Comprehensive Assessment of Activities of Daily Living in Stroke. The Copenhagen Stroke Study

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ABSTRACT. Pedersen PM, Jørgensen HS, Nakayama H, Raaschou HO, Olsen TS. Comprehensive assessment of activities of daily living in stroke. The Copenhagen Stroke Study. Arch Phys Med Rehabil 1997;78:161-5.

Objective: To assess activities of daily living (ADL) in stroke in a comprehensive way. The Barthel Index (BI) is widely used in stroke research, but is limited because it measures basic ADL functions only. This study sought to determine whether the Frenchay Activities Index (FAI) is a good choice for supplementary assessment of higher order ADL functions.

Design: Prospective and consecutive.

Setting: Follow-up investigation 6 months after stroke of patients who were admitted to, and completed rehabilitation at, a stroke unit.

Patients: 437 patients with strokes.

Main Outcome Measures: Factor analysis of the BI, FAI, and the Scandinavian Neurological Stroke Scale (SSS); distribution characteristics of a comprehensive, combined ADL scale.

Results: Five factors were found. One factor comprised all items from the BI and all the motor items from the SSS, but no items from the FAI. The FAI loaded on three other factors. Finally, orientation and speech from the SSS loaded on a separate factor. A combined score consisting of the BI total score and a simple transformation of the FAI total score had a much improved distribution without strong ceiling or floor effects.

Conclusions: The FAI supplements the BI with minimal overlap in content. A combined total score has a distribution that makes it very usable for research in stroke outcome and stroke rehabilitation effect.

DISABILITY AFTER STROKE and stroke rehabilitation outcome are usually assessed by formalized observation and scoring of activities of daily living (ADL). The Barthel Index (BI) is widely used for this purpose, is well validated,[1,2] and has been endorsed by the US Agency for Health Care Policy and Research Post-Stroke Rehabilitation Clinical Practice Guidelines.[3] It must, however, be presumed to have a pronounced ceiling effect because it only evaluates more basic ADL functions and, thus, not complex functions impaired in very mild or nearly recovered stroke. In response to this limitation, some authors have chosen to use expanded ADL scales.[2] It is, however, desirable to keep the BI unaltered because of its proven qualities and to facilitate comparisons between studies. It is therefore of interest to know whether it is possible to obtain a valid measure of the entire range of ADL functions by supplementing the BI with a scale testing higher level ADL. The Frenchay Activities Index (FAI)[4] addresses higher level ADL and social functions and has been validated with factor analysis on samples of stroke patients[5] and nonstroke elderly persons.[6,7] The FAI has also been endorsed by the US Agency for Health Care Policy and Research Post-Stroke Rehabilitation Clinical Practice Guidelines.[3] ADL functions may depend on basic neurological status and higher cognitive functions. The Scandinavian Neurologic Stroke Scale (SSS)[8] that has items in both areas was therefore included in the study.

A larger factor analysis including the BI and a neurological score to examine whether the FAI is in fact supplementing the BI and the neurological score by loadings on unique factors has not previously been reported. We present such an analysis in a prospective study of a consecutive sample of stroke patients assessed 6 months after stroke.

METHODS

Definition of stroke. Stroke was defined according to World Health Organization criteria[9]: rapidly developed clinical signs of focal disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than vascular origin. Intracerebral hemorrhage was included, whereas subaracnoidal bleeding was excluded in order to obtain a pathophysiologically homogeneous sample. Stroke was diagnosed clinically and confirmed by computed tomography (CT).

Inclusion. The study is part of the Copenhagen Stroke Study described in detail elsewhere.[10] All patients were admitted to the same stroke unit, in which all stages of acute care, workup, and rehabilitation took place. Rehabilitation based on the Bobath technique was given daily to all patients by the nursing staff, physiotherapists, and occupational therapists within the stroke unit. There were 895 patients admitted from April 1, 1992 to September 31, 1993.

