Discriminative, Predictive, and Evaluative Properties of a Trunk Control Measure in Patients With Stroke

Background and Purpose. The trunk control items of the Postural Assessment Scale for Stroke Patients (PASS-TC) have been proposed for use in examining patients with stroke. The purpose of this study was to examine the discriminative and predictive validities and the evaluative properties of the PASS-TC at 14, 30, 90, and 180 days after stroke onset. Subjects and Methods. A total of 269 patients with stroke participated in this prospective study. The PASS-TC was administered at the 4 time points after stroke onset. The distributions of the PASS-TC scores were used to determine the discriminative ability to distinguish between individuals at the 4 time points. A comprehensive activities of daily living (CADL) measure was administered 1 year after stroke onset as an external criterion for examining the predictive ability of the PASS-TC. Changes in PASS-TC scores between the intervals of 14 to 30, 30 to 90, and 90 to 180 days after stroke onset were used to examine the evaluative properties of the measure. Results. The PASS-TC scores exhibited differences between the patients with disability and the patients without disability at the 4 time points. The scale, however, showed a notable ceiling effect at the 4 time points (>30% of the subjects), indicating a limited discriminative ability between individuals. The scores of the PASS-TC at the 4 time points were moderately correlated with the CADL scores at 1 year after stroke onset (Spearman $\rho = .5$), evidence of its predictive validity. The responsiveness of the PASS-TC was moderate at 14 to 30 days after stroke (standardized response mean [SRM] = .65) and limited at 30 to 90 and 90 to 180 days after stroke (SRM = .42 and .02, respectively). Discussion and Conclusion. The results provide evidence that the PASS-TC can predict CADL function at 1 year after a stroke, but the discriminative and evaluative abilities are limited over the first 6 months after a stroke. To promote the utility of the PASS-TC in stroke research, it will be necessary to reduce its ceiling effect and improve its evaluative ability. [Wang CH, Hsueh IP, Sheu CF, Hsieh CL. Discriminative, predictive, and evaluative properties of a trunk control measure in patients with stroke. Phys Ther. 2005;85:887–894.]

Key Words: Cerebrovascular disorders, Psychometrics, Rehabilitation, Trunk control.

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he purposes for using clinical measures can be divided into 3 categories: discrimination, prediction, and evaluation. The discriminative ability of a measure is important to ensure that it can differentiate between patient groups and identify meaningful differences in patients’ abilities. A predictive measure is used to predict outcome or prognosis. Prediction of outcome at an early stage enables clinicians to select treatment programs and set treatment goals, to facilitate a proper discharge plan, and to anticipate the need for home adjustments and community support. An evaluative measure is useful in detecting the magnitude of longitudinal change in an individual or group. The evaluative ability of a measure, as reflected in its responsiveness to meaningful change, is of key importance in outcome studies. If a measure is unresponsive to change in functional performance, it may fail to indicate improvement in patients who have undergone an intervention that improves function. The purposes of using a clinical measure may be determined as early as the development stage of the measure and may include 1, 2, or all 3 purposes. The requirements for the purposes of a measure, however, may be in conflict. To ensure that a measure is properly used in both research and clinical settings, it is critical to examine the discriminative and predictive validities and the evaluative properties of the measure.

After a stroke, the ability of a patient to maintain trunk control in sitting and standing positions is a fundamental skill for achieving autonomy in activities of daily living (ADL). The trunk control performance of patients soon after a stroke has been found to be closely associated with long-term functional improvement. A recent study demonstrated that the items in the Postural Assessment Scale for Stroke Patients that measure trunk control (PASS-TC) can be used as an early predictor of comprehensive ADL (CADL) function (as measured by combining the Barthel Index of Activities of Daily Living [BI] and the Frenchay Activities Index [FAI]) in patients 6 months after a stroke. These findings provide preliminary evidence of the predictive ability of the PASS-TC.

