VALIDATION OF COMPREHENSIVE ASSESSMENT OF ACTIVITIES OF DAILY LIVING IN STROKE SURVIVORS

Jau-Hong Lin, Sing Kai Lo,[1] Yong-Yuan Chang,[2] Chwen-Yng Su,[3] and Ching-Kuan Liu[4]
Faculties of Physical Therapy, [2]Public Health and [3]Occupational Therapy, Kaohsiung Medical University, [4]Department of Neurology, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan, and [1]The George Institute for International Health, University of Sydney, Sydney, Australia.

This study determined whether the Functional Independence Measure (FIM) and the Frenchay Activities Index (FAI) could be used together as a more comprehensive score to assess the activities of daily living (ADL) in stroke survivors. Subjects were recruited from stroke patients consecutively admitted to the inpatient neurology or rehabilitation department at a university hospital in southern Taiwan. We interviewed 209 first stroke survivors at least 1 year after stroke onset during their clinical visits, at home, or in long-term care institutions. Combinations of FIM and FAI as a comprehensive assessment of ADL were measured. All items of the FIM and the FAI were included in a non-parametric factor analysis to determine their underlying constructs. Two comprehensive functional independence scores were then computed as functions of the FIM and FAI scores. The distributional characteristics of the comprehensive scores were examined. Approximately 90% of the total variation was explained by three factors. One single factor comprised all the items from FIM, while the FAI items loaded on two other factors, suggesting that FIM supplements FAI without overlap in content. We further demonstrated that the presence of ceiling or floor effects when either the FIM or the FAI was used could be removed using combined scores of the two instruments. The FIM and the FAI assessed different domains with good construct validity. A comprehensive assessment of functional independence obtained by combining the FIM and the FAI scores is potentially more appropriate and useful for clinical and research applications in stroke patients.

Key Words: activities of daily living, construct validity, stroke, Functional Independence Measure, Frenchay Activities Index
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Assessment of functional independence in stroke patients has become a basic requirement in rehabilitation at admission, in monitoring efficiency during treatment, and in predicting prognostic outcome after discharge [1]. Among measures of functional status developed, the Barthel Index (BI) and the Functional Independence Measure (FIM) are the most widely used to measure disability [2–5].

The FIM, like the BI, measures basic/personal activities of daily living (BADL). Yet, rehabilitation therapy is not simply concerned with achieving independence in BADL. Advanced skills, termed instrumental ADL (IADL), are vital to a very mild or nearly recovered stroke patient's independent living in the community [6]. Thus, an assessment tool that consists of BADL and IADL components might provide an enhanced range and sensitivity of measurement [7], and such a combined assessment has been suggested as the most suitable primary outcome measure after stroke [8]. Moreover, ADL functions may depend on higher cognitive functions, suggested by the limited ability of stroke patients with cognitive disorder to learn self-care and ADL skills [9]. Ideally, the tools used to

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Address correspondence and reprint requests to: Dr. Ching-Kuan Liu, Department of Neurology, Kaohsiung Medical University Hospital, 100 Tzyou 1st Road, Kaohsiung 807, Taiwan.
E-mail: ckliu@kmu.edu.tw

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evaluate the degree of functional independence should include motor and cognitive areas of function as well as functions required in everyday life in the household and community.

There are few existing measures for comprehensive assessment of functional independence after stroke. Two previous studies showed that the BI and the Frenchay Activities Index (FAI) can be used to assess different factors in stroke survivors and that the combination of the two scores can represent a comprehensive ADL score. In the study by Pedersen et al [10], two neuropsychologic items (speech and orientation) of the Scandinavian Neurological Stroke Scale (SSS) were found to constitute their own factor, but most items (movement and motor power) of the SSS loaded with the BI items. Cognitive factors were not fully covered by the BI or the FAI. Hsieh and Hsueh demonstrated that a combined score of the BI and the FAI had a more satisfactory distribution without obvious ceiling or floor effects, which made it useful for stroke outcome and treatment effect research [11]. However, the cognitive dimension was lacking in their BI assessment items. In order to compensate for these limitations, a separate supplemental scale covering the neuropsychologic domain could have been added.

