Scand J Rehab Med 31: 83–88, 1999

A CROSS-VALIDATION OF THE COMPREHENSIVE ASSESSMENT OF ACTIVITIES OF DAILY LIVING AFTER STROKE

Ching-Lin Hsieh, PhD and I-Ping Hsueh, MA

From the School of Occupational Therapy, College of Medicine, National Taiwan University, Taipei, Taiwan, ROC

ABSTRACT. This study aimed to determine whether the Frenchay Activities Index and the Barthel Index assess different factors in stroke patients who survive for more than one year. The Frenchay Activities Index and the Barthel Index were administered via telephone interview. One hundred and twenty-four patients from the community participated in the study. All items of the Barthel Index and the Frenchay Activities Index, except reading books, were included in a factor analysis to determine the underlying constructs of the items. Four factors were found. One factor comprised all items from the Barthel Index and one item from the Frenchay Activities Index. The rest of the Frenchay Activities Index items loaded on three other factors. The combined scores, using simple transformation, had satisfactory distributions. The results support the hypothesis that the Frenchay Activities Index and the Barthel Index assess different factors in stroke patients who survive for more than one year. The Barthel Index score and the Frenchay Activities Index score could be combined to assess the entire range of activities of daily living functions in stroke.

Key words: Frenchay Activities Index; Barthel Index; activities of daily living; cerebrovascular disorders; disability evaluation; aged.

Many rehabilitation measures have been designed to evaluate function in activities of daily living (ADL). The term ADL generally refers to basic/personal activities and represents a valid single construct (18). However, rehabilitation therapy is not simply concerned with achieving independence in basic ADL. Ideally, the tools used to evaluate the degree of independence in ADL should include all activities of everyday life. A simple measure of comprehensive ADL function would meet the needs of both clinicians and researchers.

The Barthel ADL Index (BI) (12) is widely used to measure basic ADL functions, while the Frenchay Activities Index (FAI) (4) assesses higher-level ADL and social functions. Pedersen et al. (13) found that the BI and the FAI assess different factors and that the combination of the two scores could represent a comprehensive ADL score. The combined total score has a satisfactory distribution that makes it useful for stroke outcome and treatment effect research. Since both the BI and the FAI are easy to administer, the combined scale appears promising in clinics as well. However, the psychometric characteristics of the new combined scale are not well established. Generalization of the results requires caution because the subjects in Pedersen et al.'s study (13) had suffered from a stroke for only 6 months. Because the last 5 items of the FAI refer to performance in the last 6 months, the patients would have had little opportunity to explore any ADL. The results, thus, might not be generalized to those who survive for more than half a year after stroke. Further examination of the psychometric details of the combined scale is needed.

The purpose of the study was to determine whether the BI and FAI assess different factors in stroke patients who survive for more than one year. The distribution characteristics of the combined total score were also examined.

SUBJECTS AND METHODS

Subjects

Subjects were selected from 822 consecutive stroke patients discharged from the National Taiwan University Hospital in Taipei, one of the largest academic hospitals in Taiwan, between February 1996 and January 1997. One hundred and seventy patients met the following criteria: (*i*) diagnosis (International Classification of Diseases, Ninth Revision Clinical Modification (ICD-9-CM) codes) of cerebral haemorrhage (431), cerebral infarction (434), or other (430, 432, 433, 436, 437); (*ii*) aged more than 20 years old; (*iii*) stroke onset at least one year and discharged from the hospital at least 6 months before follow-up; and (*iv*) living in Taipei. The clinical diagnosis of stroke was

confirmed by physicians using neuroimaging examination (computed tomography or magnetic resonance imaging). Patients who were diagnosed with non-vascular accident-related subarachnoid haemorrhage (ICD-9-CM code 430), or who suffered from other disabling diseases (e.g. multiple sclerosis or heart failure) likely to affect ADL functions were excluded.