Exclusion. Excluded were: (1) 258 patients who died before the 6-month poststroke follow-up; (2) 167 who did not report for the follow-up; and (3) 33 who could not be measured with all instruments for other reasons. Among the surviving patients, there were no differences between the 437 included and the 200 excluded patients in the distribution of sex (46% and 44% men, $\chi^2 = .21$, $p = .64$), age (73.6 years [SD 10.0] and 72.1 years [SD 13.4], $t = -1.44$, $p = .16$), marital status (44% and 37% married, $\chi^2 = 2.21$, $p = .14$), or nursing home residency (15% and 19%, $\chi^2 = 1.52$, $p = .22$). There were significant, but small, differences in mean Barthel Index scores at discharge from the hospital (82.1 points [SD 28.7] and 75.4 points [SD 34.9], $t = -2.28$, $p = .023$) and in mean Scandinavian Neurologic Stroke Scale scores at the discharge from the hospital (51.1 [SD 10.1] and 48.9 [SD 12.7], $t = -2.09$, $p = .038$).

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Submitted for publication March 29, 1996. Accepted in revised form August 19, 1996.

Supported by grants from the Danish Aphasia and Stroke Association (Hjernesagen), the Danish Health Foundation, the Danish Heart Foundation, Ebba Celinders Foundation, and the Gangsted Foundation.

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit upon the authors or upon any organization with which the authors are associated.

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0003-9993/97/7802-3965$3.00/0

Table 1: The Barthel Index

1. Feeding
2. Moving from wheelchair to bed and return (or if able to walk, orientation in space)
3. Personal toilet (wash face, comb hair, shave, clean teeth)
4. Getting on and off toilet (handling clothes, wipe, flush)
5. Bathing self
6. Walking on level surface (or if unable to walk, propel wheelchair)
7. Ascend and descend stairs
8. Dressing (includes tying shoes, fastening fasteners)
9. Controlling bowels
10. Controlling bladder

Procedures. Demographic variables recorded were age on admission, sex, and marital status. Also recorded was whether the patients were discharged to nursing home or independent living (ie, living in own home with support as needed). The side of the stroke lesion was assessed clinically. A history of previous stroke was obtained on admission. The hospital register containing information on diagnosis from former admissions was also studied. Information concerning comorbidity was obtained on admission and included other disabling disease apart from previous stroke (amputation, multiple sclerosis, heart failure, latent or persistent respiratory insufficiency, Parkinsonism, etc).

Neurologic function was assessed with the Scandinavian Neurological Stroke Scale (SSS)[8,11] 6 months after stroke. The SSS evaluates level of consciousness, eye movement, power in arm, hand, and leg, orientation, aphasia, facial paresis, and gait. The total score ranges from 0 to 58 (normal) points. The SSS has been found to be reliable[11] and its validity has found support in high correlations with other stroke scales.[12]

ADL was assessed by the Barthel Index[1] and the Frenchay Activity Index (FAI)[4] 6 months after stroke. The BI evaluates ten different basic abilities and ranges in total score from 0 to 100 points (table 1). Numerous studies have ascertained the validity and reliability of the BI, as reviewed by Wade and Collin.[13] The FAI comprises 15 activities, each rated from one to four points, and the total score ranges from 15 to 60 points (table 2). The index evaluates domestic chores, leisure activities, work activities, and outdoor activities. Wade and coworkers[5] have found this scale to be reliable and have also provided some validation in a stroke sample.

A comprehensive ADL score was computed in the following way. First, the FAI score was transformed by subtracting 1 from each item (giving a 0 to 3 scale) and then these item scores were multiplied by 2. The resulting, transformed FAI total score thus ranged from 0 to 90, which is comparable to the range of the BI (0 to 100). This total score was then added to the BI total score yielding a total score range of 0 to 190.

