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Assessment of the Influence of Balance on Gait of Persons with Stroke

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Abstract. [Purpose] The aim of this study was to analyze the prediction of and the relationship between gait and postural control of chronic stroke patients. [Subjects] Thirty stroke patients participated in this study. We conducted three common clinical assessments: the Berg Balance Scale (BBS), the Dynamic Gait Index (DGI), and the Performance-Oriented Mobility Assessment (POMA). [Results] Multiple regression analysis was performed. The dependent variables were the DGI and the POMA for walking and the independent variables were BBS score, post-stroke duration, age, sex, and affected side. In the regression equation for DGI, the correlation coefficient (r) was 0.776, the coefficient of determination (R^2) was 0.602, and the BBS score was the most important variable for determining the DGI score. In the regression equation for the POMA score, r was 0.769, R^2 was 0.591, and the BBS score was the most important variable for determining POMA score. [Conclusion] These results suggest that the walking ability should be determined on the basis of the balance ability of stroke patients. More assessment tools of walking ability as well as balance ability are required.
Key words: Berg balance scale, Dynamic gait index, Multiple regression analysis

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INTRODUCTION

In most countries, stroke is a primary cause of death and disability[1)]. Mobility impairments associated with sensory, motor, and visual deficits commonly affect the activities of daily living and ultimately limit their participation in community-based activities[2, 3)]. Falls and fall-related injuries affect an individual's ability to maintain their balance while walking, and these injuries are among the most common complications following stroke[4, 5)]. Therefore, improvements in rehabilitation outcomes and goal setting are important for stroke patients[6, 7)]. To set suitable therapeutic goals and develop effective treatment plans, predictions need to be made about patients' expected degree of recovery[8)]. Selection of assessments is an important process, but it is difficult because of the variability in causes, symptoms, severity, and the possibility of spontaneous recovery following stroke[9)].

Levels of functional activities in a clinical setting are good indicators of overall function and are important indices of change. Clinical measures provide a simple and convenient method for identifying problems and reducing the time spent in clinics[10)]. The most common clinical tools for assessment of postural control and gait performance are the Berg Balance Scale (BBS), Dynamic Gait Index (DGI), and Performance-oriented Mobility Assessment (POMA). The BBS is used to assess balance ability, the DGI for walking assessments, and the POMA for the determination of walking and balance ability in patients with stroke.

The BBS is mostly used to assess balance and to monitor change over time. The DGI is widely used for evaluating a patient's ability to modify their gait in response to changing task demands, and the POMA has been shown to be a good measure of fall risk in neurologically intact elderly adults living in the community[11)]. One study found that the POMA had excellent test-retest reliability and validities compared with the Timed Up-and-Go, One-Leg Standing, and Functional Reach Tests among the elderly[12)]. Another study reported that the BBS was the single best predictor of fall risk for the community-dwelling elderly without any neurologic pathologies[13)]. However, most of these studies focused on correlations associated with balance abilities, walking, and activities of daily living[14–16)].

Correlation statistics are useful for describing the relative strength of a relationship between two variables; however, to establish this relationship as a basis for prediction, regression analysis is commonly used[17)]. The ability to predict gait performance is crucial for effective clinical decision-making and goal setting for effective rehabilitative intervention. The postural control required for walking is also an important component of patient care of stroke persons. For this reason, regression analysis provides a powerful statistical approach for explaining and predicting gait performance based on clinical outcome measures. Therefore, the aim of this study was to analyze the prediction of and the relationship between the gait and postural control among chronic stroke patients.

SUBJECTS AND METHODS

Thirty subjects with chronic hemiparetic stroke participated in this study. Data were collected from the out-patient/in-patient physical therapy departments of adult rehabilitation units in rehabilitation hospitals. The subjects' general characteristics are listed in Table 1. The inclusion criteria were as follows: a medically confirmed diagnosis of stroke, the ability to communicate with evaluators, and the ability to stand without any assistance. Patients were excluded from the study if they had a history of any other neurologic, orthopedic, or psychological disorders that would have affected their ambulatory or balance abilities or precluded support for the procedures of this study. Before participation, all participants provided their informed consent after receiving a detailed explanation of the study.