At least 2 trunk performance tests have been developed for patients with stroke: the Trunk Control Test (TCT) and the PASS-TC. Both measures are very similar in content, except that the PASS-TC has an extra item (ie, sitting on the edge of the bed to supine position) and that the PASS-TC uses a 4-point scale, whereas the TCT uses a 3-point scale. A recent study demonstrated that the PASS-TC can be used as an early predictor of CADL function in patients with stroke. The psychometric properties of the PASS-TC, including internal consistency, interrater agreement, and convergent validity, appeared to be satisfactory for patients with stroke in the early stage. As pointed out by Franchignoni, however, the TCT showed a pronounced ceiling effect and could not be considered to be a promising measure for discriminative and evaluative purposes. The PASS-TC might show a less pronounced ceiling effect than the TCT because the former classifies subjects into 4 categories, whereas the latter classifies them into just 3 categories. Nevertheless, the discriminative and evaluative properties of the PASS-TC need to be examined empirically. The predictive ability of the PASS-TC, especially when it is used for the late stages after stroke, remains unknown, and the evaluative ability of the scale has yet to be examined. The purpose of this prospective study was to comprehensively examine the discriminative and predictive validities and evaluative properties of the PASS-TC at 4 different time points (14, 30, 90, and 180 days poststroke).

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Mr Wang and Dr Hsieh provided concept/idea/research design and writing. Mr Wang provided data analysis. Mr Wang and Dr Hsieh provided subjects and clerical support. Mr Wang and Dr Hsieh provided project management. Mr Wang, Ms Hsueh, and Dr Hsieh provided fund procurement and institutional liaisons. Ms Hsueh, Dr Sheu, and Dr Hsieh provided consultation (including review of manuscript before submission).

This study was approved by the institutional review board of Chung-Shan Medical University Rehabilitation Hospital.

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180 days) after stroke onset. The results of this study may help both clinicians and researchers clarify the psychometric properties and determine the utility of the PASS-TC for further applications.

**Method**

**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 patients with stroke 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 examined 14 days after stroke and reassessed at other specific times for up to 3 years in order 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 [ICD-9-CM] 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 neuroradiography examination (computed tomography or magnetic resonance imaging). Subjects were excluded if they had another stroke or other major diseases during the follow-up periods or lived more than 40 miles away from the hospital.

A total of 269 patients were registered in the Quality of Life After Stroke Study during the study period. A large percentage of the potential subjects (71.8%, 685 of 954) were not included because they did not meet the enrollment criteria for this study, they died, or they were discharged from the hospital within 2 weeks of stroke onset. Five of the 269 remaining patients later declined to participate in the study, and 77 died or could not be contacted during the follow-up period (Fig. 1). There was no difference in sex between participants and non-participants ($P=.21$). The non-participants, however, were younger than the participants ($P<.001$), because the younger subjects tended to have less severe neurological impairments or complications and were discharged from the hospital earlier than 14 days after the stroke (and thus not included in our study). A total of 187 participants with a wide spectrum of trunk control ability, ranging from patients who were asymptomatic to patients who were bedridden, completed the final year of evaluation. Table 1 shows the characteristics of the subjects in our study.

**Procedure**

At 14, 30, 90, and 180 days after stroke onset, the PASS-TC and the BI were administered to the patients at a hospital or at home. The follow-up time points selected in this study are frequently adopted in longitudinal follow-up studies for patients with stroke. At 1 year after stroke, the BI and the FAI were administered to each patient or his or her main caregiver through a face-to-face or telephone interview. The BI and FAI scores were combined to represent the CADL function of patients' activities of daily living.

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**Figure 1.**

Patient attrition during the study.

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<table>
<thead>
<tr>
<th>954 patients admitted</th>
<th>685 patients were not included because they did not satisfy the criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 days after stroke</td>
<td>269 subjects</td>
</tr>
<tr>
<td>30 days after stroke</td>
<td>246 subjects</td>
</tr>
<tr>
<td>90 days after stroke</td>
<td>203 subjects</td>
</tr>
<tr>
<td>180 days after stroke</td>
<td>193 subjects</td>
</tr>
<tr>
<td>1 year after stroke</td>
<td>187 subjects</td>
</tr>
</tbody>
</table>
patients with stroke in this study. An occupational therapist familiar with these instruments administered all the measures.

