



Original Article

Correlation between the gross motor performance measurement and pediatric balance scale with respect to movement disorder in children with cerebral palsy

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Abstract. [Purpose] To determine whether the Gross Motor Performance Measurement is useful in predicting the future score of the Pediatric Balance Scale, this study examined the correlation between the 2 measurement tools with respect to movement disorder in children with cerebral palsy. [Subjects and Methods] A total of 38 study subjects with cerebral palsy were divided into 3 groups (spastic, dyskinetic, and ataxic) by means of systematic proportional stratified sampling in accordance with the characteristics of their movement disorders. [Results] The spastic Pediatric Balance Scale had an intermediate level of positive correlation with dissociated movement ($r=0.411$), alignment ($r=0.518$), and weight shift ($r=0.461$). The dyskinetic Pediatric Balance Scale had a strong positive correlation with dissociated movement ($r=0.905$), coordination ($r=0.882$), alignment ($r=0.930$), and stability ($r=0.924$). The ataxic Pediatric Balance Scale had an intermediate level of positive correlation with the overall Gross Motor Performance Measurement ($r=0.636$), and a strong positive correlation with dissociated movement ($r=0.866$), coordination ($r=0.871$) and stability ($r=0.984$). [Conclusion] Gross Motor Performance Measurement is important in evaluating the quality of movement, and can be considered an excellent supplementary tool in predicting functional balance.

Key words: Cerebral palsy, Gross Motor Performance Measurement, Pediatric Balance Scale

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INTRODUCTION

The International Cerebral Palsy Workshop defined cerebral palsy as a clinical syndrome in which non-progressive disturbances occurring in the brain of the fetus or infant induce activity limitations by causing a permanent disorder in the development of movement and posture¹⁾. Clinicians and researchers categorize cerebral palsy into spastic (60–70%), dyskinetic or athetoid (20–30%), and ataxic types (5–10%), in accordance with the muscle tone and format of the movement disorder (predominant abnormality) arising from brain damage²⁾. Since children with cerebral palsy have diverse reflex, muscle tone, and movement patterns³⁾, there is need for the evaluation of the quality of motor activities and method of executing these activities. The Gross Motor Performance Measurement (GMPM) is a tool capable of evaluating not only functional movement but also qualitative conditions or characteristic changes in gross motor performance over time in children with cerebral palsy⁴⁾.

Since the motor disorder of cerebral palsy frequently presents along with poor balance control, and is unable to solve

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the conflict between the senses, there may be difficulty in maintaining balance in erect body posture⁵). Issues with balance associated with cerebral palsy will impair motor function, mobility, activities of daily living, and participation later in life, and eventually increase the probability and occurrence of falls⁶). Therefore, clinicians must be able to predict the ability of children with cerebral palsy to execute safe and independent functions under a diverse range of conditions through valid and reliable measurements⁷). The Pediatric Balance Scale (PBS)⁸), a modification of the Berg Balance Scale (BBS), is reportedly useful in evaluating the balancing ability of children with cerebral palsy⁶) and school children with mild to moderate motor impairments⁹).

Kembhavi et al.¹⁰) asserted that the BBS is a more precise measurement tool than the GMPM in classifying function in mild cerebral palsy, while Duarte et al.¹¹) claimed that although PBS is an excellent supplementary tool in assessing the functional performance of motility in cerebral palsy, it is not able to predict function. In addition, prior research reported a statistically significant correlation ($r=0.7$) between the Gross Motor Function Measure (GMFM)-88 and PBS in Down's syndrome children¹²); a high correlation between the PBS and GMFM (domains D and E: overall score of GMFM-88 and GMFM-66) was also reported in children with spastic cerebral palsy who were capable of walking¹³). Moreover, a high correlation was noted in the overall scores of PBS and GMFM for walking velocity and a 10-second standing up from seated posture test⁶).

Therefore, this study aimed to confirm the correlation between the GMPM and PBS as related to the nature of the movement disorder in children with cerebral palsy, and to determine whether GMPM is a useful tool in predicting the future score of the PBS. This study was also performed to provide basic clinical data for use by pediatric physiotherapists, and to determine which qualitative domains of the GMPM should be emphasized to improve functional balance ability in children with cerebral palsy, based on the nature of their movement disorders.

SUBJECTS AND METHODS

This study investigated the correlation between the GMPM and PBS in 40 children with cerebral palsy. The subjects were divided into 3 groups (spastic, dyskinetic, and ataxic) by means of systematic proportional stratified sampling in accordance with the nature of their movement disorders. Children aged 3–12 who were diagnosed with cerebral palsy by a specialist in rehabilitative medicine/neurosurgery, who were at level II–III of the Gross Motor Function Classification Scale (GMFCs), and who were capable of communicating with the researcher and following directions to perform the assigned tasks, were selected as the subjects of the study. The purposes and methods of the research as well as any risks and inconveniences were described to the subjects and their guardians (legal representatives), and written agreement to voluntary participation was obtained. Approval of the Bio-ethics Deliberation Committee of the Dong-Eui University was given in advance for this study (IRB No. DIRB-201510-HR-R-030).

