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Validity of the Performance-Oriented Mobility Assessment in Predicting Fall of Stroke Survivors: A Retrospective Cohort Study

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Falling is one of the most common complications in stroke survivors. It is therefore important to evaluate the risk of falls. In this study, we investigated the usability of the performance-oriented mobility assessment (POMA) for predicting falls in stroke patients. The POMA examines the level of balance and mobility. Data were collected on the number of falls and physical functions from 72 stroke survivors. Physical functions were measured using the POMA balance subscale, One Leg Stand test (OLS), Sit To Stand test (STS), 10-m Walk Test (10WT), Fugl-Meyer assessment (FM), and Trunk Impairment Scale (TIS). Since the accuracy of the POMA balance subscale was moderate, the cutoff value used for predicting falls was 12.5 points (sensitivity: 72%; specificity: 74%), and the area under the curve was 0.78 (95% confidence interval: 0.66-0.91, $p < 0.001$). When comparing the physical functions (i.e., OLS, STS, 10WT, FM, and TIS) to the cutoff value for the POMA balance subscale, the physical functions of the group over 12.5 points for the subscale were significantly higher than those in the group below 12.5 points ($p < 0.05$). The muscle strength shown in the STS was the most important factor affecting the performance in the POMA balance subscale ($\beta = -0.447$). For the group below 12.5 points on the POMA balance subscale, the risk of falling increased by 0.304 times more than the group over 12.5 points. The POMA balance subscale is a valid tool for assessing the physical function and fall risk of stroke survivors.

Keywords: balance subscale; fall; performance-oriented mobility assessment; physical function; stroke
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Introduction

For stroke patients, the level of functional independence is not only more reduced but it is also more frequently disclosed than the risk of falls, since impairments such as muscle weakness, abnormal muscle tone, loss of sensory function, deficit of postural control, and abnormal gait pattern appear to be due to brain lesions (Weerdesteyn et al. 2008). Generally, the rate of falls in stroke patients is very high (73%), and 60% of these falls occur after discharge (Blennerhassett and Jayalath 2008). However, over 47% of stroke patients experience at least one fall during hospitalization (Teasell et al. 2002). Furthermore, it is well established that 46.5% of stroke patients have at least one fall within 2-6 months after stroke onset, and over 73% have at least one fall within 6 months after discharge (Forster and Young 1995), with the overall rate of single falls and multiple falls being reported as 23-73% and 12-47%, respectively (Hyndman et al. 2002; Yates et al. 2002; Harris et al. 2005). A fall may result in complications such as fractures, soft tissue damage, fear of falling, prolongation of hospitalization and/or treatment, and functional limitations (Yates et al. 2002; Harris et al. 2005). Additionally, the increased risk of falls in stroke patients may be attributed to difficulties in dodging and overpassing obstacles, and in changing directions while walking (Said et al. 1999). The factors associated with falls in stroke patients have been reported as impairments in motor function (Sze et al. 2001), balance (Teasell et al. 2002), and cognitive function (Tutuarima et al. 1997). Other factors include the presence of neurological diseases, decreased vision, previous falls, and fear of falling (Hyndman et al. 2002; Harris et al. 2005). Therefore, it is important to clearly identify risk factors in order to prevent falls in stroke patients.

There are various objective and valid tools used for examination in evidence-based clinical practice, but they are unsuitable for practical use (Gary et al. 2000; Tyson et al. 2008; Tyson and Connell 2009). There are limitations of generalization since most of these available examination tools are not only improperly applied but are also designed for research purposes only (Pollock et al. 2000; Grimmer et