Instruments

The BI (12) evaluates 10 basic ADL, including feeding, transfer, grooming, toileting, bathing, ambulation, stair climbing, dressing, bowel control, and bladder control. Its validity has been well established (2, 3). It is reliable on test-retest, between raters, and whether administered by interview or by observation (18).

The FAI was developed as a means of measuring social activities, or lifestyle, following stroke (4). It comprises 15 items related to normal activities, each rated from 1–4 points: preparing meals, washing up, washing clothes, light housework, heavy housework, local shopping, social outings, walking outside > 15 min, actively pursuing hobbies, driving/bus travel, outings/car rides, gardening, household/car maintenance, reading books, and gainful employment. The original scoring system yields a range from 15 (inactive) to 60 (highly active). The scoring system is awkward. Each item was reduced by 1 point, as described in previous studies (13, 18), yielding a score range of 0–45 points. The FAI was administered to the patient or his/her relatives. The reliability and validity of the FAI have been examined in various countries (4, 14, 19), including Taiwan (5, 6). The item "reading books" was not included in this study because it correlates poorly with the rest of the items and has little discriminative value (6, 14).

Procedures

The patients were invited to participate in the survey primarily by telephone. If no telephone number or a wrong number was found in the hospital records, a written invitation letter was mailed. No subject who was contacted by telephone refused to participate. For subjects who could not answer the telephone because of speech impairment or other problems (e.g. severe cognitive disorders), their spouses or other primary caregivers were interviewed instead. A change of telephone number or address constituted the main reason for omission of follow-up interviews.

The BI and the FAI were administered by an occupational therapist via telephone interview. Patients' personal details and comorbidity were retrospectively collected from their medical records.

Data analysis

All items of the BI and the FAI, except reading books, were included in a factor analysis to determine the underlying constructs of the items. Prior to the factor analysis, the Kaiser-Meyer-Olkin (KMO) measure (7) was used to test the adequacy of using factor analysis on the data. Kaiser (7) characterized values above 0.9 as marvellous, above 0.8 as meritorious, above 0.7 as middling, above 0.6 as mediocre, above 0.5 as miserable, and below 0.5 as unacceptable. A loading matrix of correlations between observed variables and factors was made, and factor analysis was carried out with principal component analysis. Factors that accounted for variances greater than 1 (eigenvalue greater than 1) were included. The varimax procedure, which attempts to minimize the number of variables that have hi loadings on a factor, was used for orthogonal rotation to enha interpretability.

Two comprehensive ADL scores were computed. First, recommended by Pedersen et al. (13), the BI total score added to two times the FAI total score, yielding a total combi score range of 0–190. The score range of this study was 0–1 because the item "reading books" was deleted. Second, th scores of the BI and the FAI were added together (the combi Z scores), giving both of the scales equal weight. The Z sc indicates how many standard deviations above or below t mean an observation falls (10). The mean of Z scores is 0 and t standard deviation is 1.

SPSS for Windows 6.13 software was used for all da management and analysis.

RESULTS

Of the 822 consecutive stroke patients, 170 met th selection criteria and 124 (73%) participated in the stud Sixty-four of these subjects were unable to answer th telephone, and so their primary caregivers were inte viewed instead. Table I shows the characteristics of th patients. The characteristics of the 124 patients inte viewed were compared with those of the 46 patients lo to follow-up using χ^2 test or t-test. There were n significant differences between the subjects interviewe and those who were lost to follow-up in terms of gende age, diagnosis, days after onset and days after hospit discharge (all $p > 0.1$).