The FIM was developed as a more comprehensive and sensitive measure of disability than the BI in terms of communication and social cognition domains in an individual's daily life [5]. However, the FIM does not measure some higher-level IADL, such as preparing meals, going shopping, and gardening. In contrast, the FAI can be used to assess higher-level IADL and social functions, and its reliability and validity have been established [12–15]. Segal and Schall found that the FIM and the FAI were useful for assessing the functional/health status of stroke survivors, and that the relationship between FIM and FAI scores was strong [16]. Although the factor structure of both the FIM and the FAI have been reported [15,17,18], no data are available for a comprehensive assessment of functional independence combining the FIM and FAI. Moreover, all analyses performed in previous studies used the Pearson correlation or covariance matrix for initial factor extraction. As the measuring scales of the instruments are ordinal in nature, a factor analysis taking this into consideration would be more appropriate. The purpose of this study was, therefore, to determine, using a non-parametric data analysis approach, whether the FIM and the FAI could be combined to give a more comprehensive assessment of functional abilities in first stroke patients who survive for more than 1 year.

Subjects and Methods

Subjects

Subjects were recruited from stroke patients consecutively admitted to the inpatient neurology or rehabilitation department at Kaohsiung Medical University Hospital, one of the largest academic medical centers in southern Taiwan, between November 1, 1996 and December 31, 1998. Stroke was defined as a rapidly developing clinical manifestation of a focal loss of cerebral function lasting more than 24 hours [19]. For all patients, the diagnosis was based on the clinical impressions of the consulting physician and neurologist, together with the findings of neuroradiologic investigations. The selection criteria included first stroke, a diagnosis of cerebrovascular disease (International Classification of Diseases, Ninth Revision Clinical Modification [ICD-9-CM] codes 431–434, 436–437) [20], discharge from the hospital at least 6 months before assessment, and living in the southern Taiwan area (Kaohsiung City, Kaohsiung County, Tainan City, Tainan County, or Pingtung County). Patients with a diagnosis of subarachnoid bleeding (ICD-9-CM code 430) or who suffered from other disabling diseases (e.g. severe heart failure or parkinsonism) likely to affect ADL function were excluded. The study was approved by the Ethics Committee of the university. Informed consent was obtained from all participants.

Procedures

Sociodemographic data, including age at onset, gender, years of education, and marital and living status, were collected via a questionnaire during the hospitalization period. Data on stroke characteristics, including lesion area, side of paralysis, single or recurrent attack, and stroke etiology, were collected from medical records. At about 1 year after stroke onset, all subjects were evaluated by two senior physical therapists trained in using the FIM™ instrument (Uniform Data System for Medical Rehabilitation, UB Foundation Activities Inc, Buffalo, NY, USA) [21] and the FAI. Face-to-face interviews were performed during clinical visits or at the patient's home or long-term care institution. Spouses or other primary caregivers were interviewed if subjects could not answer the questions because of speech problems or cognitive disorders.

Instruments

The FIM is an 18-item, 7-level scale that is used to assess the patient's need for assistance or devices in order to accomplish daily activities in the following six areas: self care, sphincter control, transfers, locomotion, communication, and social

cognition. The total score ranges from 18 to 126 points. The reliability and validity of the FIM are well established [17, 22–24].

The FAI comprises 15 items related to normal daily activities: preparing meals, washing up, washing clothes, light housework, heavy housework, local shopping, social outings, walking outside for more than 15 minutes, actively pursuing hobbies, driving/bus travel, outings/car rides, gardening, household/car maintenance, reading, and gainful employment. Each item is rated from 0 to 3 points, yielding a score ranging from 0 to 45 points [12]. FAI reliability and validity have been examined in stroke patients [12–14].

Data analysis

A matrix of rank correlation between all the items of the FIM and FAI was constructed, which was then saved as input to a factor analysis using principal components analysis and varimax rotation. The number of factors retained was chosen to equal the number of eigenvalues greater than 1.