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al. 2004; Tyson et al. 2010). Additionally, many problems have stemmed from structural problems with the examination methods, inefficiency of time and money, the ceiling effect, and floor effect (Pollock et al. 2000; Grimmer et al. 2004; Tyson et al. 2010). Among them, the results of the examination tools are composed of an ordinal 4- or 5-point scale that is generally classified into 0 points (cannot perform), 1 point (can perform with the most help), 2 points (can perform with partial help), 3 points (can perform alone but direction or observation is required), and 4 points (can perform independently), or the results are classified as trace, poor, fair, or good (Cipriany-Dacko et al. 1997; Tyson et al. 2008; Tyson and Connell 2009). For examination tools that use these scales, there is cause to question the degree of reliability and the accuracy of the results in the repeated measuring because of ambiguous definitions of balance and differences in the therapists' professional experience. These issues may have an effect on the tools' discriminative capacity between items and the ability to sufficiently and efficiently reflect the current status of the subjects (Tyson et al. 2008; Tyson and Connell 2009). Thus, the selection and use of the most suitable examination tools to predict falls in stroke patients may be controversial even among clinical therapists. Therefore, clinical therapists should examine the balance of patients with a high-level fall risk due to loss of balance and carefully select the optimal examination tools necessary for predicting the risk of falls as well as the functional results after therapeutic intervention.

The performance-oriented mobility assessment (POMA) examines the level of balance and mobility to determine the degree of fall risk in the elderly (Tinetti 1986). The POMA has more predictive validity than the Timed Up and Go test (TUG), Functional Reach Test (FRT), and One Leg Stand test (OLS) for predicting falls in the elderly (Shumway-Cook and Woollacott 2000; Lin et al. 2004). However, an assessment using both subscales of the POMA (balance and gait) may prove difficult when assessing a specific impairment of an individual patient or predicting falls. Thus, studies have used the balance subscale of the POMA apart from the gait subscale to investigate its predictive validity for predicting falls (Harada et al. 1995; Verghese et al. 2002; Faber et al. 2006; Sterke et al. 2010; Contreras and Grandas 2012). The balance subscale of the POMA can be used efficiently for examining balance since it can provide sufficient information on an individual's balance capabilities (Russo 1997; Whitney et al. 1998), because most of the test items are comprised of tasks (e.g., 360˚ rotation, stand, and sit) where a fall may repeatedly occur (Jacobs et al. 2006). In addition, the balance subscale is easy to use in the clinical setting and requires only 5 min to perform (Kegelmeyer et al. 2007). The discrimination capacity and validity for predicting falls in patients with Parkinson's disease (Kegelmeyer et al. 2007) and the elderly (Faber et al. 2006; Sterke et al. 2010) can be verified by using the balance subscale, because it is composed of tasks that might trigger a fall and its evidence is also reported. The POMA balance subscale may be a useful tool for predicting the occurrence of falls and examining the balance ability of stroke patients. Although its reliability and validity for stroke patients has been reported (Cipriany-Dacko et al. 1997; Corriveau et al. 2004; Daly et al. 2006), its discrimination capacity and validity for predicting falls has not been reported.

This study attempts to examine the discrimination capacity of the balance subscale and its potential for predicting falls in chronic stroke patients. By analyzing the relationship between the subscale's physical function and its ability to predict falls, we aim to determine its clinical usefulness.

Methods

Participants and Procedures

During this retrospective cohort study, data were collected from 89 stroke patients who had undergone inpatient rehabilitation from June 2013 to October 2013. Patients who could walk more than 10 m without walking aids, those without lesions of the lower motor neurons, those without musculoskeletal disease of the lower extremities, and those with a score of over 24 points on the Mini Mental State Examination (MMSE) were selected for study inclusion. Patients with unmanaged diabetes mellitus and those on medication that might affect balance were excluded. Ten patients did not fit the criteria (5 took a hypnotic drug, 3 took a sedative drug, 2 took a drug for cardiovascular disease such as diuretics and beta-blockers) and were excluded, and seven patients, who dropped out during the investigating, were discharged from the hospital, or reported worsening health, were excluded. Thus, the remaining 72 patients were included. The characteristics of these participants are listed in Table 1. The purpose and procedure of the study were explained to all participants, and they signed informed consent forms. The study was approved by the Kyungnam University Institutional Review Board.

