved using the full Locomotor Index with scores achieved using only the advanced activities subscale. The advanced activity subscale appears to provide the same level of sensitivity as the full Index but with median values that represent a smaller proportion of the maximum score, i.e. ceiling effects appear to be reduced. The basic activities subscale (data not shown) also shows significant differences due to age and level when considered separately but the median values obtained from this subscale represent a higher proportion of the maximum score. For example, the median basic activities score for the transtibial amputees included in Table 4 is 19 or 90% of the maximum score.

Discussion

Functional outcome measures should be valid, reliable and unidimensional (Tennant and Young, 1997). In addition to these psychometric and measurement properties, a clinically useful functional outcome measure should reflect clinical experience. A functional outcome measure for use with lower limb amputees should, at the very least, demonstrate a statistically significant difference in the scores obtained by patients who have been subdivided by age and level of amputation. A measure that does not show that transtibial amputees have more functional capacity on average than transfemoral amputees must be considered dubious since clinical observation shows that there is a very real difference. The same is true of young and old amputees. Ideally, the measure should also have a good range such that floor and ceiling effects do not adversely affect the responsiveness of the measure. Only after these basic criteria have been met can the measure be used to investigate less obvious, and perhaps speculative, causes of variation in, functional outcome.

The Barthel Index is standardised, valid and reliable but lacks sensitivity when used with amputee patients. The data presented in Table 2 do not show a significant difference in median Barthel score between transtibial and transfemoral amputees. Further, the very high median scores are an indication that ceiling effects (i.e. a predominance of maximum scores in some items) are a significant problem. The ability of the Barthel to respond to clinically important change has been questioned by other authors (Ashburn *et al.*, 1993; Simpson and Forster, 1993; Smith, 1993) with the mobility and transfer sections receiving particular criticism. These two sections are arguably the most important for amputees as these patients generally have few problems with feeding, grooming and toileting. The feeding and grooming sections of the Index highlight the major shortcoming of the Barthel when used with amputees: it asks the wrong questions. Amputees uniformly score very high on these questions which greatly reduces the measure's sensitivity. These problems make the Barthel Index completely inappropriate for use as a functional outcome measure with lower limb amputees and SPARG stopped using it in 1995.

Russek's classification, unlike the Barthel, does show significant differences between patients of different age and level of amputation (Table 3). While these results would seem to be encouraging, the Russek's six-point scale means that large numbers of patients are required to show these differences. Annual studies conducted by SPARG (Condie *et al.*, 1996; Treweek and Condie, 1996) have generally

Table 5. Comparison of median scores achieved using the full Locomotor Index with scores achieved using only the advanced activities subscale. Amputees have been compared by level (TT v TF) and by age (TT≤40 v TT>40). CI = confidence interval.

	Whole locomotor index		Advanced subscale	
	median	% max score	medium	% max score
TT	34	81	14.5	69
TF	24	57	9	43
TT v TF	p = 0.002		p = 0.009	
Score by age: TT				
≤40	42	100	21	100
>40	33	76	13	62
TT≤40 v TT>40	p = 0.001		p = 0.001	

failed to replicate the results seen in Table 3. The number of patients assessed via the Russek's classification in these annual studies was around 330 which does not appear to be enough for differences due to level of amputation to reach significance. The situation for a single hospital conducting a local study of functional outcome is even worse since the number of primary lower limb amputees per year is often less than 30. The effect of age is, however, clear and has been seen in previous work (Treweek and Condie, 1996). The poor sensitivity of Russek's classification led SPARG to stop using it in 1997.

The Locomotor Index (Table 4) demonstrates significant differences due to age (for transtibial amputees) and level of amputation despite the much smaller number of patients that have currently been assessed using this measure. It is also likely that the Locomotor Index would have shown significant differences due to age with transfemoral amputees had more of these patients been available for assessment. These results suggest that the Locomotor Index is more sensitive than both the Barthel and Russek's classification. There is, however, a tendency for the median values to be at the higher end of the Locomotor Index's scale, the most striking example of this being the median score for young transtibial amputees. The original authors of the Locomotor Index calculated mean scores and obtained similar values to the medians presented here: mean Locomotor Index score of 30.7 (out of a possible 42) for 396 amputees of mixed amputation level (Gauthier-Gagnon, 1995, personal communication). Their mean score for the advanced activity subscale was 13.0 out of a possible 21.