**Instruments**

**PASS-TC.** The Postural Assessment Scale for Stroke Patients (PASS) contained 12 four-point items (0 = cannot perform the activity, 1 = can perform the activity with much help, 2 = can perform the activity with little help, and 3 = can perform the activity without help) that grade the ability to maintain or change a given lying, sitting, or standing posture. The PASS-TC contains 5 items (sitting without support, supine position to lying with affected side lateral, supine position to lying with nonaffected side lateral, supine position to sitting up on the edge of the table, and sitting on the edge of the table to supine position) were used to measure trunk control (PASS-TC). The total possible score of the PASS-TC ranges from 0 to 15 points. The PASS-TC has been shown to have excellent interrater agreement (intraclass correlation coefficient = .97) and high internal consistency (Cronbach’s $\alpha = .93$). The scale also has good convergent validity (the score of the PASS-TC was highly correlated with those of the BI and the balance subscale of the Fugl-Meyer Assessment Scale [Pearson $r = .89$ and $r = .73$, respectively; $P < .0001$]) in patients with stroke.

**CADL measure.** The Rasch-transformed interval score of the CADL proposed by Hsueh et al was used in this study. It has been demonstrated that the BI and FAI scores can be combined to represent CADL function, representing the entire continuum of disability. A higher score indicates greater independence in living in the community.

The BI evaluates 10 basic ADL items: 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. The BI has been shown to possess good interrater reliability (intraclass correlation coefficient = .94) and high convergent validity (Spearman $\rho = .92$) in patients with stroke.

The FAI was developed to measure social activities, or lifestyle, following stroke. The measure consists of 15 items related to normal 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 or bus travel, outings or car rides, gardening, household or car maintenance, reading books, and gainful employment. The FAI uses a 4-point scale ranging from 0 (never) to 3 (frequent), and its total possible score ranges from 0 to 45. The FAI has been shown to be a reliable and valid measure of instrumental ADL function in patients with stroke.

**Data Analysis**

**Discriminative ability.** To examine the ability of the PASS-TC to distinguish between a group of patients without disability (BI = 100) and another group with disability (BI < 100), the Mann-Whitney $U$ test was used at the 4 time points after stroke onset. To examine the ability of the PASS-TC to distinguish between individuals, the scores of the PASS-TC were plotted. The skewness of the PASS-TC was calculated for score distribution at 14, 30, 90, and 180 days after stroke onset. The floor and ceiling effects were represented by the percentages of subjects achieving the lowest and highest scores possible, respectively.

### Table 1.

Characteristics of the Patients With Stroke (N=269)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Median</th>
<th>1st–3rd Quartiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (M/F)</td>
<td>155/114</td>
<td></td>
</tr>
<tr>
<td>Mean age (y) (SD)</td>
<td>65.4 (11.2)</td>
<td></td>
</tr>
<tr>
<td>Diagnosis (n [%])</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cerebral hemorrhage</td>
<td>78 (29%)</td>
<td></td>
</tr>
<tr>
<td>Cerebral infarction</td>
<td>191 (71%)</td>
<td></td>
</tr>
<tr>
<td>Side of lesion (right/left)</td>
<td>112/157</td>
<td></td>
</tr>
<tr>
<td>At 14 days after stroke (N=269)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASS-TC score</td>
<td>13</td>
<td>6.5–15</td>
</tr>
<tr>
<td>BI score</td>
<td>40</td>
<td>20–65</td>
</tr>
<tr>
<td>At 30 days after stroke (n=246)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASS-TC score</td>
<td>15</td>
<td>11–15</td>
</tr>
<tr>
<td>BI score</td>
<td>62.5</td>
<td>35–85</td>
</tr>
<tr>
<td>At 90 days after stroke (n=203)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASS-TC score</td>
<td>15</td>
<td>15–15</td>
</tr>
<tr>
<td>BI score</td>
<td>85</td>
<td>60–100</td>
</tr>
<tr>
<td>At 180 days after stroke (n=193)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASS-TC score</td>
<td>15</td>
<td>15–15</td>
</tr>
<tr>
<td>BI score</td>
<td>95</td>
<td>70–100</td>
</tr>
<tr>
<td>At 1 year after stroke (n=187)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BI score</td>
<td>95</td>
<td>65–100</td>
</tr>
<tr>
<td>FAI score</td>
<td>6</td>
<td>0–16</td>
</tr>
</tbody>
</table>

*PASS-TC = trunk control items of the Postural Assessment Scale for Stroke Patients, BI = Barthel Index of Activities of Daily Living, FAI = Frenchay Activities Index.*

Predictive ability. We examined the strength of the association between the PASS-TC at 14, 30, 90, and 180 days after stroke and CADL function at 1 year after stroke using the Spearman correlation coefficient ($\rho$). Furthermore, 4 separate univariate ordinal logistic regressions,\(^{26}\) in which the PASS-TC scores at the 4 time points after stroke were treated as dependent variables and the CADL scores were entered as the independent variables, were used to examine the predictive validity of the PASS-TC.