Data on the general characteristics (i.e., gender, age, diagnosis, affected side, disease duration, body mass index, use of walking aids, and MMSE) of participants were retrieved from the medical records. Furthermore, a research assistant investigated the number of falls each participant had experienced in the previous year through interviews with the patient or family members. The frequency of a fall in participants who experienced a stroke in the previous year was calculated from the date of stroke onset. The participants were classified into one of three groups—non-fallers, fallers, or multiple fallers—according to the number of falls experienced in the last year. Those with more than two falls in the last year were classified as fallers (two falls = faller; three or more falls = multiple fallers), while those with no falls were classified as non-fallers. However, participants who experienced one fall were classified as non-fallers since the fall may have occurred due to overwhelming outside factors (Thomas and Lane 2005). The criteria for a fall was defined as an unexpected accident, which occurred on the lower level of the ground, an object, or floor due to an unintended change in posture and not because of paresis, epilepsy, seizure, or momentary and overwhelming outside factors (Lamb et al. 2005). After investigating the general characteristics and fall experiences, the participants' balance was examined by using the balance subscale of the POMA in order to investigate the subscale's discrimination capacity and predictive validity. The physical functions were examined using the OLS on the affected and non-affected side, Sit To Stand test (STS), Functional Reach Test (FRT), 10-m Walk Test (10WT), Fugl-Meyer assessment (FM), and Trunk Impairment Scale (TIS). All examinations were performed by two therapists who had experience using the examination tools for over 13 years, and they also had experience treating neurological patients for over 15 years. The assessors sufficiently understood the examination tools and read protocols and guides to minimize confounding variables. The participants were allowed to rest for 2-5 minutes after each examination following a verbal or physical demonstration to help the participants understand the next examination. All examinations, except for the balance subscale of the POMA, were performed over two days in the following sequence: OLS, STS, FRT, 10WT, FM, and TIS.

Outcome Measurements

Balance subscale of the POMA: The POMA is used to examine balance and mobility in the elderly (Tinetti 1986). This examination tool consists of the balance subscale (9 items, 16 points) and gait subscale (8 items, 12 points), totaling 28 points. In this study, we only used the 9 items from the balance subscale. The individual items are scored on an ordinal 2- or 3-point scale. The inter-rater reliability of the balance subscale for the elderly ranges from $r = 0.88$-0.90 (Faber et al. 2006) with an intra-class correlation coefficient (ICC) of 0.75 (McGinty et al. 1999) or 0.97 (Sterke et al. 2010). The test-retest reliability is reported as ICC = 0.93 (Harada et al. 1995).

Physical functions: The OLS in the affected and non-affected side was used to examine the static balance. This tool was used to examine how long a patient could stand on one leg without external aids. In this study, the participants crossed both arms and then stood either on the affected side or the non-affected side as long as they could. As soon as they put their foot back on the ground, the time that had elapsed was recorded using a stopwatch. The inter-rater reliability was reported as ICC = 0.99 (Franchignoni et al. 1998).

The STS test, which was repeated five times, was used to examine the muscle strength of the lower extremity. This tool is used to examine the time taken to repeat the sit to stand task five times. In this study, the participants sat on a chair with a back and without armrests and then crossed their arms on their chests and sat and stood five times without the aid of the upper extremity. The measurement started the moment the participant's back left the chair's back and stopped when the participant's back touched the chair's back again (Mong et al. 2010). The posture for standing up was achieved when both knee and hip joints were fully extended with the trunk erect. The intra-rater/inter-rater reliability was ICC = 0.99-0.97 (Mong et al. 2010).

The FRT was used to examine dynamic balance. The distance between the first point and last point of the third distal metacarpal bone was measured for the period when the participant maintained arm to the maximum reach without losing balance while maintaining a horizontal position. The bar was installed horizontally at the height of the acromion during elbow extension with 90° forward flexion with fists clenched and both feet shoulder width apart on the fixed supporting surface. The farther the distance between the two points, the better the balance. The reported inter-rater reliability was ICC = 0.92-0.99 (Franchignoni et al. 1998; Rockwood et al. 2000).

