

Relationship between the Gross Motor Function Classification System and Functional Outcomes in Children with Cerebral Palsy

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Abstract

Background/Objectives: The purpose of this study was to investigate the relationship between the Gross Motor Function Classification System (GMFCS) levels and functional outcomes in children with Cerebral Palsy (CP). **Methods/Statistical analysis:** 217 children with CP were took part in this study. To collect the data, the GMFCS, the Pediatric Evaluation of Disability Inventory (PEDI) self-care and mobility scaled scales and the Gross Motor Function Measure (GMFM) were employed. The Spearman correlation coefficient was calculated to evaluate the relationship between GMFCS levels and functional outcomes and Receiver Operating Characteristic Curve (ROC) was used to investigate the cut-off values for functional outcomes by GMFCS levels. **Results:** The mean age was 9.86 years. Spastic, dyskinetic, hypotonic, and ataxic CP were noted in 71.9%, 12.0%, 8.8%, and 7.36% of the cases, respectively. The proportions of children at each GMFCS level, from level I to V were 15.2%, 13.4%, 11.1%, 14.3%, and 46.1%, respectively. The significant correlation of the GMFCS level with the GMFM total score and PEDI self-care and mobility scaled scores were detected ($p < 0.001$). The GMFM total scores and scaled scores of self-care and mobility domain in PEDI showed significant differences according to the GMFCS levels in analyzing one-way analysis of variance ($p < 0.05$). The cut-off values for the GMFM and scores of self-care and mobility domain in PEDI for GMFCS level I were 81.48, 53.48, and 75.43, respectively; for GMFCS level IV, the cut-off values were 40.92, 34.94, and 33.05, respectively. **Conclusion/Application:** Understanding of the relationship between GMFCS level and functional outcomes, especially cut-off points according to the GMFCS levels is useful for making inference of the functional outcomes of children with CP in the clinical setting.

Keywords: Cut-Off Point, Gross Motor Function Classification System, Gross Motor Function Measure, Pediatric Evaluation of Disability Inventory

1. Introduction

Children with Cerebral Palsy (CP) have motor impairments, which include decreased strength, increased spasticity, limited range of motion, and abnormal posture¹. These impairments lead to difficulties in carrying out gross motor movements and Activities of Daily Living (ADL)². Several cerebral palsy classification systems that are based on the characteristics of CP have been used. Traditionally, a system that classifies the patient according to the type, severity of paralysis, and the distribution of impairment is employed³; however, this type of a system does not reflect the functional characteristics of a child with CP⁴.

With the development of the International Classification of Functioning, Disability and Health (ICF), the focus of many studies shifted to function (participation in daily activities) rather than motor impairments in terms of body structure and function⁵. Functional classifications such as the Gross Motor Function Classification System (GMFCS)³, Manual Ability Classification System⁶ and Communication Function Classification System⁷ have been used for collecting data of children with CP. These systems are applied for functional classification of the gross motor, manual, and communication abilities in children with CP. Moreover, these classification systems enhance interaction related to CP among team members. Among these systems,

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the GMFCS, which describes mobility-related activities in terms of self-initiated movement, is widely used in clinical settings⁸. The Gross Motor Function Measure (GMFM) and Pediatric Evaluation of Disability Inventory (PEDI) are representative instruments that are often used in clinical settings for measuring baseline functional outcomes and the changes of intervention results in children with CP^{4,9,10}.

The relationship between the GMFCS and functional outcomes, according to previous studies was significant. Gunel et al.¹¹ found a significant correlation ($r_s = -.846$) between the GMFCS and ADL measured by WeeFIM. Palisano et al.¹² reported that the variation of maximum GMFM scores is explained the GMFCS level up to 83%. Although the relationships between the GMFCS and functional outcomes, including gross motor movements and ADL have been identified in previous studies through analyzing correlation or regression, the functional outcome consequences for each GMFCS level have not been provided.

As mentioned, the GMFCS level is widely used in the clinical setting and this classification is designed to improve understanding of parents. For that reason, clinicians need to have a good understanding of the GMFCS and should use when communicating with other professionals and parents. However, the information available on whether clinicians are capable of estimating the functional status at each GMFCS level is scarce. In this study, we aimed to confirm the relationship between the GMFCS and functional outcomes and examine the cut-off values for the GMFM and PEDI functional skill scores according to the GMFCS level.

