

Correlation between the selective control assessment of lower extremity and pediatric balance scale scores in children with spastic cerebral palsy

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Abstract. [Purpose] The purpose of this study was to investigate the correlation between the Selective Control Assessment of Lower Extremity (SCALE) and Pediatric Balance Scales (PBS) in children with spastic cerebral palsy and further to test whether the SCALE is a valid tool to predict the PBS. [Subjects and Methods] A cross-sectional study was conducted to evaluate the SCALE and PBS in 23 children (9 females, 14 males, GMFCS level I–III) with spastic cerebral palsy. [Results] Both the SCALE and PBS scores for children with spastic hemiplegia were significantly higher than those for children with spastic diplegia. The scores for SCALE items were low for distal parts. The PBS items that were difficult for the participants to perform were items 8, 9, 10, and 14 with the highest difficulty experienced for item 8 followed by items 9, 10, and 14. The correlation coefficient (0.797) between the SCALE and PBS scores was statistically significant. The correlations between each SCALE item and the PBS scores were also statistically significant. SCALE items were significantly correlated with two PBS dimensions (standing and postural change). [Conclusion] In SCALE assessment, more severe deficits were observed in the distal parts. Standing and postural changes in the PBS method were difficult for the participants to perform. The two tests, that is, the SCALE and PBS, were highly correlated. Therefore, the SCALE is useful to prediction of PBS outcomes and is also applicable as a prognostic indicator for treatment planning.

Key words: Selective Control Assessment of Lower Extremity, Pediatric Balance Scales, Spastic cerebral palsy

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INTRODUCTION

It is known that children with cerebral palsy (CP) show neurodevelopmental disorders including spasticity, contracture, reduced coordination, selective voluntary motor control, and muscle weakness¹⁾. Even when spasticity and contractures are more apparent impairments, deficits in selective motor control can produce an increased negative effect on function^{2, 3)}. Selective voluntary motor control (SVMC) is the ability to isolate the activation of muscles in a selected pattern by voluntary movement or posture⁴⁾.

Evaluative tools widely used for the effects of physical therapy intervention for children with CP in clinics to date are the Gross Motor Function Measurement (GMFM), Timed Up and Go Test, Pediatric Balance Scale (PBS), Functional Independence Measure (WeeFIM), etc. Abnormal movement patterns occur in children with CP due to the absence or insufficiency of the ability to control coordination. However, the assessment of motor impairment is poorly considered,

even though it is the most important factor for determining motor function.

The Selective Control Assessment of the Lower Extremity (SCALE) was designed for clinical assessment of selective motor control. In the SCALE, participants are asked to perform specific isolated movements at each joint. The SCALE score for each limb is the sum of all the points given to each joint, up to a maximum of 10 points per limb. Significant inverse correlation (Spearman's $r = -0.83$, $p < 0.001$) between SCALE scores and Gross Motor Function Classification System (GMFCS) levels indicates construct validity for the SCALE. The SCALE also shows high interrater reliability, with intraclass correlation coefficients ranging from 0.88 to 0.91⁵⁾. The SCALE requires only minimal training and 10 to 15 minutes to perform. Therefore, it is applicable to participants with the ability to follow simple motor commands. It is not suitable for participants under 4 years of age or those with severe motor and intellectual impairments (e.g., GMFCS level V). It does not require any equipment⁵⁾.

SVMC at the ankle strongly predicts functional movement ability in children with CP and is used for determining candidates for selective posterior rhizotomy^{6, 7)}. Reduced selective motor control caused by flexor or extensor synergies interfering with isolated joint movement impairs functional movements such as gait and reaching⁸⁾. Impaired selective motor control usually occurs with muscle weakness, spasticity, and short muscle-tendon length. These motor deficits are

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Table 1. General characteristics of the participants

Spastic type	Number (gender)	Age (mean±SD)	GMFCS level
Hemiplegia	5 (2 males, 3 females)	8.00±1.58	I = 5 (100%) I = 8 (44.4%)
Diplegia	18 (12 males, 6 females)	9.67±2.32	II = 7 (38.9%) III = 3 (16.7%)
Total	23	9.30±2.26	

GMFCS: Gross Motor Function Classification System

associated with injury to the corticospinal tract (CST) and other descending tracts and the subsequent loss of descending signals. Therefore, the SCALE is a typical assessment tool for measuring motor impairment⁸).