The 10WT was used to assess gait ability, which measured the 10-m zone after subtracting the 2-m acceleration zone and the 2-m deceleration zone when walking 14 m. In this study, we marked ground zero and an endpoint on the flat ground and had the participants walk at a comfortable walking pace when an assessor gave the start signal. As soon as the participants arrived at the endpoint of 10 m, the stopwatch recorded the time. The test-retest reliability was reported high (ICC = 0.88-0.97) (Flansbjer et al. 2005).

The FM was used to examine the motor function of the affected side (Fugl-Meyer et al. 1975). It is a tool used to examine the degree of motor recovery in stroke patients quantitatively. The reported inter-rater reliability was ICC = 0.97, 0.9 (Sanford et al. 1993).

The TIS was used to examine the ability of trunk control, and it was composed of three sections totaling 23 points. The items for static sitting balance examined the ability to maintain posture with the non-affected side crossed on the affected limbs and both feet touching the ground (7 points). The items for dynamic sitting balance examined the separated movement of both the upper trunk and lower trunk through trunk lateral flexion (10 points). The items for coordination examined the rotating movement at the horizontal plane of both the upper trunk of the shoulder girdle and the pelvic girdle (6 points). The reliability for stroke patients was ICC = 0.96 (Verheyden et al. 2004).

Statistical Analysis

Statistical analysis was performed using SPSS, version 16.0 (IBM, Armonk, New York, USA). Descriptive statistics were used to analyze the general characteristics of the participants. One-way analysis of variance or chi-square test was used to compare differences of the general and medical characteristics among the groups, and Scheffe's post-hoc test was also was conducted. The cutoff value of the balance subscale of the POMA for predicting falls was determined by using a Receiver Operating Characteristic curve (ROC curve). The accuracy of prediction was measured by the area under the ROC curve (AUC), which was classified into less informative (AUC = 0.5), less accurate ($0.5 < AUC \leq 0.7$), middle level of accuracy ($0.7 < AUC \leq 0.9$), very accurate ($0.9 < AUC < 1$), and perfect accuracy (AUC = 1) (Greiner et al. 2000). If the cutoff value of the balance subscale of the POMA for predicting falls was significant, an independent t-test was performed to compare differences in the participants' physical functions (OLS, STS, FRT, 10WT, FM, and TIS) between two groups depending on the cutoff value of the balance subscale of the POMA ($12.5 \leq$ balance subscale of the POMA score or $12.5 >$ balance subscale of the POMA score). Multiple linear regression analysis was performed to determine the influence of general characteristics, the number of falls, and physical functions of participants on the balance subscale of the POMA. Logistic regression analysis was performed in order to address the most influencing variable on falling between the general characteristics and physical functions. The statistical significance level was $\alpha = 0.05$.

Results

General Medical Characteristics of Participants Depending on Fall Experience

With regard to the general medical characteristics of the participants depending on fall experience, there was no significant difference in gender, age, diagnosis, affected side, disease duration, and BMI. However, a significant difference existed between the fallers and non-fallers with 19 of 28 (67.86%) participants having independent gait compared to the fallers, 6 of 15 (40%) participants being 1st fallers, 7 of 29 (24.14%) participants being multiple fallers. There was a significant difference between the fallers and the multiple fallers on the balance subscale of the POMA, OLS of the non-affected side, STS, and static balance in the TIS. The non-fallers showed a more significant difference than the multiple fallers in the OLS of the affected side, FM, and TIS. The non-fallers showed a more significant difference than the fallers in the 10WT, and the fallers showed a more significant difference than the multiple fallers. A significant difference could not be found among the groups for the FRT (Table 1).

Cutoff Value in the Balance Subscale of the POMA as Factors for Predicting Falls

The cutoff values of the balance subscale of the POMA as factors for predicting falls came from the ROC curve analysis with 12.5 points (sensitivity: 72%; specificity: 74%), and the AUC was 0.78 (95% CI: 0.66-0.91, p < 0.001). The total score for the balance subscale of the POMA is 16 points; therefore, a group composed of partici-

Table 1. Characteristics of the participants (n = 72).