Statistics. All items from the BI, the FAI, and the SSS were included in a factor analysis in order to determine (1) whether a smaller number of latent (or hidden) variables (factors) could explain the variations and (2) whether latent variables (factors) were shared between the scales, suggesting overlap in content. Factor analysis "summarizes patterns of correlations among observed variables".[14] Orthogonal rotation of the factors enhaces interpretability by making the factors uncorrelated. A loading matrix of correlations between observed variables and factors is produced. The contribution of each factor to the variation in an observed variable is, thus, also called the "loading" of the variable on that factor.[14]

Comparisons for continuous data were carried out with Students's nonpaired t test. Categorical tables were analyzed with the χ^2 test. The required two tailed significance level for all statistical tests was set to $p < .05$. Factor analysis was carried out with principal components analysis. All factors with an eigenvalue of ≥ 1 were retained and subjected to orthogonal rotation using the Varimax procedure. All analyses were done with the SPSS for Windows 6.0 statistical package.[15]

Ethics. The study was approved by the Ethics Committee of Copenhagen.

Table 2: The Frenchay Index

1. Preparing main meals
2. Washing up
3. Washing clothes
4. Light housework
5. Heavy housework
6. Local shopping
7. Social outings
8. Walking outdoors over 15 min
9. Pursuing active interest in hobby
10. Driving a car
11. Outings/car rides
12. Gardening
13. Household and/or car maintenance
14. Reading books
15. Gainful work

Table 3: Basic Patient Characteristics and Neurological and Functional Status at the 6-Month Follow-Up

N	437
Age, mean years (SD)	73.6 (10.0)
Sex, male/female	199/238 (46%/54%)
Lesion side, left/right	212/174 (55%/45%)
Previous stroke, present/absent	87/340 (20%/80%)
Comorbidity, present/absent	69/359 (16%/84%)
Married/single	186/242 (44%/56%)
Discharge to nursing home/own home	65/372 (15%/85%)
SSS, mean (SD)	51.4 (10.3)
Aphasia, present/absent*	86/371 (15%/85%)
Impaired orientation, present/absent†	43/394 (10%/90%)
BI, mean (SD)	83.8 (27.6)
FAI, mean (SD)	30.0 (11.6)

* A score below 10 on the SSS Speech score.
† A score below 6 on the SSS Orientation score.

RESULTS

Basic patient characteristic are presented in table 3. With a mean SSS score of 51 6 months after stroke, these patients usually had a good neurological recovery; 2% had a very severe neurologic impairment at this time (score, 1 to 14 points), 5% a severe impairment (15 to 29 points), 9% a moderate impairment (30 to 44 points), and 85% mild or no impairment (44 to 58 points).

Two scores from the SSS were left out of the factor analysis because only one patient scored below maximum in these scores: the Consciousness and the Eye Movements scores. The result of the factor analysis is shown in table 4. To obtain a parsimonious interpretation we decided to include all factor loadings above .40 in the interpretation. Factor one, then, consists exclusively of items from the BI (Toilet Use, Dressing, Mobility, Transfer, Stair Walking, Grooming, Bowel Control, Feeding, Bladder Control, and Bathing) and from the SSS (Gait, Leg Power, Arm Power, Hand Power, and Facial Palsy). Factor two consists of items from FAI (Washing Clothes, Light Housework, Preparing Meals, Heavy Housework, Dish Washing, Local Shopping, Walking Outside, Reading Books, and Hobby), as does factor three (Driving a Car, House/Car Maintenance, Gainful Work, Gardening) and factor four (Outings and Social Outings). Factor five consists of the two neuropsychological items from the SSS (Speech and Orientation).

Figures 1, 2, and 3 show histograms of the distribution of the BI total score (kurtosis 2.2, skewness −1.8), the FAI total

Table 4: Rotated Factor Matrix for Scandinavian Stroke Scale, Barthel Index, and Frenchay Activities Index