Since the KMO value (0.89) was close to 0.9, w

Table I. *Characteristics of patients who survived mor than one year after stroke* (n = *124*)

Characteristics	*n* (%)
Gender	
Male	73 (58.9)
Female	51 (41.1)
Marital status	
Married	91 (73.4)
Single/divorced/widowed	33 (26.6)
Age (years)	64.3 (13.0)*
Diagnosis	
Cerebral haemorrhage	38 (30.6)
Cerebral infarction	62 (50.0)
Other	24 (19.4)
Side of hemiplegia	
Left	53 (42.8)
Right	71 (57.2)
Days after onset	492.2 (110.7)*
Days after discharge	460.2 (112.3)*
Barthel Index scores	81.9 (30.3)*
Frenchay Activities Index scores	14.3 (11.7)*

*Values are mean (±SD).

proceeded with the factor analysis. Almost 73% of the total variance was attributable to four factors (Table II). The remaining factors together accounted for only 27.1% of the variance. Thus, a model with these four factors may be adequate to represent the data.

Factor 1 accounted for nearly half (47%) of the total variance and was closely related to basic ADL. Items of this factor included all the items of the BI and one FAI item (walking outside). Factor 2 was closely related to domestic chores as measured by five FAI items (washing up, washing clothes, preparing main meals, heavy housework and light housework). Factor 3 consisted of five items from the FAI (social occasions, pursuing hobbies, driving/bus travel, travel outings/car rides, and shopping), and Factor 4 consisted of three items from the FAI (household/car maintenance, gainful employment, and gardening).

Figures 1, 2, 3, and 4 show histograms and normal curves of the distribution of the BI total score (skewedness −1.74, kurtosis 1.77), the FAI total score (skewedness 0.23, kurtosis −1.25), the combined scores (skewedness −0.94, kurtosis −0.10), and the combined Z scores (skewedness −0.76, kurtosis −0.40). The combined scores and the combined Z scores appeared to have a more normal distribution than was the case for either the BI or the FAI scores.

DISCUSSION

This study validated that the FAI and the BI assess different factors in stroke patients who survive for more than a year. Four factors were found. One factor comprised all items from the BI and one item from the FAI. The rest of the FAI items loaded on three other factors. The results of the study were extremely similar to those of Pedersen et al. (13), although their subjects were investigated 6 months after stroke onset. These findings also support their findings that the FAI supplements the BI with minimum overlap in content, and extends their findings to stroke patients who survive for more than one year.

Factor 1 was closely associated with self-care as measured by all the items of the BI and one FAI item (walking outside). All the items of the BI loaded on this factor. Most of the variation of the BI items could be

Table II. *Varimax rotated factor matrix for the Barthel Index (BI) and the Frenchay Activities Index (FAI)*

Item	Factor 1	Factor 2	Factor 3	Factor 4	Communality
BI toileting	*0.91*	0.20	0.13	0.11	0.90
BI transfer	*0.91*	0.16	0.20	0.08	0.90
BI feeding	*0.88*	0.07	0.07	0.06	0.78
BI bladder control	*0.83*	0.10	0.08	0.07	0.72
BI grooming	*0.82*	0.13	0.14	0.08	0.71
BI stair climbing	*0.81*	0.26	0.30	0.13	0.83
BI dressing	*0.80*	0.29	0.30	0.14	0.82
BI bowel control	*0.79*	0.07	0.05	0.05	0.64
BI mobility	*0.74*	0.28	0.39	0.15	0.80
FAI walking outside	*0.59*	0.35	0.50	0.07	0.72
BI bathing	*0.53*	0.42	0.41	0.24	0.67
FAI washing up	0.17	*0.87*	0.14	0.07	0.82
FAI washing clothes	0.17	*0.87*	0.14	0.04	0.81
FAI preparing main meals	0.14	*0.84*	0.07	−0.04	0.74
FAI heavy housework	0.13	*0.79*	0.23	0.21	0.73
FAI light housework	0.31	*0.76*	0.16	0.20	0.75
FAI social occasions	0.21	0.19	*0.81*	0.01	0.74
FAI pursuing hobbies	0.22	0.06	*0.77*	0.18	0.68
FAI driving/bus travel	0.27	0.15	*0.69*	0.40	0.73
FAI travel outings/car rides	0.02	0.11	*0.67*	0.14	0.48
FAI shopping	0.36	0.41	*0.61*	0.19	0.71
FAI household/car maintenance	0.06	−0.01	0.17	*0.83*	0.73
FAI gainful employment	0.11	0.19	0.19	*0.70*	0.58
FAI gardening	0.13	0.10	0.11	*0.69*	0.51
Eigenvalue	11.19	2.88	2.15	1.26	
Percentage of variation (72.9% in total)	46.6%	12.0%	9.0%	5.3%	

Italics show major contributory items to each factor.