	Non-faller (A) (n = 28)	Fallers (B) (n = 15)	Multiple fallers (C) (n = 29)	F	p
Gender (male/female)	18/10	9/6	22/7	1.444	.49
Age (years)	60.07 (10.87)	61.67 (13.16)	63.52 (18.27)	.391	.68
Etiology (infarction/hemorrhage)	23/5	8/7	19/10	4.173	.12
Affected side (left/right)	12/16	6/9	16/13	1.263	.53
Stoke duration (months)	10.54 (2.44)	10.00 (2.04)	10.45 (2.92)	.224	.80
BMI (score)	23.44 (1.73)	22.96 (2.48)	22.77 (1.76)	.902	.41
Walking aids type (independent/one-point cane/four-point cane)	19/5/4	6/4/5	7/9/13	11.618	.02*
Balance subscale of POMA (score)	13.75 (3.38)	9.87 (4.44)	9.34 (1.84)	15.661	.001*** A│B C
OLS-affected side (sec)	5.16 (5.99)	2.74 (2.37)	1.95 (1.72)	4.715	.012* A│C
OLS-non-affected side (sec)	12.32 (8.64)	6.52 (3.90)	5.01 (1.99)	11.977	.001*** A│B C
STS (sec)	13.30 (8.48)	15.54 (6.32)	21.88 (3.89)	13.029	.001*** A│B C
FRT (cm)	21.68 (10.67)	17.56 (8.86)	16.38 (6.35)	2.763	.07
10WT (m/s)	.87 (.30)	.75 (.42)	.51 (.18)	10.866	.001*** A│C, B│C
FM-upper extremity (score)	35.71 (19.11)	34 (15.65)	24.00 (13.11)	4.135	.02* A│C
FM-lower extremity (score)	24.29 (6.66)	22.40 (7.12)	18.17 (5.73)	6.718	.002** A│C
FM-total (score)	60.00 (24.27)	56.40 (18.78)	42.17 (17.58)	5.711	.005** A│C
TIS-static balance (score)	6.00 (1.49)	4.80 (2.11)	4.72 (.96)	6.238	.003** A│B C
TIS-dynamic balance (score)	7.64 (2.73)	6.80 (2.91)	5.55 (2.87)	3.944	.024* A│C
TIS-coordination (score)	4.43 (1.64)	3.47 (1.41)	3.41 (1.64)	3.345	.041* A│C
TIS-total (score)	18.07 (5.36)	15.07 (5.60)	13.69 (4.76)	5.237	.008** A│C

Table 1 shows the characteristics of the participants who fulfilled the inclusion criteria for the study.

The values are presented as mean (S.D.) or mode. Significant differences among three groups were presented as *p < .05, **p < .01, ***p < .001.

A│B C, There were significant differences between non-faller group and fallers or multiple fallers, However there were no significant differences between fallers or multiple fallers.

A│C, There were significant differences between non-faller group and multiple fallers.

A│C, B│C, There were significant differences between non-faller group and multiple fallers, and there were significant differences between fallers and multiple fallers.

BMI, Body Mass Index; OLS, One Leg Stand test; STS, Sit to Stand test; FRT, Functional Reach Test; 10WT, 10-m Walk Test; FM, Fugl-Myer; TIS, Trunk Impairment Scale.

pants with a score lower than 12.5 points was considered to have a higher chance of experiencing falling compared to the group composed of participants with a score higher than 12.5 points (Table 2).

Comparison of Physical Functions Depending on the Cutoff Values in the Balance Subscale of the POMA

In the comparison of physical functions, depending on the cutoff values in the balance subscale of the POMA, there appeared to be a significant difference in the OLS, STS, 10WT, FM, and TIS. However, there was no difference in the FRT (Table 3).

Analysis of Factors Affecting the Balance Subscale of the POMA

For analysis of the factors affecting the balance subscale of the POMA, the STS produced the largest effect (β = −0.447) followed by the OLS of the affected side, number of falls, FM of the lower extremity, and dynamic balance in the TIS (explanation ability: 63%) (Table 4).

Analysis of Factors Affecting Falls

Factors affecting the occurrence of falls followed the sequence of the balance subscale of the POMA and the OLS of the affected side. Among the factors, it was found that in participants who received 12.5 points for the balance subscale of the POMA, the risk of falling increased by 0.304 times compared to participants with over 12.5 points. A 0.712 times increase in the risk of falling was observed in participants with shorter OLS time on the affected side than in participants with longer OLS time (Table 5).