Two comprehensive functional independence scores were computed, as recommended by two previous reports that assessed the validity of comprehensive ADL scores [10,11]. First, the FIM score was transformed by subtracting 1 from each item (giving 0 to 6 points). The FIM total score was added to twice the FAI total score, yielding a total combined score range of 0 to 198 [10]. Second, the scores of every item in the FIM and the FAI were standardized to have a mean of 0 and standard deviation of 1, and then added together, thus giving both scales equal weight [11]. The standardized score is also known as the Z score, and indicates how many standard deviations above or below the mean the observation falls [25]. SAS statistical software version 8.02 (SAS Institute Inc, Cary, NC, USA) was used for all analyses.

RESULTS

Of 499 consecutive stroke patients, 265 met the selection criteria and 209 (79%) participated in the study. Among the patients who were not interviewed, 17 died before the interview and 39 refused to cooperate or complete data were not available due to difficulty in scheduling time or other reasons. Table 1 shows the characteristics of the 209 patients who completed an interview.

The results of the non-parametric factor analysis are shown in Table 2. Approximately 90% of the total variation was explained by using three factors. In fact, Factor 1 alone accounted for nearly 60% of the total variance and included all items in the FIM instrument plus the item related to pursuing hobbies in FAI. All the factor loadings for the first factor were nearly the same, indicating that the correlation between each item and the factor was almost identical; hence, the contributions of each item to the factor were similar. Factor 2 was closely related to domestic chores as measured using six FAI items (washing dishes, washing clothes, preparing meals, light housework, heavy housework, and social activities). Factor 3 was mainly correlated with outdoor activities away from home, including eight items from the FAI (driving car/bus travel, travel outing/car rides, shopping, walking outside, gainful employment, gardening, household/car maintenance, and reading books). From the factor loadings, we also noticed that a few leisure-related items from the FAI, namely social

Table 1. Characteristics of first stroke patients (n = 209)

Characteristic	Mean ± SD or n (%)
Male gender	130 (62.2)
Age, yr	62.7 ± 10.6
Education level, yr	6.7 ± 4.7
Stroke type	
Infarction	156 (74.6)
Hemorrhage	53 (25.4)
Side of hemiplegia	
No	16 (7.7)
Left	95 (45.5)
Right	97 (46.4)
Bilateral	1 (0.5)
Marital status	
Married	156 (74.6)
Single/divorced/widowed	53 (25.4)
Living status at follow-up	
Independent	116 (55.5)
Dependent at home	82 (39.2)
Dependent at long-term care institution	11 (5.3)
Follow-up days after onset	390.6 ± 98.1
Follow-up FIM scores	104.0 ± 29.6
Follow-up FAI scores	10.1 ± 9.8

SD = standard deviation, FIM = Functional Independence Measure; FAI = Frenchay Activities Index.

Table 2. Varimax rotated factor matrix for the Functional Independence Measure (FIM) and the Frenchay Activities Index (FAI)

Item	Communality	Factor 1	Factor 2	Factor 3
FIM transfer toilet	0.96	*0.94*	–	0.24
FIM transfer chair or bed	0.95	*0.84*	0.30	0.39
FIM transfer tub or shower	0.96	*0.94*	–	0.24
FIM walk	0.95	*0.87*	0.27	0.34
FIM toileting	0.95	*0.86*	0.28	0.35
FIM grooming	0.96	*0.93*	–	0.25
FIM lower body dressing	0.94	*0.97*	–	–
FIM upper body dressing	0.93	*0.96*	–	–
FIM stairs	0.96	*0.94*	–	0.23
FIM eating	0.96	*0.94*	–	0.24
FIM bathing	0.96	*0.94*	–	0.24
FIM urinary control	0.96	*0.93*	–	0.25
FIM bowel control	0.94	*0.86*	0.26	0.37
FIM memory	0.92	*0.95*	–	–
FIM problem solving	0.92	*0.95*	–	–
FIM expression	0.92	*0.95*	–	–
FIM social interaction	0.92	*0.95*	–	–
FIM comprehension	0.92	*0.95*	–	–
FAI washing dishes	0.98	–	*0.97*	–
FAI preparing main meals	0.98	–	*0.98*	–
FAI washing clothes	0.97	–	*0.96*	–
FAI light housework	0.95	–	*0.95*	0.21
FAI heavy housework	0.90	–	*0.88*	0.31
FAI social activities	0.95	0.41	*0.73*	0.50
FAI driving car/bus travel	0.73	0.52	0.33	*0.59*
FAI pursuing hobbies	0.84	*0.83*	–	0.34
FAI travel outing/car rides	0.83	0.30	0.55	*0.66*
FAI shopping	0.86	0.44	0.50	*0.65*
FAI walking outside	0.81	0.22	0.30	*0.82*
FAI gainful employment	0.71	–	–	*0.84*
FAI gardening	0.78	–	–	*0.88*
FAI household/car maintenance	0.81	–0.2	0.29	*0.83*
FAI reading book	0.60	0.44	0.14	*0.62*
Eigenvalue		19.7	7.4	2.6
Percent of variation explained (90.0%)		59.6%	22.5%	8.0%

