Trunk Control as an Early Predictor of Comprehensive Activities of Daily Living Function in Stroke Patients

Ching-Lin Hsieh, PhD; Ching-Fan Sheu, PhD; I-Ping Hsueh, MA; Chun-Hou Wang, BS

**Background and Purpose**—Prediction of activities of daily living (ADL) functions at an early stage after a stroke is critical because it enables clinicians to set treatment programs and goals. The objective of this study was to assess the relationship between trunk control at an early stage and comprehensive ADL function (as assessed by combining basic ADL and instrumental ADL [IADL]) in patients at 6 months after stroke.

**Methods**—A total of 169 stroke patients participated in this prospective study. Trunk control was measured with the use of the trunk control items of the Postural Assessment Scale for Stroke Patients (PASS-TC). In addition to the PASS-TC score, age, sex, type of stroke, side of hemiparesis, urinary incontinence, limb paresis (measured by the Fugl-Meyer motor test), balance (measured by the Fugl-Meyer balance test), and basic ADL (measured by the Barthel Index) were also selected as predictor variables. These variables were assessed at 14 days after stroke or earlier. The Barthel Index and Frenchay Activities Index (measuring IADL) were administered at 6 months after stroke. The sum of the standardized Barthel Index and standardized Frenchay Activities Index scores was used to assess comprehensive ADL function.

**Results**—Multivariable stepwise linear regression analysis showed that PASS-TC score, age, Fugl-Meyer motor test score, and Barthel Index score (listed by the order of forward selection) were the strongest predictors of comprehensive ADL function. These results were internally validated with the use of the bootstrap resampling technique. The PASS-TC score alone accounted for 45% of the variance in predicting comprehensive ADL function. Results also indicated that the PASS-TC score had slightly more power in predicting comprehensive ADL function than either the Fugl-Meyer motor test score or Barthel Index score.

**Conclusions**—The findings of this study provide strong evidence of the predictive value of trunk control on comprehensive ADL function in stroke patients. The results imply that early assessment and management of trunk control after stroke should be emphasized. (*Stroke*. 2002;33:2626-2630.)

**Key Words:** cerebrovascular disorders ▪ disability evaluation ▪ outcome ▪ rehabilitation

**Stroke** is the most common cause of disability or dependence in activities of daily living (ADL) among the elderly. Reducing the degree of dependence in ADL is often a central aim of rehabilitation programs and other related interventions for patients who have suffered a stroke. Prediction of ADL function at an early stage enables clinicians to select treatment programs and goals for stroke patients, to facilitate a proper discharge plan, and to anticipate the need for home adjustments and community support.

ADL generally refers to basic ADL, which has been widely used as a main outcome measure after stroke. However, basic ADL does not capture significant losses in higher levels of physical functions or activities that are necessary for independence in the home and community (ie, instrumental ADL [IADL]). Thus, both basic ADL and IADL are suggested to be the primary outcome measures after stroke.

Several authors have recommended combining the IADL and the basic ADL to measure ADL function more comprehensively. According to Spector and Fleishman, combining IADL and ADL items would provide an enhanced range and sensitivity of measurement.

Trunk control is a crucial component to perform ADL. Some studies found that trunk control or sitting balance at an early stage could predict ADL outcome at a late stage in patients after a stroke. However, the ADL function examined in these previous studies included only basic ADL and not comprehensive ADL. Several studies have addressed only sitting balance without including bed mobility. Furthermore, the observations of other studies were not timed from stroke onset. To the best of our knowledge, the significance of trunk control at an early stage after stroke in predicting comprehensive ADL outcome has not been inves-
tigated. The objective of this study was to assess the relationship between trunk control at 14 days after stroke and comprehensive ADL function in patients at 6 months after stroke.