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Communalities
BI Toilet Use	**.86**	.18	.06	.27	.06	.85
BI Dressing	**.84**	.27	.08	.18	.07	.83
BI Mobility	**.84**	.28	.12	.14	.03	.82
SSS Gait	**.82**	.31	.12	.14	.07	.81
BI Transfer	**.82**	.25	.08	.25	.08	**.82**
SSS Leg Power	**.82**	.15	.07	−.12	.19	.75
SSS Arm Power	**.82**	.20	.08	−.21	.25	.82
BI Stairs	**.80**	.35	.12	.18	.02	.81
SSS Hand power	**.78**	.23	.07	−.26	.20	.76
BI Grooming	**.76**	.14	.06	.17	.24	.69
BI Bowels	**.75**	.01	.03	.29	.23	.71
BI Feeding	**.73**	.07	.04	.26	.32	.71
BI Bladder	**.67**	.12	.04	**.45**	.08	.68
BI Bathing	**.63**	**.43**	.13	.18	−.02	.63
SSS Facial Palsy	**.50**	.16	.05	−.14	.39	.45
FAI Washing clothes	.15	**.86**	.12	.02	.08	.78
FAI Light Housework	.23	**.85**	.11	.14	.07	.81
FAI Preparing Meals	.24	**.83**	.08	.03	.10	.76
FAI Heavy Housework	.09	**.77**	.36	.06	.07	.74
FAI Dish Washing	.37	**.75**	.09	.07	.10	.72
FAI Local Shopping	.35	**.66**	.20	.32	.01	.69
FAI Walking Outside	**.49**	**.56**	.15	.35	−.07	.70
FAI Reading Books	.22	**.47**	.12	**.47**	.12	.52
FAI Hobby	.13	**.45**	.39	.35	.13	.51
FAI Driving Car	.05	.12	**.82**	.08	.01	.69
FAI House/Car Maintenance	.15	.32	**.77**	.01	.03	.72
FAI Gainful Work	.02	.001	**.66**	.15	.02	.46
FAI Gardening	.10	.20	**.60**	−.06	.04	.41
FAI Outings	.23	**.45**	.09	**.59**	.06	.61
FAI Social Outings	.34	.33	.21	**.44**	.26	.53
SSS Speech	.23	.11	.07	.03	**.84**	.78
SSS Orientation	.35	.10	.02	.20	**.76**	.75
Eigenvalue	14.45	3.62	1.70	1.34	1.21	
Percentage of Variation	45.2%	11.3%	5.3%	4.2%	3.8%	

score (kurtosis −1.0, skewness 0.4), and the comprehensive ADL score (kurtosis .008, skewness −0.9). Inspection of these figures shows that the comprehensive ADL score has a considerable more normal distribution than is the case in both the BI and the FAI scores.

DISCUSSION

The FAI was included in a single factor analysis with the BI scale of basic ADL functions and the SSS scale of neurological function. Our interpretations of the results are: (1) the FAI is providing unique information as it supplements the BI and the SSS without major redundancy in content; (2) the BI and the SSS are rather redundant in content except for the cognitive items of the SSS; (3) the BI is a homogeneous scale, whereas the FAI is heterogeneous; and (4) the SSS falls in two distinct parts, a movement and motor power part and a cognitive part.

A unique contribution of the FAI. The items of the FAI loaded on three factors, none of which included primary loadings of items from BI or SSS. The loading of a variable on a factor reflects how much of the variance in the variable that is attributable to that factor. The FAI items, thus, reflect other sources of variation than the BI and the SSS, providing unique information. The very few overlaps between the BI and the FAI factor loadings confirm the value of supplementing the assessment of basic ADL functions with assessment of higher level activities. Moreover, it was found that BI Bathing had a high secondary loading with the FAI items on factor two. Because Bathing has been found to be the most difficult item to

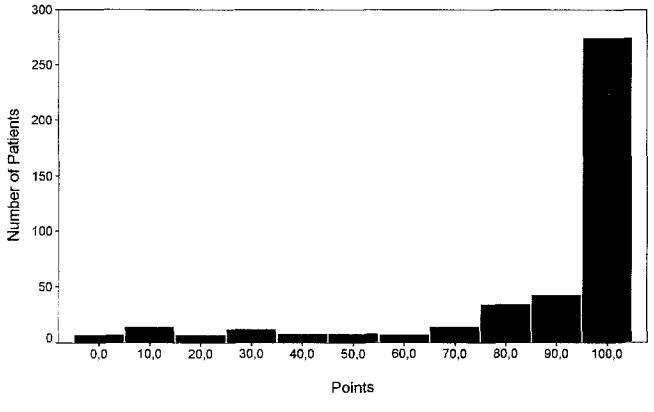

Fig 1. Histogram of the distribution of the Barthel Index total score 6 months after stroke.