Italics show major contributory items to each factor; factor loadings less than the absolute value of 0.2 are listed as "–".

activities, reading books, shopping, travel outing/car rides, and driving car/bus travel, contributed fairly evenly to at least two of the three factors.

Figures 1 to 4 show histograms and normal curves of the distribution of the FIM total score (skewness = –1.55, kurtosis = 1.56), FAI total score (skewness = 0.88, kurtosis = –0.26), combined score (skewness = –0.65, kurtosis = –0.20), and combined Z score (skewness = –0.31, kurtosis = –0.53), respectively. The combined score and the combined Z score appeared to be more normally distributed than either the FIM or the FAI scores. Unlike the FIM total score or FAI total score, both combined scores had the mode much closer to the middle point, with only relatively few observations at either end of the distributions.

Discussion

We examined the factors and structure of items from the FIM and the FAI in a community sample that included patients with a wide range of disabilities, to validate that the composite scores of FIM and FAI provide a more comprehensive assessment of functional status of stroke patients. Three factors were found. One factor included

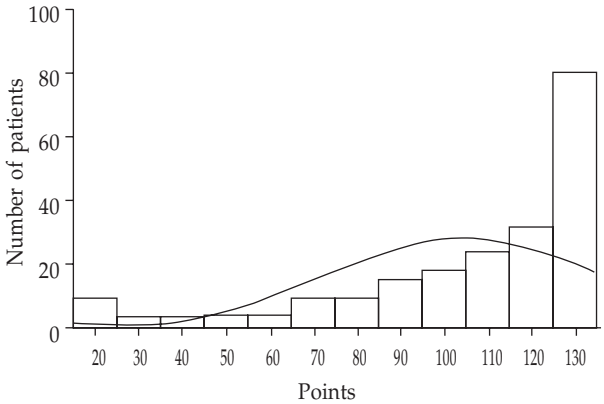

Figure 1. *Histogram with normal curve superimposed over the distribution of the FIM total score.*

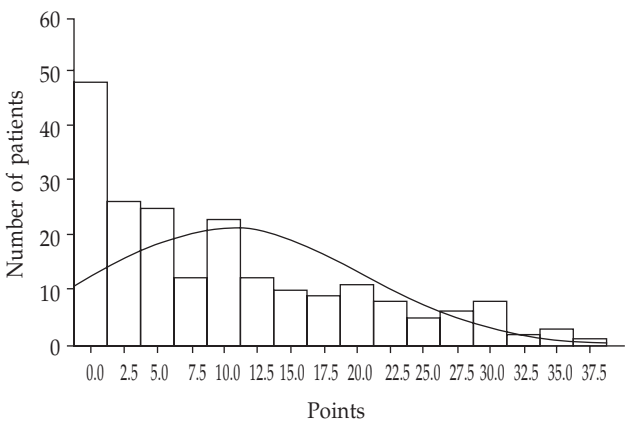

Figure 2. *Histogram with normal curve superimposed over the distribution of the FAI total score.*