Subjects and Methods

Subjects
The study sample was recruited from the registry of the Quality of Life After Stroke Study in Taiwan between December 1, 1999, and December 31, 2000. The Quality of Life After Stroke Study is an ongoing prospective cohort study of stroke patients admitted to National Taiwan University Hospital (one of the largest medical centers and a referral hospital for patients throughout Taiwan). Individuals enrolled in the Quality of Life After Stroke Study were evaluated at 14 days after stroke and reassessed at other specific days after stroke for up to 3 years after stroke to characterize their recovery in terms of neurological impairment, functional ability, and health-related quality of life. Patients were included in the study if they met the following criteria: 1) diagnosis (International Classification of Diseases, Ninth Revision, Clinical Modification codes) of cerebral hemorrhage (431), cerebral infarction (434), or other (430, 432, 433, 436, 437); 2) first onset of cerebrovascular accident, without other major diseases; 3) stroke onset within 14 days before hospital admission; 4) ability to follow commands; and 5) ability to give informed consent personally or by proxy. The clinical diagnosis of stroke was confirmed by neuroimaging examination (CT/MRI). Subjects were excluded if they suffered from another stroke or other major diseases during the follow-up period or lived >40 miles from the hospital.

Procedure
Data were collected at 14 days after stroke and 6 months after stroke of subjects who participated in the Quality of Life After Stroke Study. The study protocol was divided into 2 parts. The first part investigated the reliability (intrater reliability and internal consistency) and convergent validity of the trunk control measure (ie, the trunk control items of the Postural Assessment Scale for Stroke Patients (PASS-TC)). This part of the study involved collection of data from subjects at 14 days after stroke. Two occupational therapists (A and B) independently administered the PASS-TC to the same sample of patients. The assessments were completed within 24 hours to minimize the effects of any spontaneous recovery. The therapists administered the assessments in a randomized order and were not informed of each other’s assessment results during the study period.

The second part of the protocol investigated the predictive value of trunk control at 14 days after stroke for comprehensive ADL function in patients at 6 months after stroke, controlling for age, sex, type of stroke, side of hemiparesis, urinary incontinence, limb paresis (measured by the Fugl-Meyer motor test [FM]), balance (measured by the Fugl-Meyer balance test [FM-B]), and basic ADL (measured by the Barthel Index [BI]). All the variables considered likely to influence ADL function in this study were assessed at 14 days after stroke or earlier. At follow-up 6 months after stroke, the BI and Frenchay Activities Index (FAI) (measuring IADL) were administered to the patient or his/her main caregiver via face-to-face or telephone interview. The occupational therapist administered all the measurements.

Outcome: Comprehensive ADL Function
The BI evaluates 10 basic ADL items including feeding, transfer, grooming, toileting, bathing, ambulation, stair climbing, dressing, bowel control, and bladder control. The total possible score of the BI ranges from 0 to 100. It has been shown to be a reliable and valid measure of basic ADL. However, the BI assesses only a limited range of daily functioning concerning self-care and mobility recovery. Moreover, it has been shown that the BI exhibits ceiling effects at a later stage of stroke recovery.

The FAI was developed as a means of measuring social activities, or lifestyle, after stroke. It comprises 15 items related to normal activities, each rated from 0 to 3 points: preparing meals, washing up, washing clothes, light housework, heavy housework, local shopping, social outings, walking outside for >15 minutes, actively pursuing hobbies, driving/bus travel, outings/car rides, gardening, household/car maintenance, reading books, and gainful employment. The total possible score of the FAI ranges from 0 to 45. It has been shown to be a reliable and valid measure of IADL in stroke patients.

Previous studies found that the BI and FAI scores could be combined to represent comprehensive ADL function representing the entire continuum of disability. Hsieh and Hsu proposed combining the standardized scores of the BI and FAI (Z score of BI plus Z score of FAI) to measure comprehensive ADL. The combined Z scores were used in this study.

Trunk Control and Selected Prospective Predictors

Trunk Control
The PASS contains 12 four-point (from 0 to 3) items that grade the varying difficulty in maintaining or changing a given lying, sitting, or standing posture. The psychometric properties of the PASS have been reported to be satisfactory. Five items (ie, sitting without support, supine to affected side lateral, supine to nonaffected side lateral, supine to sitting up on the edge of the table, and sitting on the edge of the table to supine) were used to measure trunk control (PASS-TC) in this study. The possible scores of the PASS-TC range from 0 to 15 points.

Limb Paresis
The severity of upper and lower limb paresis was measured with the use of the FM. Each item of the FM is graded on a 3-point scale (from 0 to 2). The total possible score ranges from 0 to 100 points. The FM is known to be a reliable and valid measure of motor impairment for stroke patients.

Balance
The FM-B contains 3 items to evaluate sitting balance and 4 items to evaluate standing balance. The total possible score for the FM-B ranges from 0 to 14. The reliability and validity of the FM-B were acceptable.