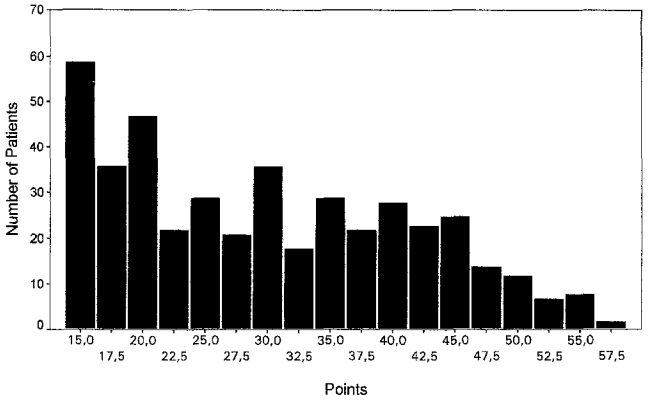

Fig 2. Histogram of the distribution of the Frenchay Activities Index total score 6 months after stroke.

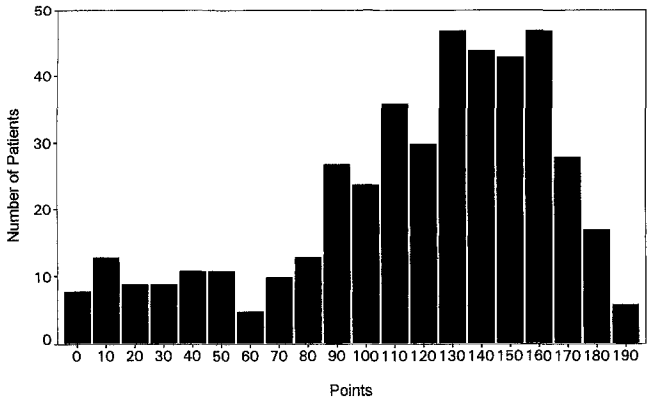

Fig 3. Histogram of a comprehensive ADL score computed by adding the BI score and a simple transformation of the FAI total score at 6 months after stroke.

perform on the BI,[16] this suggests a continuity in terms of difficulty between the two scales and justifies a combined score.

Redundancy of the BI and the SSS. All movement and motor power items from the SSS had high loadings on the same factor as the BI items, showing them to reflect the same underlying source of variance. It allows the conclusion that these SSS items do not add new information to the information obtained by the BI. This can probably be attributed to the importance of movement and power for basic ADL functions. It should, however, be remembered that the data are from intensively rehabilitated patients 6 months after stroke expected to have completed the major part of their recovery and compensation potential. It should also be noted that two SSS items were left out of the analysis: level of consciousness and eye movement. The conclusion about redundancy of the SSS and the BI can therefore not be generalized to more acute patients, in whom more variation is expected on these variables.

The communality of the SSS facial palsy item is rather low (.45). This means that the factors account for a relatively small proportion of the variance in this variable. This supports the interpretation of factor 1 as a movement and motor power factor.

Homogeneity of the scales. All items of the BI loaded on a single factor. The major part of variation of all the BI items can, thus, be explained by a single underlying latent variable, making the BI a homogeneous scale. Although the loading on three factors makes the FAI a heterogeneous scale, most items loaded on a single factor, except activities not often undertaken by this elderly population (Factor 3: Driving a car, House/Car Maintenance, Gainful Work, and Gardening), and getting out of home for other reasons than shopping or walks (Factor 4: Outings and Social Outings).