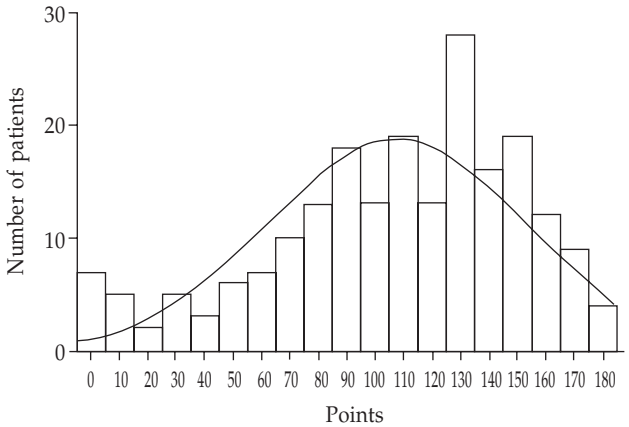

Figure 3. *Histogram with normal curve superimposed over the comprehensive ADL score computed by adding the transformed FIM score and twice the FAI score.*

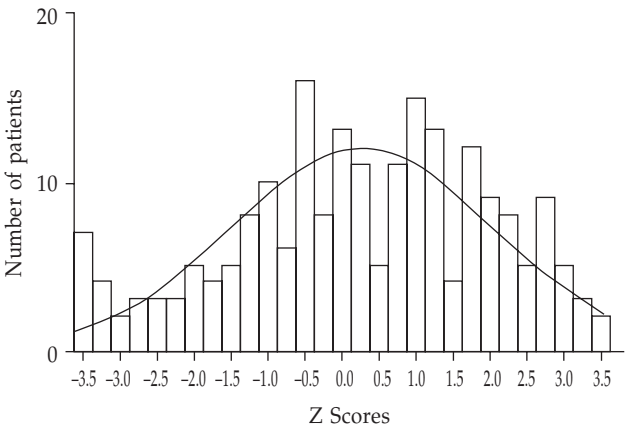

Figure 4. *Histogram with normal curve superimposed over the other comprehensive ADL score computed by adding the Z score of the FIM score and the Z score of the FAI score.*

primarily items in FIM, whereas the FAI items were loaded mainly on two other factors.

Factor 1 was closely associated with basic ADL function as measured using all the items of the FIM and one FAI item (pursuing hobbies). Our interpretation is that the combination of motor and cognitive subscales together reflects a broader degree of total physical and neuropsychologic impairment, which are important factors for basic ADL function in stroke patients.

Items of the FAI loaded on Factors 2 and 3 and made the FAI a heterogeneous scale not covered by items in the FIM. The underlying constructs of the FAI have been examined by several researchers [12–15]. Schuling et al suggest that the FAI instrument can be improved by deleting two items (gainful work and reading books) and by creating two major factors (indoor and outdoor activities) [14]. Our findings seem to support such an interpretation. On the other hand, our data did not disagree totally with the findings of other studies that the FAI is comprised of three factors [12,13,15]. To be specific, if we input the Pearson correlation coefficient matrix (as other studies have done) to a factor analysis for FAI only, then the first three factors would have an eigenvalue greater than 1. The first factor consisted of five items of domestic chores (washing dishes,

washing clothes, preparing meals, light housework, and heavy housework), implying that indoor housework should be interpreted as an instrumental activity in Taiwan that is more difficult to perform than the FIM motor items. The second factor consisted of seven outdoor activities away from home (social activities, driving car/bus travel, pursuing hobbies, travel outing/car rides, shopping, walking outside, and gainful employment), which seemed to be indicative of the extent of demand for outside activities and gainful work that implied the ability to leave home. The third factor was highly correlated with leisure activities at home (gardening, household/car maintenance, and reading books). We noticed that the FAI scores in our study suggested that the area of higher-level ADL and social functions were represented by three groups of daily activities with different item categorization. This discrepancy between results obtained in Taiwan and Western countries can be partly explained by cultural differences.