By considering the advanced activity subscale separately, it is possible to reduce the median value as a proportion of the maximum score without losing sensitivity. This extends the use of the Locomotor Index to more active, but elderly, amputees although no improvement is seen for younger active amputees. Perhaps it is too much to expect the same functional outcome measure to be suitable for a fit, 25 year old traumatic amputee and a 75 year old amputee with peripheral vascular disease and diabetes. Although the seven-point advanced activities subscale gives similar results to the full 14-point Locomotor Index, the temptation to drop the seven items of the basic activities subscale should be resisted since only the full measure has been validated. The use of the complete measure is the approach recommended by the original authors and should be used until the subscales are found to be valid and reliable when used alone.

Conclusion

SPARG has gained a great deal of experience with functional outcome measures during the five year period covered by this paper. Had SPARG the benefit of this experience in 1992, the Barthel Index and Russek's classification would not have been chosen as functional outcome measures. The Barthel Index has very poor sensitivity and although Russek's classification does demonstrate significant differences due to age and level of amputation, this six-point scale requires a large number of patients to achieve this. Differences in functional outcome having more subtle explanations than age and level of amputation are likely to require even more patients. Conversely, the Locomotor Index gives significant results for smaller numbers of patients and the advanced activities subscale allows the range of the measure to be increased to include some of the more active amputees.

The Locomotor Index is a promising measure of functional outcome for lower limb amputees and this is the only measure SPARG currently uses. A system of post-discharge functional assessment based around the Prosthetic Profile for Amputees and including the Locomotor Index is now being developed. This will allow monitoring of long-term functional ability and raises the prospect of being able to link elements of acute rehabilitation care to long-term functional outcome, This will provide some much needed information about long-term clinical effectiveness and give a more evidence-based foundation to some aspects of amputee rehabilitation.

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Appendix

Table A1. The Barthel Index. Patients unable to do a particular activity score zero for that activity.

	With help	Independent
1 Feeding (if food needs to be cut up = help)	5	10
2 Moving from wheelchair to bed and return (includes sitting up in bed)	5-10	15
3 Personal toilet (wash face, comb hair, shave , clean teeth)	0	5
4 Getting on and off toilet (handling clothes, wipe, flush)	5	10
5 Bathing self	0	5
6 Walking on level surface	10	15
(or if unable to walk, propel wheelchair)	0	5
7 Ascend and descend stairs	5	10
8 Dressing (includes tying shoes, fastening fasteners)	5	10
9 Controlling bowels	5	10
10 Controlling bladder	5	10

Table A2. Russek's classification. Note that some authors choose to reverse the scoring, i.e. 1 = 'Full restoration', 6 = 'Not feasible'.

Score	Characteristics
1	Not feasible (the prosthesis offers no advantage to the patient)
2	Cosmetic plus (only short distances walking indoors, insecurity, discomfort)
3	Self-care minus (help needed in varying degrees-fatigue)
4	Self-care plus (complete independence, job alterations may be necessary, regular activities)
5	Partial restoration (restriction of only certain activities-dancing, sport etc.)
6	Full restoration (not disabled by impairment)

Table A3. The Locomotor Index.

1	Get up from a chair
2	Pick up an object from the floor when standing*
3	Get up from the floor (e.g. if they fell)*
4	Walk indoors
5	Walk outside on even ground
6	Walk outside on uneven ground (e.g. grass, gravel, a slope)*
7	Walk outside in bad weather (e.g. rain, snow)*
8	Go up the stairs with a hand-rail
9	Go down the stairs with a hand-rail
10	Step up a kerb
11	Step down a kerb
12	Go up a few step without a hand-rail*
13	Walk down without a hand-rail*
14	Walk while carrying an object*

The scale is scored according to whether a patient can perform the activity:
0 = No, 1 = Yes if someone helps,
2 = Yes if someone is near, 3 = Yes alone.

Items marked with a "*" form the advanced activity subscale.