The PBS was developed by modifying the Berg Balance Scale (BBS) to apply to children with CP who have impaired balance ability to respond to postural stability and external changes. The PBS has been further developed as a balance measure to be used for children with mild or severe motor deficits. It has been reported that the modified PBS shows both high intrarater and interrater reliabilities (intraclass correlation coefficient = 0.998 and interrater correlation coefficient = 0.997)⁹).

It is necessary to develop a method with high reliability and validity for proper evaluation. Therefore, the purpose of this study was to investigate the correlation between the SCALE (especially measuring the degree of motor impairment in the lower extremity) and PBS (measuring functional balance) and thus further examine whether the SCALE is a valid tool to predict the PBS score.

SUBJECTS AND METHODS

The subjects of this study were 23 children with CP treated in local clinics in South Korea. The inclusion criteria were diagnosis of spastic CP, the ability to independently maintain a standing position for at least four seconds, level I to III according to the GMFCS, and the ability to understand and follow verbal commands. Before conducting this study, consent forms that described the purpose and detailed procedures of the study, were provided to the participants and their legal guardians. All participants signed the informed consent forms, which were approved by the Institutional Review Board of Dankook University, prior to participation in this study. Following evaluation, scores were given by one pediatric physical therapist with 12 years of experience. The PBS was performed 5 minutes after the SCALE test. The SCALE and PBS were performed in triplicate, and the highest scores were chosen to be analyzed further.

The SCALE tool was used to bilaterally assess the movements of hip, knee, ankle, subtalar, and toe joints within 15 minutes without specialized equipment. Evaluations were performed in the sitting position, except for hip flexion, which was tested in the side-lying position for proper joint excursion. For each joint, the participants were asked to perform the task by passively moving their limbs through the desired movement sequence using a three-second verbal count.

The SCALE was graded at each joint as “normal” (2 points), “impaired” (1 points), or “unable” (0 points). A grade of “normal” was given when the participant completed the desired movement sequence within the verbal count without movement of untested ipsilateral or contralateral lower extremity joints. A grade of “impaired” was given when the participant isolated the motion during the task but showed any of the following errors: only one directional movement, less than 50% of movement achieved, movement of a non-tested joint (including mirror movements), or the time exceeding a three-second verbal count. A grade of “unable” was given when the participant showed no initiation of the requested movement or when the participant performed a synergistic mass flexor or extensor pattern.

The PBS is a standard tool to measure standing balance and is used to evaluate functional balance for children with CP having mild to severe motor impairment. It takes around 15 minutes to perform without any specialized equipment. It is composed of a total of 14 items in 3 dimensions, including sitting, standing, and postural change. A score from 0 to 4 points was given to each item, with a higher score representing a better balance ability.

Means and standard deviations of age, gender, and SCALE and PBS scores were obtained. An independent t-test was used to determine the differences between PBS and SCALE total scores in the subjects with spastic hemiplegia and spastic diplegia. Spearman's rank correlation coefficients were calculated to estimate the correlation between each SCALE item and the PBS total score, and that between each SCALE item and PBS dimension. The significance level was set to $\alpha=0.05$. PASW Statistics (version 18.0) was used for statistical analysis.

RESULTS

Twenty-three children (6 to 15 years old) diagnosed with spastic CP were selected for this study. This included 5 children with spastic hemiplegia (2 males and 3 females) and 18 children with spastic diplegia (12 males and 6 females). The average age was 9.30±2.26. The general characteristics of the participants are shown in Table 1.