Discussion

In general, stroke patients continue to adapt to their balance deficits by avoiding the risk of falling or by using compensatory strategies; however, their physical activity is further limited because of their fear of falling due to the psychological burden after a fall (Weerdesteyn et al. 2008). For stroke patients, a fall is a factor that reduces quality of life, so these patients should be treated more appropriately.

In this study, we investigated whether a discrimination capacity existed, if the balance subscale of the POMA could

Table 2. Cut-off value of the balance subscale of the POMA as the factor for predicting falls.

Variable	Type	AUC	Sensitivity (%) Specificity (%)	PPV (%) NPV (%)	ROC curve (95% CI)	*p*
Balance subscale of POMA (score)	Non-fallers verse fallers	≤ 12.5	72 74	80% 70.4%	.78(.66-.91)	.001*

The PPV and the NPV were calculated by the following formula: PPV = number of fallers / (number of fallers + number of non-fallers) × 100; NPV = number of non-fallers / (number of non-fallers + number of fallers) × 100. PPV = 80%, If the participants were diagnosed as fallers (positive), the probability of participants who had experienced falls; NPV = 70.4%, If the participants were diagnosed as non-fallers (negative), the probability of participants who had not experienced falls.

Significant differences were presented as $*p < .001$.

CI, Confidential Interval; PPV, Positive Predictive Value; NPV, Negative Predictive Value.

Table 3. Comparison of physical funtions depending on the cut-off value of the balance subscale of the POMA.

Variables	Type		*t*	*p*
	Balance subscale of POMA (≤ 12.5 score, *n* = 45)	Balance subscale of POMA (> 12.5 score, *n* = 27)		
OLS-affected side (sec)	2.45 (2.98)	4.87 (5.54)	−2.402	.019*
OLS-non-affected side (sec)	6.05 (5.03)	11.69 (7.60)	−3.796	.001***
10WT (m/s)	.56 (.26)	.92 (.32)	−5.193	.001***
STS (sec)	20.56 (6.39)	11.66 (5.86)	5.901	.001***
FRT (cm)	17.42 (7.80)	20.80 (10.47)	−1.566	1.22
FM-upper extremity (score)	25.93 (15.34)	38.48 (16.71)	−3.250	.002**
FM-lower extremity (score)	19.24 (6.33)	25.07 (6.32)	−3.785	.001***
FM-total (score)	45.18 (19.26)	63.56 (21.80)	−3.729	.001***
TIS-static balance (score)	4.67 (1.63)	6.19 (.83)	−4.474	.001***
TIS-dynamic balance (score)	5.82 (3.21)	7.96 (1.79)	−3.179	.002**
TIS-coordination (score)	3.42 (1.70)	4.48 (1.34)	−2.762	.007**
TIS-total (score)	13.91 (5.78)	18.63 (3.31)	−3.872	.001***

The values are presented as mean (S.D.). Significant differences were presented as $*p < .05$, $**p < .01$, $***p < .001$.

OLS, One Leg Sand test; 10WT, 10-m Walk Test; STS, Sit to Stand test; FRT, Functional Reach Test; FM, Fugl-Meyer; TIS, Trunk Impairment Scale.

Table 4. Analysis of factors affecting the balance subscale of the POMA.

Independent Variables	Regression Coefficient	Standard error	β	t	p	$adj\ R^2$	F
Constant	11.027	1.636		6.738	.001***	.63	30.634***
STS	−.221	.041	−.447	−5.409	.001***		
OLS-affected side	.617	.151	.317	4.074	.001***		
Number of falls	−1.299	.421	−.312	−3.086	.003**		
FM-lower extremity	1.349	.454	.235	2.970	.004**		
TIS-dynamic balance	.506	.216	.213	2.347	.022*		

Significant differences were presented as $^*p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Independent variables: gender, age, etiology, affected side, stoke duration, BMI, walking aids type, number of fall, OLS-affected side, OLST-non-affected side, STS, FRT, 10WT, FM-upper extremity, FM-lower extremity, FM-total, TIS-static balance, TIS-dynamic balance, TIS-coordination, TIS-total.