The two neuropsychological items of the SSS constituted their own factor. The lack of overlap between neuropsychological items and motor items in the SSS confirms earlier observations of the heterogeneity of this scale.[12] It also shows that the cognitive factor is not fully covered by the BI or the FAI. Thus, if a more pure neurological scale is employed in place of the SSS, it should be supplemented by a separate scale covering the neuropsychological domain.

Interpretation of factors. The first factor can be interpreted as a movement and motor power factor and it suggests that paresis is the most important factor for basic ADL functions in a stroke population. The homogeneity of the BI and the overlap with the SSS can be caused by the high incidence of concurrent hand, arm, and leg paresis in the stroke population and might not be true for other populations of neurological patients. FAI Walking Outside had a high secondary loading on factor one with the BI and SSS motor items, which supports the interpretations of this factor.

Factor two and three can be interpreted as different levels of difficulty in ADL functions. As mentioned, factor two seems to be the next step in difficulty after the BI items level of difficulty, and factor three might be the next level of difficulty. Age and sex could also make a difference, gainful work is only relevant for patients before the pension age, some activities are typically male, and the men in the stroke population are generally younger than the women.

Factor four seems to be related to the extent of activities away from home. BI Bladder Control had a high secondary loading on factor four, which can be interpreted as an influence of bladder control on the degree of participation in social events and outings. It follows that treatment of urinary incontinence and instruction in coping with incontinence when continence cannot be achieved are of importance for the social life of the stroke patient.

Previous research. One previous study found the BI to have two factors in contrast to the single factor found in the present study.[16] However, the second factor found in that study explained a very small amount of variance compared with the first factor. Moreover, the BI was assessed only 3 weeks after stroke. In the present study, many patients had reached the ceiling, reducing the variability, which might have the effect of hiding a two-factor structure. That more factors were found for the FAI is consistent with the larger degree of variability on this scale in our population, as is evident from figures 1 and 2.

Factor analysis of the FAI has been presented by three previous studies. Two studies examined the prestroke scores of stroke patients.[4,5] The third study examined the scores of nonstroke elderly.[7] All three studies found the FAI to comprise three factors, as we found. Although not all items load on the same factors, the same general trend is found, thus lending credibility to the three factor structure of the FAI.

Bond[7] suggested that the area of high level ADL and social activities should logically have four factors, work and leisure, that each can be either indoor or outdoor, and that the FAI only includes items for three of these four factors. Our findings do not support such an interpretation. It seems that our first factor (factor 2) concerns home work that is not too difficult and leisure activities, the second factor (factor 3) more demanding activities, and the third factor (factor 4) leisure activities that imply leaving the home. It is, however, natural that a nonstroke and a stroke sample show different factor structures. In a nonstroke sample the factors must be assumed to express sex roles, interests, and the economic structure of the society. In a stroke sample, physical and neuropsychological impairments are expected to play a major role. An obvious example of this is the association of BI Bladder Control with the Outings and Social Outings FAI items.

Both the BI and the FAI have been subjected to factor analysis previously, but they have not been included in a single factor analysis and they have not been analyzed together with neurological scales. Such an analysis is important to show the factor structure of the whole area of function after stroke. It is also important to the external validation of the scales.

Properties of a combined scale. The ceiling effect on the BI is obvious in figure 1 as is the floor effect on the FAI in figure 2. The combined score on figure 3 has a much more satisfactory distribution. Although it deviates slightly from a normal distribution having a long tail toward lower scores, such a tail is very much what one would expect to find in rehabilitated stroke patients 6 months after stroke, where a small group of patients will have persistent severe disability.

CONCLUSION

The present analysis shows that the BI and FAI assess different factors and that they represent a continuity of ADL levels. The sensitivity of studies of stroke and stroke rehabilitation outcome can, thus, be enhanced through the use of a comprehensive ADL score obtained by combining the two scores. The SSS was found to be heterogeneous; most items load with the BI items and, thus, do not seem to supplement the BI. The two cognitive items load on a separate factor. More information might thus be gained if the SSS was replaced by a purely cognitive scale.

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