Within 1 hour and with minimal tools, the GMPM is able to measure the developmental stage over time, as well as additional skills and coordination, in children with cerebral palsy aged 5 months–12 years⁴). This evaluation is composed of 20 items selected for the GMPM (3 static movements and 17 dynamic movements), and includes a minimum of 3 domain characteristics among the 5 elements of alignment, stability, coordination, weight shift, and dissociated movement. Scores in the range of 1 point (severely abnormal) to 5 points (consistently normal) are allocated to each of the items. For the scores in each of the domains, percentage (%) of maximum possible score was computed on the basis of the relative number of items executed¹⁴). The GMPM displayed very high inter-rater, intra-rater, and test-retest reliabilities^{3, 15}), and was reported to be a useful measurement tool with validity coefficients in the range of 0.74–0.84 for children with cerebral palsy⁴). The PBS¹⁶), which was developed to measure balance in children with brain lesions and developmental disorders, is composed of 14 items in 3 domains of sitting, standing, and posture change, and is capable of measuring functional balance within 20 minutes under everyday task situations without the need for specialized equipment⁸). Scores in the range of 0–4 points are allocated to each of the items in accordance with the extent of independent execution, with the best among 3 scores from repetition of each item 3 times being chosen. If the subject receives the highest possible score of 4 points in the first trial, no further assessment is made. Total score is computed after having allocated scores in accordance with the duration of measurement, distance, supervision, and extent of the request for assistance. In children with motor impairments, the PBS is a useful measurement tool with inter-tester reliability of 0.997 and test-retest reliability of 0.998⁹).

Children with cerebral palsy participated in the study wearing garments that allowed ease of movement and in bare feet. Moreover, the guardian (legal representative) of the research subject was always present during the entire evaluation procedure. Evaluation of the measurement tool was executed by a pediatric physiotherapist with more than 10 years of clinical experience, who was fully familiarized with the evaluation method and score computation guidelines after having received specialized training in neurodevelopmental treatment. First, the evaluator confirmed that the state of health of the children was good, and allowed the children to practice after explanation of the items in the 2 measurement tools by personal demonstration. The order in which the measurement tools were applied was decided randomly by drawing a note with the name of the tool from a box. The evaluation of the second measurement tool was made at an interval of 15 minutes to enable the subjects to recover from any fatigue caused by the first evaluation¹³).

The data were analyzed statistically by using SPSS 22.0 (IBM Corp, USA) for Windows with a level of significance set at 0.05. Technical statistics were computed for the general characteristics of the research subjects, with the normality of the

measurement variables confirmed through the Kolmogorov-Smirnov test. In order to compare the GMPM and PBS as related to the nature of the movement disorder, one-way analysis of variance was performed, with Bonferroni post hoc analysis. Pearson's correlation coefficient was used to examine the correlation between GMPM and PBS, including the domains of alignment, stability, coordination, weight shift, and dissociated movement for each of the groups.

RESULTS

Two subjects dropped out for personal reasons, and a total of 38 subjects participated in the study; their general characteristics are shown in Table 1. Although there was no significant difference for the domains of dissociated movement, coordination, and weight shift among the spastic, dyskinetic, and ataxic groups, there were statistically significant differences in the overall GMPM and PBS, including the domains of alignment and stability; the results of the post hoc test are shown in Table 2. The results of the correlation analysis between the GMPM and PBS as related to the nature of the movement disorder are shown in Table 3. Spastic PBS had an intermediate level of positive correlation with dissociated movement ($r=0.411$), alignment ($r=0.518$), and weight shift ($r=0.461$). Dyskinetic PBS had a strong positive correlation with dissociated movement ($r=0.905$), coordination ($r=0.882$), alignment ($r=0.930$), and stability ($r=0.924$). Ataxic PBS had an intermediate level of positive correlation with overall GMPM ($r=0.636$), and a strong positive correlation with dissociated movement ($r=0.866$), coordination ($r=0.871$) and stability ($r=0.984$).

Table 1. Characteristics of the subjects (mean \pm SD)

	Spastic (n=27)	Dyskinetic (n=6)	Ataxic (n=5)
Gender (male/female)	13/14	3/2	2/4
Age (years)	6.63 \pm 3.34	5.60 \pm 1.52	6.17 \pm 2.79
Height (cm)	111.34 \pm 17.89	108.05 \pm 15.47	104.41 \pm 16.57
Weight (kg)	21.24 \pm 8.46	17.20 \pm 1.58	17.59 \pm 7.22
Pregnancy week (weeks)	33.81 \pm 3.69	36.20 \pm 4.38	34.33 \pm 5.57
Birth weight (g)	2,231.85 \pm 662.83	2,768 \pm 685.87	2,590.00 \pm 273.43
Incubator care (weeks)	5.81 \pm 4.07	6.20 \pm 7.01	14.17 \pm 20.33

Table 2. Comparison of GMPM and PBS in the different groups (mean \pm SD) (unit: scores)