Urinary Incontinence
Urinary incontinence was defined as the reporting of urinary accidents (eg, wet his or her clothes) or the presence of an indwelling catheter within 48 hours of assessment.

Other Predictor Variables
The BI score at 14 days after stroke, diagnosis, lesion side, age, and sex were treated as other prospective predictors.

Data Analysis
First, the reliability and validity of the PASS-TC were examined. The interrater agreement of the total scores of the PASS-TC rating made by the 2 occupational therapists was analyzed with the use of the intraclass correlation coefficient statistic. The internal consistency of the PASS-TC was expressed as a Cronbach α coefficient. Convergent validity of the PASS-TC was determined by examining the relationships between the PASS-TC and instruments measuring related constructs (ie, BI and FM-B) with the use of the Pearson correlation coefficient.

Second, we examined the strength of the association between the prespecified predictors at 14 days after stroke and comprehensive ADL function at 6 months after stroke using Pearson correlation coefficients. Stepwise multiple regression analyses were performed to identify the variables associated with comprehensive ADL function. A forward selection procedure was used, and the criterion for entering variables adopted was a P value <0.05. In addition, variance inflation factors were computed to examine the possible collinearity problem among the predictors. Finally, the internal validity of the regression model was assessed by bootstrapping.
In this technique, described in detail by Efron and Tibshirani \(^\text{24}\) and Harrell, \(^\text{25}\) a model is developed with all subjects and then reanalyzed on repeated random samples of the data set. Two hundred random bootstrap samples were drawn with replacement from the full sample.

### Results

A total of 206 patients were registered in the Quality of Life After Stroke Study during the study period. This represented approximately 20\% of all patients with stroke admitted to the National Taiwan University Hospital during the study period. Most of the patients with stroke admitted to the hospital during the study period were not included in this study because of discharge from the hospital or death in the first 2 weeks after stroke onset, stroke onset >14 days before hospital admission, or living >40 miles from the hospital. Five of the 206 patients later declined to participate in the study, and 32 patients died or could not be contacted during the follow-up period. A total of 169 participants with a wide spectrum of postural control deficits, ranging from asymptomatic patients to the bedridden, completed the final 6-month evaluation. Table 1 shows the characteristics of the cohort of patients analyzed in the study. The Figure is a histogram of the combined \(Z\) scores. The normality of the distribution was not rejected at the 0.05 significance level with the use of the 1-sample Kolmogorov-Smirnov test.

### Reliability and Validity of the PASS-TC

Nineteen patients were excluded from the analysis because they were not assessed by both raters within 24 hours. One hundred eighty-two patients then remained for inclusion in the reliability investigation. This group consisted of 96 men and 86 women with a mean age of 68 years (SD=11.4).

The intraclass correlation coefficients for the total scores of the PASS-TC were 0.97 (95\% CI, 0.95 to 0.98), indicating excellent interrater agreement. The Cronbach \(\alpha\) values of the

### Variables Predicting Comprehensive ADL Function

Table 2 shows the relationships between age and 5 clinical variables at 14 days after stroke and comprehensive ADL function at 6 months after stroke. The results of the forward stepwise multiple regression analysis are shown in Table 3. The PASS-TC score, age, FM score, and BI score (listed by order of forward selection) were the strongest predictors of comprehensive ADL function. The largest value of the variance inflation factors was 7, indicating that multicollinearity among the predictors did not unduly influence the regression estimates. \(^\text{26}\) We also examined the adequacy of the final regression model. The residuals appeared to be normally