Dependent variable: Balance subscale of POMA.

BMI, Body Mass Index; OLS, One Leg Stand test; STS, Sit to Stand test; FRT, Functional Reach Test; 10WT, 10-m Walk Test; FM, Fugl-Myer; TIS, Trunk Impairment Scale.

Table 5. Analysis of factors affecting the experience of falls.

Independent Variables	Dependent Variables	Regression Coefficient	Standard error	Wald	p	Odd ratio (95% CI)
Balance subscale of POMA	Fall	−1.190	.437	8.151	.004	.304 (.134 ~.689)
OLS-affected side		−.339	.143	5.603	.018	.712 (.538 ~.943)

Significant differences were presented as $^*p < .05$, $^{**}p < .01$.

Independent variables: gender, age, etiology, affected side, stoke duration, BMI, walking aids type, OLS- affected side, OLS-non-affected side, STS, FRT, 10WT, FM-upper extremity, FM-lower extremity, FM-total, TIS-static balance, TIS-dynamic balance, TIS-coordination, TIS-total, Balance subscale of POMA (≤ 12.5 score = 0, > 12.5 score = 1).

Dependent variable: fall (non-fall = 0, fall = 1).

BMI, Body Mass Index; OLS, One Leg Stand test; STS, Sit to Stand test; FRT, Functional Reach Test; 10WT, 10-m Walk Test; FM, Fugl-Myer; TIS, Trunk Impairment Scale.

predict falls in stroke patients, and if the examination tool had clinical usefulness by analyzing the relationship between physical function and falls. Our findings indicated that the cutoff value for the balance subscale of the POMA, which could predict falls in chronic stroke patients, was 12.5 points (curve under area = 78%; sensitivity: 72%; specificity: 74%), and the possibility of a fall was larger for the group below 12.5 points than the group over 12.5 points. In previous studies of the elderly, it was reported that the cutoff values for the balance subscale of the POMA were 10 points (sensitivity: 64%, specificity: 66.1%), 11 points (sensitivity: 70%, specificity: 51%) (Faber et al. 2006; Sterke et al. 2010), and 14 points (sensitivity: 68%, specificity: 78%) (Harada et al. 1995). Sensitivity and specificity were at a satisfactory level, and the AUC also showed a middle level of accuracy (0.7 below the AUC ≤ 0.9) (Greiner et al. 2000), which suggests that the balance subscale of the POMA had a discrimination capacity for predicting falls in chronic stroke patients. Additionally, as a result of comparing the physical functions, it was found that there was a significant difference in the OLS, STS, FRT, 10WT, FM, and TIS for the group with a balance score of the POMA below 12.5 points in comparison with the group over 12.5 points.