2. Methodology

2.1 Participants

In total, 217 children with CP (121 boys and 96 girls; age range 3–17 years), who were receiving services at 5 rehabilitation centers, were included in this cross-sectional study (Table 1). Among these, the proportion of children with spastic, dyskinetic, hypotonic, and ataxic CP were 71.9%, 12.0%, 8.8%, and 7.3%, respectively. The number of children classified as GMFCS level I, II, III, IV, and V were 33 (15.2%), 29 (13.4%), 24 (11.1%), 31 (14.3%), and 100 (46.1%), respectively. The parents of all children filled in informed consent for participation in this study. This study was approved by the Ethics Committee of Ulsan College.

2.2 Instruments

The GMFCS, which was applied to classify the participants' gross motor function level, consists of five ordinal levels of gross motor function based on self-initiated movement in the clinical setting. Children at GMFCS level I are capable of walking without any limitations, while those at level V have severe limitations of body control and need assisted technology and physical assistance for ADL. The children should have to learn how to operate a power wheelchair for self-mobility¹³. The criterion for distinguishing abilities of motor function according to different levels is the degree of functional limitations, and the need for assistive technology, mobility devices, and wheeled mobility. High reliability and stability of the GMFCS have been reported in previous studies¹⁴.

The GMFM, as a criterion-referenced assessment, was administered to quantitatively measure gross motor function. The GMFM consists of 88 items related to gross motor tasks clustered into five dimensions: lying and rolling (17 items); sitting (20 items); crawling and kneeling (14 items); standing (13 items); and walking, running, and jumping (24 items). Items are scored ordinal scale (scale from 0–3). Scores for each dimension are expressed as a percentage of the maximum possible score for that dimension. A total score is obtained by adding the scores

Table 1. Characteristics of 217 children with CP

Category		Frequency (%)
Gender	Male	121 (55.8)
	Female	96 (44.2)
Type	Spastic	156 (71.9)
	Dyskinetic	26 (12.0)
	Hypotonic	19 (8.8)
	Ataxic	16 (7.3)
GMFCS	I	33 (15.2)
	II	29 (13.4)
	III	24 (11.1)
	IV	31 (14.3)
	V	100 (46.1)
Age (years)		9.86±4.71*
Height (cm)		121.89±30.87
Weight (kg)		29.48±15.43

*Mean±SD. GMFCS, Gross Motor Function Classification System.

for all dimensions and dividing by five, and the total score can be in the range of 0–100. GMFM scores have high reliability and validity^{15,16}. This study used the Korean version of the GMFM to measure gross motor abilities¹⁷.

The PEDI measures children's functional performance in the self-care, mobility, and social function domains. This study administered the Korean version of the PEDI to measure self-care and mobility through parent interviews¹⁸. Although The PEDI includes three measurement scales (functional skills, caregiver assistance, and modification), we measured functional skills only. This study used scaled scores indicating of the children's functional skills on a continuum of 0–100. High scaled score represents a high level of functional performance in a particular domain. Typically, when developing children are 4–6 years old, scaled scores of mobility and self-care domain reach 100 points⁴. The PEDI has demonstrated high reliability and validity¹⁹. Berg et al.²⁰ recommended scaled scores to measure functional performance and evaluate changes. In this study, the GMFCS, GMFM and PEDI were assessed by therapists with at least 3 years of experience with pediatric therapy.

2.3 Statistical Analysis

The inferential statistics methods such as one-way analysis of variance and the Scheffé test were employed to identify the statistical differences in total GMFM scores and scaled scores of self-care and mobility in PEDI according to the GMFCS levels. The Spearman correlation coefficient was used to assess the relationship between GMFCS levels and GMFM total and PEDI self-care and mobility scaled scores. P values of <0.05 were considered statistically significant. The Receiver Operating Characteristic curve (ROC) was used to investigate the cut-off values for the GMFM total and scaled scores of self-care and mobility in PEDI at the different GMFCS levels.

3. Findings

3.1 GMFM Total Scores and Scaled Scores of Self-care and Mobility in PEDI by the GMFCS Levels

Table 2 shows the differences in mean GMFM total and scaled scores of self-care and mobility in PEDI according to the GMFCS levels. For GMFCS level I, the mean GMFM score was 92.65 and the PEDI self-care and mobility skill scores were 77.54 and 89.27, respectively. For GMFCS level V, the mean GMFM score was 22.48 and the PEDI

self-care and mobility skill scores were 20.62 and 12.83, respectively.

The mean GMFM total and scaled scores of self-care and mobility in PEDI differed significantly based on the GMFCS level ($p < 0.001$). Post-hoc testing revealed that the GMFM total and scaled scores of mobility in PEDI were significantly different among all GMFCS levels except for levels I and II ($p < 0.05$), while the scaled scores of self-care in PEDI were significantly different among all GMFCS levels except for levels I and II, II and III, and II and IV ($p < 0.05$).