The average total scores of the SCALE and PBS in the children with spastic hemiplegia type were 15.00±1.58 and 53.80±1.10, respectively. In the children with spastic diplegia, the average SCALE and PBS total scores were 9.94±6.13 and 45.67±8.90, respectively. The scores obtained from the children with spastic hemiplegia were higher than those from the children with spastic diplegia, and the differ-

Table 2. SCALE and PBS total scores

Assessments	Spastic type	
	Hemiplegia (n=5)	Diplegia (n=18)
SCALE	15.0±1.58	9.9±6.13*
PBS	53.8±1.10	45.7±8.90*

*p<0.01.

SCALE: Selective Control Assessment of the Lower Extremity; PBS: Pediatric Balance Scale

Table 4. Correlation between SCALE and PBS assessments

	SCALE item					
	Total	Hip	Knee	Ankle	Subtalar	Toe
PBS	0.797*	0.672*	0.795**	0.790**	0.747**	0.626**

*p<0.05; **p<0.01

ences were statistically significant ($p<0.05$) (Table 2).

The numbers of points obtained from each SCALE item were highest for the knee and lowest for the subtalar joint. The numbers of points obtained from each PBS item were lowest for PBS item 8 (Table 3). Low numbers of points for PBS items (PBS 8, 9, 10, and 14) indicated that these items were difficult for participants to perform.

The correlation coefficient between the SCALE and PBS scores was 0.797 and found to be statistically significant ($p<0.05$). When examining the correlation between each SCALE item and PBS scores, all SCALE items were significantly correlated with the PBS (most items, $p<0.01$; hip joint item, $p<0.05$). The correlation coefficients between each SCALE item and the PBS were 0.672, 0.795, 0.790, 0.747, and 0.626, respectively (Table 4). When comparing SCALE items with PBS dimensions, all SCALE items were significantly correlated with two PBS dimensions (standing and postural change) ($p<0.01$) (Table 5).

DISCUSSION

Children with CP show various muscle recruitment patterns and magnitudes when compared with normal children. These differences can affect voluntary muscle recruitment, leading to impairments in motor ability. Tedroff et al. reported that during maximal voluntary contractions, children with spastic CP showed activation of muscles other than the intended muscles, particularly when the intended muscles were located at a more distal part¹⁰. In addition, children with spastic CP show 52% or less maximum contractile force in the main lower extremity muscles in ankle dorsiflexion and plantar flexion compared with the same-aged normally developing children¹¹. It has also been reported that SVMC impairment of distal joints of the lower limb was increased¹². These results indicate decreased ability to perform joint movements isolated from the distal part of the limb. As individuals with impaired SVMC lack normal interjoint coordination¹³, children with good SVMC are more capable of moving out of synergy during the swing phase of gait¹⁴. Therefore, this study was conducted to examine the correlation between the newly developed SCALE and

Table 3. Average scores of the SCALE and PBS items

SCALE items (score)				
Hip	Knee	Ankle	Subtalar	Toe
(2.6)	(3.1)	(2.0)	(1.6)	(1.7)
PBS items (score)				
1	2	3	4	5
(3.8)	(3.8)	(3.9)	(4.0)	(4.0)
6	7	8	9	10
(3.9)	(3.8)	(2.0)	(2.2)	(3.0)
11	12	13	14	
(3.2)	(3.8)	(3.0)	(3.0)	

Table 5. Comparison of SCALE items and PBS dimensions

SCALE item	PBS dimension	
	Standing	Postural change
Hip	0.676**	0.570**
Knee	0.788**	0.733**
Ankle	0.778**	0.707**
Subtalar	0.754**	0.629**
Toe	0.619**	0.563**

**p<0.01

the well-established PBS methods and to test whether the SCALE is useful as a tool to predict PBS outcome.

In the present study, the SCALE and PBS scores obtained from the spastic hemiplegia group were 5.06 (15.00±1.58 versus 9.94±6.13) and 8.13 (53.80±1.10 versus 45.67±8.90) points higher than those from the spastic diplegia group, respectively. These results agree with a report indicating that the PBS can be used to predict the GMFCS level, due to the presence of differences between the PBS total score and GMFCS level. The main reason for the difference in total PBS between GMFCS levels I and II is that individuals assigned to level I are capable of performing more complex motor tasks such as running and jumping, maintaining balance when standing without support, and walking long distances¹⁵. The children in the spastic hemiplegia group were assigned to GMFCS level I, indicating that they were more capable of following verbal commands and performing tasks. Therefore, it is assumed that the SCALE and PBS scores obtained from the spastic hemiplegia group were higher than those from the spastic diplegia group in this study.