Variances	Spastic	Dyskinetic	Ataxic
Dissociated movement	51.08 \pm 12.50	36.06 \pm 11.22	47.32 \pm 12.14
Coordination	55.10 \pm 11.46	44.14 \pm 7.21	45.76 \pm 3.71
Alignment**	61.77 \pm 11.62 ^b	35.58 \pm 2.54 ^a	51.30 \pm 2.73 ^b
Weight shift	51.26 \pm 12.96	46.70 \pm 17.96	48.85 \pm 9.12
Stability**	65.83 \pm 14.89 ^b	41.41 \pm 14.30 ^a	40.98 \pm 8.06 ^a
Total GMPM**	59.33 \pm 11.22 ^b	39.41 \pm 8.33 ^a	50.76 \pm 2.97 ^{ab}
PBS**	29.33 \pm 10.04 ^b	6.80 \pm 2.77 ^a	17.00 \pm 6.03 ^a

* $p < 0.05$, ** $p < 0.01$

^aStatistically no significant difference between the a, but statistically significant difference the b ($p < 0.05$).

^bStatistically no significant difference between the b, but statistically significant difference the a ($p < 0.05$).

Table 3. Correlation of GMPM and PBS (mean \pm SD)

GMPM domains	Spastic PBS	Dyskinetic PBS	Ataxic PBS
Dissociated movement	0.411*	0.905**	0.866**
Coordination	0.331	0.882**	0.871**
Alignment	0.518*	0.930**	0.383
Weight shift	0.461*	0.222	0.253
Stability	0.105	0.924**	0.984**
Total GMPM	0.334	0.228	0.636*

* $p < 0.05$, ** $p < 0.01$

DISCUSSION

Although “function,” which is the ability to accomplish a specific motor activity, is not necessarily associated with the quality of motor control, “performance” signifies the quality of motor activities or the extent to which a child is able to execute accurate activities¹⁷⁾. Since children with cerebral palsy have impairments not only in the accomplishment of work but also in the quality of movement¹⁸⁾, functional balancing ability is very important to safely and independently execute routine tasks at home, school, and in the community¹²⁾.

In spastic cerebral palsy¹⁹⁾, muscle tone (resistance against stretch) increases according to movement in a velocity-dependent manner; flexion or extension synergy due to spasticity for activities limits selective dissociated movements during muscle activation in voluntary posture or movement²⁰⁾. In addition, insufficient strength due to abnormal stretching of the skeletal muscle²¹⁾ generates compensatory actions in other parts of the body as a result of excessive effort. Accordingly, shortening of the length of the muscle-ligament, and contracture and deformity of the spine and limbs, occur due to repetition of abnormally restricted movement, thereby resulting in poor alignment of the body and restrictions in weight shifting ability.

In the dyskinetic type, velocity is irrelevant with resistance during passive and active movement²²⁾. This type is divided into two types as; dystonia is that sluggish motion with twisting single leg and arm, or entire body²³⁾, athetoid is known as involuntary movement occurs irregularly in the limbs or facial muscles with slow and fidgeting motion²⁴⁾. Accordingly, execution of dissociated movement becomes difficult due to loss of the ability to control between co-activation and reciprocal innervation of particular muscle groups, arising from fluctuation and spasticity of muscle tone; thus, grading control in continuous movement becomes impossible. Abnormal control^{22–24)}, rhythmic movement^{22, 23)}, and tremor or suddenly altered finger movements^{23, 25)} make coordination of the patterns of muscle activities difficult, as related to time, direction, and space. In addition, insufficient co-contraction and involuntary movements induce instability and poor alignment of the body, since they make adjustment of the head and visual fixation difficult.

In the ataxic type, there is low or normal muscle tone, with muscle weakness, incoordination, and intention tremor, accompanied by walking with a wide base of support due to swaying^{22, 24)}. Since the muscle tone is low, it is difficult to maintain a fixed posture due to insufficient co-contraction of the trunk; as a result, instability of moving body parts occurs. An immature mass pattern generated due to the lack of stability and swaying of the trunk makes dissociated and grading movement difficult, due to loss of the ability to control between reciprocal innervations. In addition, movement by abnormal force, and loss of rhythm and ordered, accurately executed muscle coordination²⁶⁾ make the direction of movement large and incomplete, and induce difficulties in executing harmonious movements because of problems in the control of velocity and timing.

Accordingly, in children with cerebral palsy, functional activities such as stretching or walking may be impaired, since the differences in motor performance as related to the characteristics of the movement disorder exert an influence on balance control ability for the maintenance of stability. It has been stated that it is not only possible to reduce effort and improve functional abilities and stability, but also to prevent secondary problems in the muscles and joints; this would be accomplished by improving the quality of movement, such as the promotion of higher velocity, improvement of stability, and coordinated movement, since children with cerebral palsy not only have problems accomplishing work but also show impairment in the quality of their movements¹⁸⁾.

Therefore, GMPM is important in evaluating the quality of movement, and can be considered an excellent supplementary tool in predicting functional balance. If pediatric physiotherapists provide interventions based on the correlation between the 2 measurement tools shown in this study, children with cerebral palsy might show added improvement in functional balancing ability. However, GMPM cannot be used as an independent method since it is not able to examine execution domains such as velocity, effort, and efficiency of movement, and does not specifically suggest the causes of the functional insufficiency of motor control.

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