3.2 Correlation between GMFCS Level and GMFM Total Score and PEDI Scaled Scores

Table 3 describes the Spearman correlation coefficients for the correlations between GMFCS levels and GMFM total score and PEDI self-care and mobility scaled scores. The GMFCS level was strongly associated with the GMFM total score and PEDI self-care and mobility scaled scores. The correlation coefficients were -0.882 , -0.691 , and -0.826 , respectively ($p < 0.001$).

3.3 Cut-off Values for GMFM and PEDI Scaled Scores by GMFCS Level using ROC

Table 4 and Figure 1 show the cut-off values for the GMFM total scores and scaled scores of self-care and

Table 2. Differences in the mean GMFM and PEDI scores by GMFCS levels

GMFCS level	GMFM Total Score (%)	PEDI scaled score	
		Self-care	Mobility
I	92.65±8.97 ³⁻⁵	77.54±12.64 ³⁻⁵	89.27±13.35 ³⁻⁵
II	81.88±18.30 ³⁻⁵	61.26±23.85 ⁵	79.49±21.91 ³⁻⁵
III	65.60±18.36 ^{1,4,5}	55.14±27.39 ^{1,4,5}	53.81±26.55 ^{1,4,5}
IV	44.28±21.88 ^{1-3,5}	48.69±29.96 ^{1,3,5}	34.99±21.94 ^{1-3,5}
V	22.48±19.36 ¹⁻⁴	20.62±20.35 ¹⁻⁴	12.83±15.96 ¹⁻⁴
p value	<0.001	<0.001	<0.001

GMFCS, Gross Motor Function Classification System.

GMFM, Gross Motor Function Measure.

PEDI, Pediatric Evaluation of Disability Inventory.

1: Significantly Different Compared With GMFCS level I, 2: significantly different compared with GMFCS level II, 3: significantly different compared with GMFCS level III, 4: significantly different compared with GMFCS level IV and 5: significantly different compared with GMFCS level V.

Table 3. Correlation between GMFM score and PEDI scaled scores

Category	GMFM total score	PEDI scaled scores	
		Self-care	Mobility
GMFCS levels	-0.882*	-0.691*	-0.826*

*p < 0.001. GMFCS, Gross Motor Function Classification System. GMFM, Gross Motor Function Measure. PEDI, Pediatric Evaluation of Disability Inventory

mobility in PEDI at the different GMFCS levels. For GMFCS level I, the cut-off value for the GMFM score was 81.48, and those for the PEDI self-care and mobility scaled scores were 55.48 and 75.43, respectively. For GMFCS level IV, the cut-off value for the GMFM score was 40.92, and those for the scaled scores of self-care and mobility in PEDI were 34.94 and 33.05, respectively. Overall, the sensitivity and specificity were in the range of 0.72–1.00. All of the area under the ROC curve (AUC) values were >0.8.

Table 4. Cut-off values for GMFM and PEDI by GMFCS levels

GMFCS Level	Category	GMFM total score (%)	PEDI Scaled Scores	
			Self-Care	Mobility
I	Cut-off value	81.48	55.48	75.43
	AOC	0.98	0.87	0.92
	Sensitivity	0.94	1.00	0.91
	Specificity	0.87	0.72	0.85
II	Cut-off value	75.98	50.00	72.04
	AOC	0.96	0.85	0.96
	Sensitivity	0.90	0.87	0.87
	Specificity	0.94	0.78	0.92
III	Cut-off value	53.33	48.64	38.14
	AOC	0.95	0.85	0.95
	Sensitivity	0.94	0.78	0.87
	Specificity	0.84	0.80	0.86
IV	Cut-off value	40.92	34.94	33.05
	AOC	0.91	0.88	0.93
	Sensitivity	0.89	0.82	0.81
	Specificity	0.92	0.79	0.90

AOC, Area under the ROC curve. GMFCS, Gross Motor Function Classification System. GMFM, Gross Motor Function Measure. PEDI, Pediatric Evaluation of Disability Inventory.