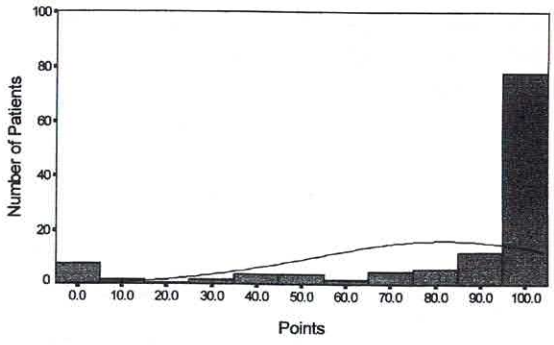

Fig. 1. Histogram with normal curve superimposed over the distribution of the Barthel Index total score.

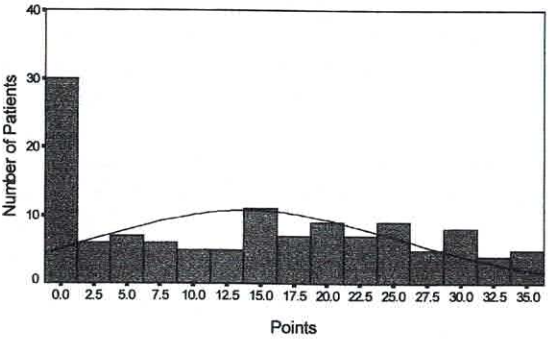

Fig. 2. Histogram with normal curve superimposed over the distribution of the Frenchay Activities Index total score.

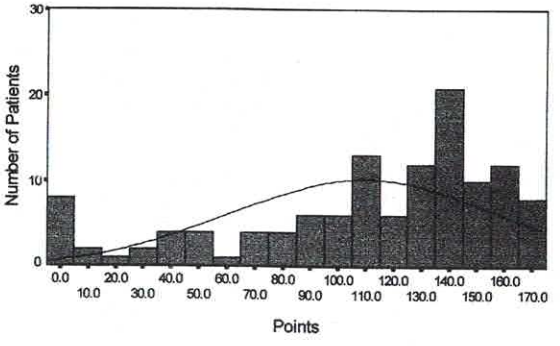

Fig. 3. Histogram with normal curve superimposed over the comprehensive ADL score computed by adding the BI score and 2 times the FAI score.

explained by a single underlying latent variable, reflecting the fact that the BI is a homogeneous scale.

The items of the FAI loaded on three factors, none of which included primary loadings of items from the BI. The loading of an item on a factor reflects how much of

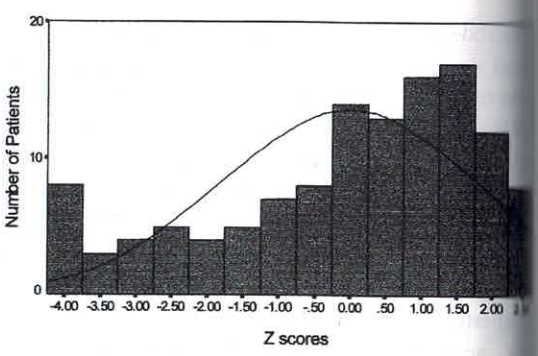

Fig. 4. Histogram with normal curve superimposed over the other comprehensive ADL score computed by adding the Z score of the BI score and the Z score of the FAI score.

the variance of the item is attributable to that factor. The FAI items reflect sources of variation different from those of the BI, thereby providing unique information. The limited overlap between the BI and the FAI factor loadings confirms the value of supplementing the assessment of basic ADL functions with assessment of higher-level ADL. Our results also showed that the bathing item of the BI had minor loadings with the FAI items on Factors 2 and 3. Bathing has been found to be the most difficult item of the BI (1), suggesting a continuity in terms of difficulty between the two scales, and justifying a combined score (13).