Evaluative ability. The responsiveness of the PASS-TC can be used to indicate its evaluative ability. Because there is no consensus regarding how best to assess the responsiveness of measurement instruments, 2 different approaches were used in our study. First, the standardized response mean (SRM), one type of effect size, was calculated by dividing the mean changes in scores by the standard deviation of the changes in scores in the same subject. The changes in PASS-TC scores at the intervals 14 to 30, 30 to 90, and 90 to 180 days after stroke were calculated. According to Cohen's criteria,\(^{27}\) an effect size greater than .8 is large, .5 to .8 is moderate, and .2 to .5 is small. Second, Wilcoxon matched-pair signed rank tests were performed to determine the statistical significance of the changes in scores.

**Results**

The PASS-TC scores exhibited differences between the patients with disability (BI scores $< 100$) and the patients without disability (BI scores $\geq 100$) at the 4 time points after stroke onset ($P < .001$). Figure 2 shows that the distributions of the PASS-TC scores at 30, 90, and 180 days after stroke had significant skewness ($< -1.5$). We
Table 2.
Floor and Ceiling Effects of the Trunk Control Items of the Postural Assessment Scale for Stroke Patients (PASS-TC) at 4 Time Points After Stroke

<table>
<thead>
<tr>
<th>Days After Stroke</th>
<th>Floor Effect (n [%])</th>
<th>Ceiling Effect (n [%])</th>
<th>Skewness of the Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 (N=269)</td>
<td>17 (6.3)</td>
<td>101 (37.5)</td>
<td>-0.87</td>
</tr>
<tr>
<td>30 (n=246)</td>
<td>11 (4.5)</td>
<td>143 (58.1)</td>
<td>-1.56</td>
</tr>
<tr>
<td>90 (n=203)</td>
<td>6 (3)</td>
<td>154 (75.9)</td>
<td>-2.82</td>
</tr>
<tr>
<td>180 (n=193)</td>
<td>7 (3.6)</td>
<td>148 (76.7)</td>
<td>-2.82</td>
</tr>
</tbody>
</table>

Table 3.
Relationships Between the Trunk Control Items of the Postural Assessment Scale for Stroke Patients (PASS-TC) at 4 Time Points After Stroke Onset and Comprehensive Activities of Daily Living (CADL) Function at 1 Year After Stroke

<table>
<thead>
<tr>
<th>Days After Stroke</th>
<th>Predictive Validity for CADL Function* (ρ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 (n=214)</td>
<td>.51</td>
</tr>
<tr>
<td>30 (n=212)</td>
<td>.59</td>
</tr>
<tr>
<td>90 (n=188)</td>
<td>.61</td>
</tr>
<tr>
<td>180 (n=187)</td>
<td>.60</td>
</tr>
</tbody>
</table>

* As measured by the combined Barthel Index of Activities of Daily Living and Frenchay Activities Index.

Table 4.
Responsiveness of the Trunk Control Items of the Postural Assessment Scale for Stroke Patients (PASS-TC) at Different Stages of Stroke Recovery

<table>
<thead>
<tr>
<th>Days After Stroke</th>
<th>Standardized Response Mean</th>
<th>Wilcoxon z</th>
</tr>
</thead>
<tbody>
<tr>
<td>14–30 (n=246)</td>
<td>.65</td>
<td>9.12a</td>
</tr>
<tr>
<td>30–90 (n=203)</td>
<td>.42</td>
<td>5.73a</td>
</tr>
<tr>
<td>90–180 (n=189)</td>
<td>.02</td>
<td>0.11b</td>
</tr>
</tbody>
</table>

*p<.001.
*b P=.912.

We found that the PASS-TC had a notable ceiling effect at 14, 30, 90, and 180 days after stroke (Tab. 2).