In the balance subscale of the POMA, the time for performing the STS of the group that was below 12.5 points was 20.56 seconds while the group over 12.5 points was 11.56 seconds, and it is noted that the cutoff value of STS was reported at 17.9 seconds (Beninato et al. 2009). According to the results of this study, the group below 12.5 points had a larger risk of falling than the group with over 12.5 points. Additionally, the 10WT score of the group whose balance score of the POMA was below 12.5 points was 0.56 m/s, which classified them into the limited community ambulators (0.4~0.8 m/s) (Taylor-Piliae et al. 2012). The intensity of the physical function level was 1.7 on the metabolic equivalent test (MET) if converting gait speed to 2.02 km/h. The group whose balance subscale of the POMA was over 12.5 points was classified into the group where independent gait is possible at a local society as 0.92 m/s, gait speed is 3.31 km/h, and the strength of physical function level is about 2.8 MET. Considering that a light walk in the garden is 2.3 MET while activities of daily life, such as preparing a meal or cleaning the home, is 2.5 MET for healthy adults, it suggests that stroke patients whose balance score of the POMA is over 12.5 points are limited for independent gait capacity at the community level where a light walk in the garden is impossible. Additionally, they are at risk for falling. It was noted that the lower extremity motion function of the affected side was, the more the possibility of experiencing falls increases for the stroke patients, and the possibility of experiencing a fall increases by 2.2 times if the FM of the lower extremity is less than 28 points (Belgen et al. 2006). The possibility of experiencing a fall once increases if it is less than 23.8 points (Verheyden et al. 2005). The risk of falls was large considering that the FM of the lower extremity was 9.4 points for the participants whose balance subscale of the POMA was below 12.5 points in this study. It was noted that the ability to normally adjust the trunk and the independent activities of daily living are impossible if the TIS was less than 20 points (Verheyden et al. 2005). In the balance subscale of the POMA, the group below 12.5 points (TIS = 13.19 points) was lower than the group over 12.5 points (TIS = 18.63 points). It did not reach the suggested standard, but there was a significant difference between both groups. It was reported that the TIS of chronic stroke patients had a significant relationship with the balance subscale of the POMA (explanation ability = 58%), gait (53%), Functional Ambulation Category (50%), 10WT (27%), TUG (50%), motor scale of the Functional Independence Measure (55%) (Verheyden et al. 2006), TIS, and balance subscale of the POMA ($r = 0.91$) (Jijimol et al. 2013). Since there is a deficit of trunk control, the reduction of balance ability, slow gait speed, and low functional independent level are the largest problems among stroke patients, and these variables are closely related with falls (Mong et al. 2010). It seems that the balance subscale of the POMA may be a useful examination tool in the clinical setting for examining the balance ability or predicting falls in stroke patients since sufficient validity exists when comparing the results of this study with previous studies.

There was a need to study which factors had an effect on the balance subscale of the POMA. Generally, the lower the balance subscale of the POMA was, the more physical function was reduced; thus, it seems more frequently that a risk of falling exists. In this study, the factors appeared as sequences of the STS, OLS of the affected side, number of falls, FM of the lower extremity, and dynamic balance of the TIS. As result of this study, it can be considered that balance has an interdependent relationship with the muscle strength of the lower extremity, dynamic balance, falls, motor function of the affected lower extremity, and trunk adjusting ability. It was proven that the balance subscale of the POMA has sufficient validity for the use in the clinical setting, and it is reasonable that it can also examine the capacity of adjusting weight-bearing and weight-shifting of the trunk and pelvic, which are required for selected separate movements as well as for examining the static balance of a one leg stand on the affected or non-affected side. Additionally, the balance subscale of the POMA is capable of examining gait and can measure the degree of symmetrical weight-bearing and the muscle strength of the lower extremity (Kegelmeyer et al. 2007).

For stroke patients whose balance score of the POMA was below 12.5 points, the fall risk increased by 0.304 times compared to groups over 12.5 points, and it can be predicted that for patients whose time for the OLS on the affected side was short, the probability of experiencing a fall increased by 0.712 times than in those whose time was long. In this result, all variables having an effect on falls were the affected side OLS, FRT, STS, and 10WT. The FM and TIS were excluded, and the cutoff values for the balance subscale of the POMA were selected. Therefore, the balance subscale of the POMA was variable with sufficient discrimination capacity and factors for predicting falls. Thus, it seems that the balance subscale of the POMA can become a useful tool in the clinical setting since it has a satisfactory discrimination capacity and predictive validity for predicting the risk of falls in the chronic stroke patients.

However, a few limitations exist in this study. There may be cases deviating from the definition of falls since records for whether a fall occurred were based on the participants' recollection. It was impossible to exclude the selection bias since the number of falls was recorded on the subjective report by the participants. In addition, environmental factors and other influential factors affecting falls such as visual problems were not included as variables in this study. The exclusion criteria also may not completely control for participants who took a drug that might have an effect on balance, because most elderly patients use one or more fall-risk-increasing drugs. Therefore, the results of this study may not be generalized. Thus, a prospective study including numerous important factors on whether the balance subscale of the POMA can predict falls for stroke patients should be performed in the future.

Conflict of Interest

The authors declare no conflict of interest.

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