Furthermore, the fact that FAI items loaded on the other three factors reflects that the FAI is a heterogeneous scale. The underlying constructs of the FAI have been examined in several studies, although results differed in terms of factor number and item categorization (4–6, 14, 19). To establish the most appropriate categorization, further research is needed.

The properties of the combined scores were explored by examination of their distribution characteristics. The ceiling effect of the BI was extreme (Fig. 1), while the FAI had an obvious floor effect (Fig. 2). The combined scores had greatly improved distributions without obvious ceiling or floor effects (Figs. 3 and 4). The combined scores thus appear useful for research in stroke outcome and stroke rehabilitation effects. The *Z* scores describe the relative position of an observation within a distribution; the original distribution is not altered. Furthermore, both the BI and the FAI were given equal weight. The combined *Z* scores are thus more informative compared with the combined scores proposed by Pedersen et al. (13).

The combination of the BI and the FAI expands the

scale and makes it more sensitive for higher-level ADL functions than a scale that includes only basic ADL items. The combined scale has practical implications for the field of stroke outcome measurement and treatment effect research. A broader range of levels of needs of stroke patients can be described, especially for those who are living in the community. The combined scale also enables description of changes in functional ability during long-term recovery.

There are few existing measures for comprehensive assessment of ADL after stroke. Two instruments could be considered as alternatives to the combined BI and FAI. The Functional Independence Measure (FIM) (9) is a comprehensive scale that includes a fairly broad range of ADL items, social behaviour, communication, and cognitive dysfunction. However, the FIM does not measure some higher-level ADL, such as preparing meals, going shopping and gardening. The items of the FIM thus do not appear to include the entire range of ADL. Furthermore, it has been suggested that interviewers receive formal training before administering the FIM (9), making it less feasible than the BI and FAI. The Staircase of ADL (16), which combines the basic ADL index and some activities of instrumental ADL (IADL), might be another alternative. The basic ADL section is the widely known Katz ADL Index (8). The IADL section includes four items: cleaning, shopping, transportation, and cooking. The psychometric characteristics of the Staircase of ADL have been well established for the elderly (16, 17), but not for stroke patients. Reliability and validity of the Staircase of ADL should be re-assessed before using the instrument in stroke patients. Thus, the combined BI and FAI scale is preferable because both instruments are well validated in stroke patients and easy to administer in both clinics and research. Further study is needed to compare various comprehensive ADL scales in terms of validity and sensitivity.

The present study examined the factor structure of items from the BI and the FAI on a community sample that might include patients with a wide range of disabilities. However, the representativeness of the sample was not considered, because no nation-wide stroke patient registry exists. Similar findings in other areas or subject characteristics would need investigation.

Our data was obtained via telephone interview. One problem that arises from using a telephone interview is that some patients might be lost to follow-up because of a change of telephone number. To increase the participation rate, we mailed a written invitation letter to subjects who could not be contacted by telephone. One might also doubt the agreement between the results of telephone and face-to-face interviews. A telephone-administered BI showed strong agreement with one that was administered face-to-face (11). However, agreement between the two methods of administration for the FAI has not been tested. Although there is no evidence that the quality of response in face-to-face interviews is better than for telephone interviews (15), the intermodal agreement for the FAI needs to be examined.

In brief, the results of the study support that the FAI and the BI assess different factors in stroke patients who survive for more than one year. The BI score and the FAI score could be combined to assess the entire range of ADL functions in stroke survivors.