### Table 1. Characteristics of Stroke Patients at 14 Days and 6 Months After Stroke (n=169)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>Sex, M/F</td>
<td>90/79</td>
</tr>
<tr>
<td>Age, mean (SD), y</td>
<td>66.8 (11.3)</td>
</tr>
<tr>
<td><strong>Diagnosis</strong></td>
<td></td>
</tr>
<tr>
<td>Cerebral hemorrhage</td>
<td>45 (27%)</td>
</tr>
<tr>
<td>Cerebral infarction</td>
<td>124 (73%)</td>
</tr>
<tr>
<td>Side of hemiplegia, right/left</td>
<td>66/103</td>
</tr>
<tr>
<td><strong>Scores at 14 days after stroke</strong></td>
<td></td>
</tr>
<tr>
<td>PASS-TC, mean (SD)</td>
<td>10.6 (5.2)</td>
</tr>
<tr>
<td>BI, mean (SD)</td>
<td>43.2 (30.2)</td>
</tr>
<tr>
<td>FM, mean (SD)</td>
<td>52.8 (34.5)</td>
</tr>
<tr>
<td>FM-B, mean (SD)</td>
<td>6.4 (4.5)</td>
</tr>
<tr>
<td><strong>Scores at 6 months after stroke</strong></td>
<td></td>
</tr>
<tr>
<td>BI, median (interquartile range)</td>
<td>95 (67.5–100)</td>
</tr>
<tr>
<td>FAI, median (interquartile range)</td>
<td>6 (0–15)</td>
</tr>
<tr>
<td>Comprehensive ADL*, mean (SD)</td>
<td>0.01 (1.79)</td>
</tr>
</tbody>
</table>

*Sum of standardized BI and standardized FAI scores.

PASS-TC were 0.94 and 0.93 for rater A and B, respectively, indicating high internal consistency.

The score of the PASS-TC was highly correlated with the BI and FM-B scores (Pearson \(r=0.89\) and \(r=0.73\), respectively; \(P<0.0001\)), indicating good convergent validity of the PASS-TC.

### Table 2. Relationships Between Age and 5 Clinical Variables at 14 Days After Stroke and Comprehensive ADL Function at 6 Months After Stroke (n=169)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pearson (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-0.42 (\dagger)</td>
</tr>
<tr>
<td>PASS-TC score</td>
<td>0.68 (\dagger)</td>
</tr>
<tr>
<td>BI score</td>
<td>0.66 (\dagger)</td>
</tr>
<tr>
<td>FM score</td>
<td>0.58 (\dagger)</td>
</tr>
<tr>
<td>FM-B score</td>
<td>0.66 (\dagger)</td>
</tr>
<tr>
<td>Urinary incontinence</td>
<td>0.45 (\dagger)</td>
</tr>
</tbody>
</table>

*For relationship between age and 5 clinical variables at 14 days after stroke and comprehensive ADL function (sum of standardized BI and standardized FAI scores) at 6 months after stroke.

\(\dagger P<0.001\).
TABLE 3. Forward Stepwise Multiple Regression Analysis of Predictor Variables at 14 Days After Stroke Related to Comprehensive ADL Function at 6 Months After Stroke

<table>
<thead>
<tr>
<th>Variable*</th>
<th>Regression Coefficient†</th>
<th>Accumulated Model Adjusted $R^2$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASS-TC score</td>
<td>0.29</td>
<td>0.45</td>
<td>0.001</td>
</tr>
<tr>
<td>Age</td>
<td>-0.34</td>
<td>0.55</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>FM score</td>
<td>0.23</td>
<td>0.59</td>
<td>0.006</td>
</tr>
<tr>
<td>BI score</td>
<td>0.2</td>
<td>0.60</td>
<td>0.024</td>
</tr>
</tbody>
</table>

*The variables are listed on the basis of the order selected by the forward stepwise multiple regression analysis. The other variables, including the FM-B score, urinary incontinence, diagnosis, sex, and side of lesion, were originally included in the stepwise regression but are not shown in the table because of nonsignificant relationships with the comprehensive ADL outcome after controlling for the variables in the table.

†Regression coefficient and $P$ value were adjusted for all the other variables in the table.

distributed on examination of the normal probability plot and the histogram. In addition, the sample contained no obvious outliers, and the average value of the Cook’s distance was 0.001. These results suggested that the regression analysis was appropriate. Furthermore, these findings were well validated in that the PASS-TC score, FM score, BI score, and age were the most frequently selected variables among the predictors in the 200 random bootstrap samples.

The PASS-TC score was first selected as the strongest predictor among the preselected variables, and it alone accounted for 45% of the variance in predicting comprehensive ADL function. We further found that the PASS-TC score explained an additional 4%, 6%, and 38% of the variance in predicting comprehensive ADL outcome given that the FM score, BI score, or age, respectively, was already in the model. On the other hand, the FM score, BI score, and age explained only an extra 1%, 2%, and 10% of the variance in predicting comprehensive ADL function in addition to the PASS-TC score, respectively. These results indicated that the PASS-TC score was powerful in predicting comprehensive ADL function and that the PASS-TC score had slightly more power in predicting comprehensive ADL function than either the FM score or BI score.