To investigate the influence of the postural control on walking on the basis of the outcome measures of stroke patients, three common clinical assessments (BBS, DGI, and POMA) were performed in a with random order in a day by two physical therapists. The raters were not allowed to consult with each other during the tests, and they had no access to previous test results. The tests were performed in a quiet, well-organized therapy room, and the subjects were given standard verbal instructions related to the clinical tools. Although the verbal instructions were generally given once only, they were repeated if required by the study subjects. Participants were allowed a rest period between each test, and they wore their normal shoes during the assessments.

The BBS is commonly used to assess the balance control of individuals with neurological disorders while sitting and standing. The scale consists of 14 items and has a maximum possible score of 56 points. It uses an ordinal scoring system in which each detail is rated, 0 being the lowest and 4 being the highest level of function. The test-retest reliability among stroke survivors was reported to be 0.99[18]. The DGI consists of the following 8 walking tasks: walking walking at different speeds walking while turning the head horizontally and vertically walking with a pivot turn walking over and around obstacles and stair climbing. The DGI has a maximum possible score of 24, and a score of 19 or less indicates an increased risk of falls. Each task is scored on a 4-point ordinal scale ranging from 0 (severe impairment) to 3(normal ability). The DGI has been shown to have good inter-rater and test-retest reliabilities and is a valid predictor of the risk of fall among the elderly[19]. The POMA evaluates steady-state balance while sitting and standing as well as reactive and proactive balance and includes a sensory component related to postural control and gait. The maximum score is 28 points. Performance is rated on a 3-point scale. The reported inter-rater reliability of this test is good[20].

Descriptive analysis was used to describe characteristics such as age, post-stroke duration, and BBS, DGI, and POMA score; frequency analysis was used for sex and the affected side of stroke patients with hemiplegia or hemiparesis. Multiple regression analysis was used to determine the relationships between gait and balance in the context of the outcome measures. Since the dependent variables were the DGI and POMA scores, the predictor variables were BBS score, age, post-stroke duration, sex, and affected side; sex and the affected side were recorded as dummy variables. A significance level of $\alpha<0.05$ was adopted. Data analyses were performed using SPSS version 18.0.

Table 1. General characteristics of the participants (N=30)

Characteristics	Mean ± SD
Age (yr)	54.1 ± 11.2
Sex (Male : Female)	18:12
Affected Side (Left : Right)	17:13
Post-stroke duration (month)	16.4 ± 9.0
BBS[a] (Range)	31 ~ 56
DGI[b]	16.3 ± 4.9
POMA[c]	21.9 ± 4.6

[a]Berg Balance Scale, [b]Dynamic Gait Index, [c]Performance-Oriented Mobility Assessment.

RESULTS

Table 2 shows the regression equation for calculating the predicted DGI and POMA scores by using the BBS score. For the regression equation for the DGI score, the correlation coefficient (r) was 0.776, the coefficient of determination (R^2) was 0.602, the regression constant was −9.197, and the regression coefficient for the BBS score was 0.552. As shown in Table 3, the BBS score was the most important variable for determining the DGI score. Post-stroke duration (p=0.967), age (p=0.943), sex (p=0.136), and affected side (p=0.573) were not significant for predicting the DGI score. For the regression equation for the POMA score, r was 0.769, R^2 was 0.591, the regression constant was −1.969, and the regression coefficient for the BBS score was 0.518. As shown in Table 3, the BBS score was the most important variable for determining the POMA score. Furthermore, post-stroke duration (p=0.993), age (p=0.137), sex (p=0.311), and affected side (p=0.992) were not significant for predicting the POMA score.