REFERENCES

1. Barer, D. H. & Murphy, J. J.: Scaling the Barthel: a 10-point hierarchical version of the activities of daily living index for use with stroke patients. Clin Rehabil *7:* 271–277, 1993.
2. Collin, C., Wade, D. T., Davies, S. & Hoene, V.: The Barthel ADL Index: a reliability study. Int Disabil Stud *10:* 61–63, 1988.
3. de Haan, R., Limburg, M., Schuling, J., Broeshart, J., Jonkers, L. & van Zuylen, P.: Clinimetric evaluation of the Barthel Index, a measure of limitations in daily activities [abstract]. Nederlands Tijdschrift voor Geneeskunde *137:* 917–921, 1993 [in Dutch].
4. Holbrook, M. & Skilbeck, C. E.: An activities index for use with stroke patients. Age Ageing *12:* 166–170, 1983.
5. Hsieh, C.-L.: Reliability and validity of the Frenchay Activities Index. Tzu Chi Med J *9:* 123–130, 1997 [in Chinese].
6. Hsueh, I.-P. & Hsieh, C.-L.: A revalidation of the Frenchay Activities Index in stroke: a study in Taipei area. Formorsan Med J *6:* 123–130, 1997 [in Chinese].
7. Kaiser, H. F.: An index of factorial simplicity. Psychometrika *39:* 31–36, 1974.
8. Katz, S., Ford, A. B., Moskowitz, R. W., Jackson, B. A. & Jaffe, M. W.: Studies of illness in the aged. The index of ADL: a standardized measure of biological and psychosocial function. JAMA *185:* 914–919, 1963.
9. Keith, R. A., Granger, C. V., Hamilton, B. B. & Sherwin, F. S.: The functional independence measure: a new tool for rehabilitation. *In* Advances in Clinical Rehabilitation (ed. M. G. Eisenberg & R. C. Grzesiak), pp. 6–18. Springer, New York, 1987.
10. Kiess, H. O.: Statistical concepts for the behavioural sciences. Allyn & Bacon, London, 1989.
11. Korner-Bitensky, N. & Wood-Dauphinee, S.: Barthel Index information elicited over the telephone: is it reliable? Am J Phys Med Rehabil *74:* 9–18, 1995.
12. Mahoney, F. I. & Barthel, D. W.: Functional evaluation: Barthel Index. Md State Med J *14:* 61–65, 1965.
13. Pedersen, P. M., Jorgensen, H. S., Nakayama, H., Raaschou, H. O. & Olsen, T. S.: Comprehensive assessment of activities of daily living in stroke. Arch Phys Med Rehabil *78:* 161–165, 1997.
14. Schuling, J., de Haan, R., Limburg, M. & Groenir, K. H.:

The Frenchay Activities Index: assessment of functional status in stroke patients. Stroke *24:* 1173–1177, 1993.
15. Siemiatycki, J.: A comparison of mail, telephone, and home interview strategies for household health surveys. Am J Publ Health *69:* 238–245, 1979.
16. Sonn, U. & Åsberg, K. H.: Assessment of activities of daily living in the elderly. A study of a population of 76-year-olds in Gothenburg, Sweden. Scand J Rehabil Med *23:* 193–202, 1991.
17. Sonn, U.: Longitudinal studies of dependence in daily life activities among elderly persons. Scand J Rehabil Med Suppl *34:* 1–35, 1996.
18. Wade, D. T.: Measurement in neurological rehabilitation. Oxford University Press, Oxford, 1992.
19. Wade, D. T., Leigh-Smith, J. & Hewer, R. L.: So activities after stroke: measurement and natural hist using the Frenchay Activities Index. Int Rehabil Med 176–181, 1985.

Accepted June 8, 1998

Address for offprints:

Dr. Ching-Lin Hsieh
School of Occupational Therapy
College of Medicine
National Taiwan University
7, Chun-Shan South Rd, Taipei
Taiwan, ROC