Discussion

This is the first study to examine how well comprehensive ADL function of patients at 6 months after stroke can be predicted by their trunk control at 14 days after stroke. The study controlled for a number of relevant demographic and clinical variables, including age, sex, type of stroke, side of hemiparesis, urinary incontinence, limb paresis (measured by FM), balance (measured by FM-B), and basic ADL (measured by BI). We found strong evidence of the predictive value of trunk control on comprehensive ADL function in stroke patients. At an early stage after a stroke, the PASS-TC had slightly more power in predicting comprehensive ADL function than either the FM or the BI. Furthermore, compared with the 50-item FM and 10-item BI, the 5-item PASS-TC is easier to use for both clinicians and researchers. Franchignoni et al. also found that at hospital admission, a trunk control test could predict basic ADL function (measured by the motor subscale of the Functional Independence Measure) even better than the Functional Independence Measure. These results further support the value of early assessment of trunk control in predicting ADL function in stroke patients. The findings of this study indicate the need for early assessment and management of trunk control in stroke patients.

The identification of simple clinical predictors (eg, trunk control) of stroke outcome is of the most practical value in clinical settings. In this study our aim was not to establish a comprehensive model to predict ADL outcome. Some researchers have argued that multivariable models not only were difficult to use in practice but also had little advantage over simple clinical predictors. The more complex these models are, the less likely they are to be widely used. It is possible that some variables not included in this study, such as perceptual/cognitive and motivational variables, could have increased the predictive value of the model. On the other hand, modern imaging techniques could provide valuable information for improving the early prediction of stroke outcome. These technologies are, however, unlikely to become accessible for routine clinical use soon. Further study including more comprehensive variables might be needed to substantiate the predictive effect of trunk control on comprehensive ADL function.

The validity of a regression model cannot be established when simply determined on the sample of subjects that was used to construct the model. Steyerberg et al examined several internal validation methods that sought to give a more accurate assessment of model selection. They concluded by recommending bootstrapping for estimating the internal validity of a predictive regression model. Bootstrap validation demonstrated the internal validity of our findings. This method of internal validation assesses how accurately the models will predict outcome in a new similar sample of stroke patients. It assesses whether the model is biased because it overfits the data. Our results suggest that we did not overfit the model to this single data set and that the findings of this study are therefore well supported.

The psychometric properties of the PASS-TC, such as reliability and validity, denoting the precision of measurement, are of importance for this study. According to Kwakkel et al, the reliability and validity of the predictor could be a threat to the internal validity of models predicting ADL function. In this study we found a high internal consistency and a high intrarater agreement of the PASS-TC. The convergent validity of the PASS-TC was also well supported. In addition, the PASS-TC is easy to use in both clinical and research settings. Therefore, the usage and the psychometric properties of the PASS-TC were well confirmed.

We found age, FM score, and BI score to be significant predictors of comprehensive ADL function, controlling for the effect of trunk control. These results are similar to previous studies. Kwakkel et al reviewed 78 studies investigating variables predicting basic ADL function in stroke patients and found that the aforementioned 3 variables were common predictors of ADL outcome. Therefore, our findings further extend the prognostic value of these variables in predicting comprehensive ADL function.
In the univariate analysis, balance and urinary incontinence were significantly associated with the comprehensive ADL outcome. After we controlled for PASS-TC score, age, FM score, and BI score, neither balance nor urinary incontinence was a significant predictor. This means that measures such as the PASS-TC probably had a stronger predictive value for comprehensive ADL function than balance or urinary incontinence. These results could also be a consequence of the interrelationships among these variables. Therefore, our data only indicate that these variables do not provide additional information to the models containing the aforementioned significant predictors.

Several limitations should be considered to properly interpret the findings of this study. We assessed trunk control at a specific time point after stroke (ie, 14 days after stroke), which might also limit the generalization of our findings. Further studies using serial trunk control evaluations at an early stage after stroke might help to identify those patients whose trunk control improves and who will have better ADL function at a later stage. Although the value of trunk control in predicting comprehensive ADL outcome was well supported, validation of our findings on another sample of patients may be needed.

In summary, the predictive value of trunk control at an early stage after stroke on comprehensive ADL function in patients surviving for 6 months was well supported. Assessment and management of trunk control at an early stage after stroke are recommended.

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