DISCUSSION

The purpose of this study was to predict walking ability on the basis of balance abilities of stroke patients by using outcome measurement tools commonly used in clinical assessment, namely the BBS, DGI, and POMA. The results of our study revealed significant findings. First, the BBS score had a predictive ability of 60% for the DGI score and a predictive ability of 59% for the POMA score among individuals with chronic hemiparetic stroke, even though they had a high correlation coefficient (r=0.776 for the DGI, and r=0.769 for the POMA). In addition, these findings were not affected by post-stroke duration, age, sex, or the affected side.

Postural control generally affects the walking abilities of stroke patients in any clinical setting. Therefore, the BBS is widely used to assess balance abilities, and thus to indirectly predict gait performance. However, the BBS is not a

Table 2. The regression equations for BBS, the DGI and POMA by multiple regression analysis (N=30)

Outcome Measures	Regression equation	r	R²
DGI[a]	(-9.197) + (0.552×BBS[c])*	0.776	0.602
POMA[b]	(-1.969) + (0.518×BBS)*	0.769	0.591

[a]Dynamic Gait Index, [b]Performance-Oriented Mobility Assessment, [c]Berg Balance Scale, *: $p<0.05$

Table 3. Output for multiple regression analyses for the prediction of the DGI and POMA from the BBS, post-stroke duration, sex, and affected side (N=30)

DGI[a]	Standardized coefficient (β)	POMA[b]	Standardized coefficient(β)
R^2=0.602*		R^2=0.591*	
BBS[c]*	0.776	BBS[c]*	0.769
Post-stroke duration	0.005	Post-stroke duration	0.001
Age	-0.009	Age	0.181
Sex	0.184	Sex	0.128
Affected side	0.069	Affected side	0.001

[a]Dynamic Gait Index, [b]Performance-Oriented Mobility Assessment, [c]Berg Balance Scale, *: $p<0.05$

sufficiently predictive variable for gait based on measurements made with the DGI and POMA. Shumway-Cook and Woollacott[10] suggested that functional measures such as mobility and balance are indicators of the end-product only. The multiple regression analyses performed in our study show that post-stroke duration, age, sex, and the affected side did not significantly affect the BBS predictions of the DGI and POMA. Gait requires balance abilities as well as other components such as the ability of the central nervous system to integrate sensation with mobile environments, and postural control is also necessary for walking. However, balance abilities should be not used to predict gait performance in the stroke population. A study by Harris et al.[21] examined the relationship between BBS and falls in 99 community-dwelling individuals with chronic stroke and found that performance on the BBS did not differ between those with high and low risks of falls. Some previous studies have also shown floor and ceiling effects in individuals following stroke, although another study indicated that BBS could always predict fall risk in stroke patients and that falls occurred during walking[22, 23]. The lack of a meaningful interpretation of a score indicating a specific function level has led to further investigations using Rasch analysis.

The POMA is a test that screens balance and gait over 2 sessions. The POMA evaluates steady-state balance while sitting and standing as well as proactive and reactive balance, and it has a sensory component. Our results reveal that the BBS score had a lower predictive ability for the POMA than the DGI, even though the POMA contains a balance component for assessing stroke persons. One possible reason for the lower predictive ability of BBS for the POMA scores is that POMA was developed for use among the elderly. The psychometric parameters in POMA involve screening risk factors for fall and fall-related impairments among the elderly rather than among individuals who have suffered a stroke and the risk factors for fall may differ between these populations. Individuals with stroke would generally have a higher risk of fall if they had motor and sensory function, deficits, spasticity, synergies, and depression, but the POMA is a direct measure of the risk of fall.

Outcome measures related to the walking abilities of stroke patients must combine measures of balance and walking to improve their sensitivity compared to measures that predict fall risk based on balance abilities alone. As discussed earlier, only the balance of the individuals who participated was assessed in relation to their walking abilities. Therefore, the results cannot be generalized to other measures of walking of stroke patients. In conclusion, the BBS score does not provide a strong prediction of the walking abilities of individuals with chronic hemiparetic stroke. Further studies should analyze the influence of balance on walking using other measurement tools for stroke populations.

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