When ranked by SCALE items scores in order from highest to lowest, the knee joint was the highest, followed by the hip, ankle, toe, and subtalar joint. It was difficult for participants to perform PBS dimension tasks, with the highest difficulty experienced for item 8, followed by items 9, 10, and 14. It has been reported that SVMC impairments are more severe in the distal part of the limb than in the proximal part¹². Similar results were shown in this study except with the knee and subtalar joints. Fowler et al.¹² reported that one participant (15 years old) with spastic diplegia (GMFCS level I) had a subtalar score of 2 and an ankle joint score of 1,

owing to a restricted range of motion. Therefore, it is likely that because the average age of the participants in this study was 9.3 years, contracture developed.

The most frequent exceptions for proximal to distal concordance occurred when the toes were graded as 1 and the subtalar joint was graded as 0, indicating absence of subtalar SVMC with sparing at the toes¹⁶. Similar exceptions were observed in the present study. These exceptions could be explained by the fact that the origin of the muscles controlling the ankle, subtalar joint, and toes are similar, although the insertions of the toe musculature are more distal. In addition, eversion was described as a challenging movement in adults after stroke, and it is an indicator of the highest level of recovery for the lower extremity¹⁶. Furthermore, isolated movement of the subtalar joint was very difficult for children with CP to understand and perform¹².

In a previous study, the SCALE hip test was performed for participants with spastic CP showing crouch gait in an antigravity side-lying position¹⁷. In this position, it was difficult for the participants to raise their hip joints due to muscle weakness, and thus they had limitations of hip extension because of hamstring shortness. Therefore, this is likely why higher scores were observed for the knee joint than the hip joint in the SCALE test in this study.

It has been reported that performance of PBS tasks involving items 7, 8, 9, 10, 11, and 13 reveals significant differences between individuals assigned to GMFCS levels I and II¹⁵. Similar results were observed in this study; that is, the standing test in PBS items 8, 9, 10, and 14 was the hardest task for the participants to perform. It is assumed that the lowest score, which was found for item 8 (standing with one foot in front), was the result of absence of postural stability for maintaining balance due to a narrow base of support.

The correlation coefficient between the SCALE and PBS scores was 0.797. All SCALE items were significantly correlated with the PBS (most items, $p < 0.01$; hip joint item, $p < 0.05$). Total SCALE scores were very useful for explaining the overall functional capacity of the participants. There are many previous reports showing that PBS assessment for children with CP was capable of predicting the GMFCS level, and the correlations between the total PBS score and GMFM and those between muscle strength and GMFM were significantly higher^{15, 18–22}. Most of the participants in this study were assigned to GMFCS levels I and II (~83.0%) indicating high correlation between the SCALE and PBS tests.

All SCALE items were significantly correlated with two PBS dimensions (standing and postural change). The ability to perform SVMC is dependent on the capability to perform the movements of hip and knee joints uncoupled during the swing period. Therefore, it is assumed that improvement of the SCALE score increases gross motor function but decreases the synergistic pattern and thus improves PBS. To examine the correlation between SCALE and PBS dimensions, the present study included only subjects who had the ability to stand for at least 4 seconds and a GMFCS level of I to III. Therefore, there were limitations regarding the number of subjects and exclusion of severely disabled children.

The present study was conducted to investigate the correlation between the SCALE (especially measuring the

degree of motor impairment in the lower extremity) and PBS (measuring functional balance), and to examine if the SCALE is a valid tool for predicting the PBS. In SCALE assessment, impairments of distal parts were more severe than those of proximal parts. Standing and postural changes were more difficult to perform in the PBS test. High correlations between the SCALE and PBS were observed. Based on these results, it is likely that the SCALE is a useful tool to predict PBS outcome.

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