Table 3 shows that the scores of the PASS-TC at the 4 time points were moderately correlated with the CADL scores at 1 year after stroke (Spearman ρ=.5, P<.001). Furthermore, we used 4 separate univariate ordinal logistic regressions and found that all the Cox and Snell pseudo $R^2$ values of the regression models were larger than .4 (P<.001).

Table 4 shows the responsiveness of the PASS-TC to be moderate at 14 to 30 days after stroke (SRM=.65, Wilcoxon z=9.12, P<.001), small at 30 to 90 days after stroke (SRM=.42, Wilcoxon z=5.73, P<.001), and very poor at 90 to 180 days after stroke (SRM=.02, Wilcoxon z=.11, P=.912).

Discussion
To our knowledge, this is the first study to examine the discriminative and predictive validities and the evaluative properties of the PASS-TC in patients with stroke at 14, 30, 90, and 180 days after onset. Our results show that the PASS-TC can uncover differences in trunk control between 2 groups of patients with stroke, one with disability (BI scores<100) and the other without disability (BI scores=100), at the 4 time points after stroke. Our study’s finding that trunk control is a crucial component in the performance of ADL was consistent with that of a previous study. The distribution of the PASS-TC at 30, 90, and 180 days after stroke, however, had notable skewness, and the PASS-TC had large ceiling effects at 14, 30, 90, and 180 days after stroke onset. More than 75% of the patients achieved the highest scores of the PASS-TC at 90 and 180 days after stroke. These results indicate limitations in the ability of the PASS-TC to discriminate between individual patients with stroke. The items on the scale may be too easy for the patients with stroke, thus allowing them to achieve the highest scores, and in turn resulting in the limited ability of the PASS-TC to differentiate the trunk control ability of individuals.

We found good evidence of the predictive ability of the PASS-TC for CADL function in the patients at all 4 time points after stroke (Spearman ρ≥.5, P<.001). Franchignoni et al also found that administration of the TCT (its items are very similar to those of the PASS-TC) at admission could predict basic ADL function (measured by the motor subscale of the Functional Independence Measure [FIM]) at discharge even better than the FIM at admission alone. Our results extend previous findings that the predictive ability of the PASS-TC was well supported not only at early stages after stroke but also at later stages after stroke. Because the PASS-TC contains only 5 items and is easy and quick to use, its predictive ability is of practical value in clinical settings.

The evaluative abilities of the PASS-TC varied at different times after stroke. The PASS-TC could not detect change in trunk control more than 90 days after stroke onset. This result is consistent with the large ceiling effects of the PASS-TC, which adversely influenced the evaluative ability of the scale. In our study, the notable ceiling effects also made the PASS-TC scores skewed toward the highest score. The notable ceiling effects, as reflected by the PASS-TC scores, indicated that no further improvement could be expected from the patients, even though certain patients continued to show improvement. The ceiling effects, which limit the ability to...
to differentiate trunk control abilities between individual patients, and the poor evaluative ability of the PASS-TC lessen the usefulness of the scale. In the clinical setting, a trunk control measure is used to identify meaningful differences between patients’ respective abilities and to monitor their recovery.

There are several limitations to the study. Our sample could potentially be biased from the real population of patients with stroke because it was hospital based and was limited to people who had had only one stroke and stayed in the hospital for about 14 days. The sample, therefore, was likely to under-represent patients with very mild stroke who are discharged from the hospital within 2 weeks. It was also likely to under-represent patients with the most severe kinds of stroke, because our eligibility criteria excluded people who could not follow instructions to complete the assessment. Our results, however, are relevant to most people with stroke in clinics, who would be hospitalized initially and enter institutional rehabilitation or community-based programs such as day hospital or home health care.

Conclusions
Our results provide evidence that the PASS-TC can predict CADL function at 1 year after a stroke, but the discriminative ability and evaluative ability are limited over the first 6 months after a stroke. To promote the utility of the PASS-TC, it will be necessary to minimize the ceiling effect and to improve the evaluative ability of the scale. We may revise the scale by adding more challenging tasks (e.g., picking up objects on the floor while sitting). Another possibility is to include items measuring trunk muscle strength (i.e., muscle force), which is supported by the findings that trunk muscle force is associated with trunk control. Further studies, however, are needed to investigate these propositions to improve the measurement of trunk control in patients with stroke.

References
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