Both the high communality and the general lack of overlap between the FIM and the FAI factor loadings confirm the value of supplementing the assessment of basic ADL function and cognitive function with higher-level activities, justifying the hypothesis that using the scores together could potentially provide a more comprehensive assessment of functional abilities, at least in first stroke survivors [10,11]. Thus, a scale that makes use of FIM and FAI is preferable as it can provide more information than the combined BI and FAI scale proposed by previous studies [10,11].

The fact that the FIM and the FAI seemingly measure different domains leads to an important question: can the two scales be used together by forming a combined score? Creating a summary score by combining items belonging to different domains has been used in health studies, for example, in quality of life studies [26]. However, the summarized score must provide useful information for the assessment of patients. The properties of the comprehensive scores were explored by examining their distributional characteristics. The average FAI and FIM scores in this study are similar to previous studies of stroke patients with at least 6 months of follow-up [11,16]. The ceiling effect of the FIM was extreme (Figure 1), while the FAI had an obvious floor effect (Figure 2). The combined scores shown in Figures 3 and 4 have much more satisfactory distributions without obvious ceiling or floor effects. Thus, the combined scores appear to be more useful tools for use in clinical practice, research in stroke rehabilitation efficiency during treatment, and prognostic outcome assessment after discharge.

The Z score describes the relative position of an observation within a distribution. In this study, the original distribution remained unchanged for the combined scores [25]. Moreover, both the FIM and the FAI were given equal weight. The combined Z score was thus more informative. The combination of the FIM and the FAI expanded the scale and made it more sensitive to higher-level ADL functions than a scale that included only either basic ADL items or social activities. These findings indicate that the comprehensive scale is a more useful instrument for stroke outcome measurement and treatment effect research. The inclusion of a broader range of levels of needs of stroke patients enables a better description of changes in functional ability during long-term recovery.

A limitation of this study was the inability to determine the extent to which our sample represents the actual first-time stroke population in Taiwan because no nationwide stroke patient registry exists. Furthermore, first stroke survivors in this study were limited to those without serious sequelae from previous attacks, which undoubtedly decreased the percentage of patients with severe disability. In summary, this study has demonstrated that the FIM and the FAI assess different aspects of functional activities in first stroke patients who survive for at least 1 year. The combination of the FIM and FAI scores provides a more comprehensive assessment covering a wider range of functional abilities in first stroke survivors.

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腦中風病患全面性日常生活活動量表的驗證

林昭宏[1] 盧成皆[2] 張永源[3] 蘇純瑩[4] 劉景寬[5]

高雄醫學大學 [1]物理治療學系 [3]公共衛生學系 [4]職能治療學系
[5]附設中和醫院 神經科 [2]澳洲雪梨大學喬治國際公共衛生學院

本研究目的探討功能獨立自主量表 (Functional Independence Measure ， FIM) 及芙蘭切活動量表 (Frenchay Activities Index ， FAI) 是否能夠組合成為腦中風患者預後全面性日常生活活動評估量表。研究對象來至南臺灣某大學附設醫院神經科或復健科住院中風病患，共計徵召有 209 位初次腦中風患者於發病一年後在門診、居家或長期照護機構完成病患訪視及量表評估。使用無母數因素分析來檢定 FIM 及 FAI 量表組合成為全面性量表各個項目之共同建構特質，然後依據 FIM 及 FAI 量表個別得分，檢定兩種不同統計組合得分分佈情況。結果發現可以由三個共同因素來解釋量表 90% 的整體變異量，其中一個因素包括所有 FIM 測量項目， FAI 項目分別包含於另外兩個因素中，顯示 FIM 及 FAI 量表組合並無重疊項目。兩種量表組合後得分數不會出現個別使用時得分有上限或下限的效應。兩者組成全面性日常生活活動量表具備良好的建構效度，更適合使用於臨床及研究中風病患預後全面性日常生活活動能力的評估。

關鍵詞：日常生活活動，建構效度，腦中風， Functional Independence Measure ， Frenchay Activities Index

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通訊作者：劉景寬醫師
高雄醫學大學附設中和醫院神經科
高雄市 807 自由一路 100 號