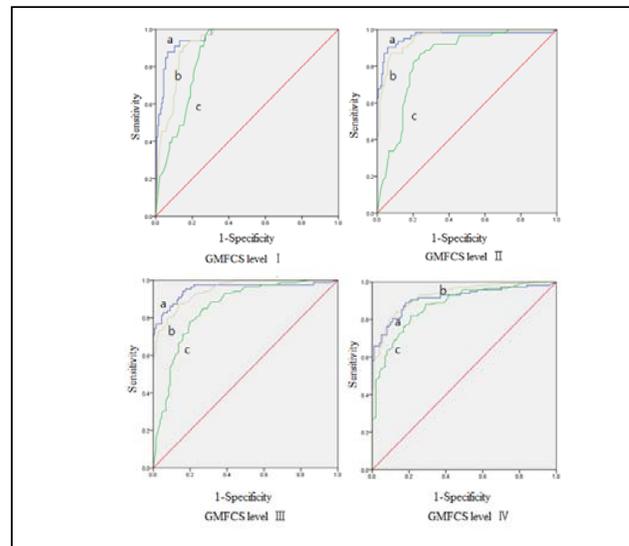


Figure 1. ROC Curve by GMFCS Level. a=GMFM; b=PEDI mobility; c=PEDI self-care.

4. Discussion

With functional assessment and intervention becoming increasingly important in rehabilitation, various functional classification systems have been developed and used in clinical practice and research. Although classification systems help facilitate communication among professionals and caregivers, they do not provide useful information about the relationship between the classification system and functional outcomes; this information is often necessary for the assessment and treatment of patients in clinical settings. This study was designed to identify the relationship and cut-off values for the GMFM total and the scaled scores of self-care and mobility domain in PEDI according to the GMFCS level.

Both GMFM and PEDI functional skills are applied to measure the functional outcomes in children with CP in clinical settings²¹. Although the GMFM and PEDI mobility domains are in line with measuring gross motor function, GMFM measures objective gross motor capacity while the PEDI mobility domain measures subjective gross motor performance in daily life²².

Oeffinger et al.²³ reported that the GMFM section E score was an important factor to estimate a child’s GMFCS level. GMFCS levels were closely correlated with GMFM total ($r_s = -0.882$) and PEDI mobility ($r_s = -0.826$) scaled scores in present study. This finding was bear a close parallel to those of previous studies^{4,24}. However, the correlation coefficient between the GMFCS level and PEDI self-care

($r_s = -0.691$) scaled score was lower than with GMFM total score and PEDI mobility scaled score indicating that the GMFCS level is strongly associated with the mobility function rather than self-care or upper extremity function^{4,23}.

The mean GMFM total and PEDI functional skill scaled scores of patients at GMFCS levels I–V in this study were higher than the mean GMFM-66 scores in the Oeffinger et al. study²⁴. This difference may be attributable to the measurement tools and participants. Damiano et al.²⁵ indicated that the GMFM scores by GMFCS level differed according to the type of paralysis. In our sample, although children at GMFCS level I showed a higher functional level than children at other GMFCS levels, their functional outcome measures were lower than those of typical children. A GMFM score of 100 was achieved by only two (0.9%) participants and a PEDI mobility score of 100 was achieved by 14 (6.5%) participants. In addition, a score of 100 on GMFM and PEDI mobility was not achieved until the age of 15 and 17 years in children with CP, respectively. None of the participants achieved a score of 100 in the PEDI self-care domain.

The results of this study show that the mean of GMFM total and PEDI self-care and mobility scaled scores were significantly affected by the GMFCS level. These results indicate that the GMFCS effectively classifies groups of children with different activity limitations and participation restrictions^{23,26}. However, the PEDI mobility scaled and GMFM scores were not significantly different between children at GMFCS level I and those at the level II, and PEDI self-care scaled scores did not differ significantly between certain levels ($p > 0.05$). Because self-care is related to upper extremity function, this result is acceptable. Although GMFM and PEDI mobility scores are correlated with gross motor function, they did not differ between children at GMFCS level I and those at level II. Palisano et al.³ reported that it was difficult to distinguish between children at GMFCS levels I and II. Furthermore Voorman et al.²² reported that could not find a difference in GMFM-66 and PEDI mobility scores according to the GMFCS levels. Hence, future studies are required for developing more detailed criteria for distinguishing between GMFCS levels I and II.

Some researchers have studied the relationship between the GMFCS and functional outcomes. Palisano et al.¹² reported the predicted maximal GMFM scores according to the GMFCS level. Barnes et al.²⁷ found that the GMFCS level was a significant predictor of pediatric outcome data data collected based on instrument scores. Voorman et al.²² found that the GMFCS level was intensely connected

with mobility (explained variance, 87.92%), self-care, and domestic life scores. However, a few studies identified specific GMFM and PEDI functional skills scores related to the GMFCS level. In this study, we investigated the cut-off values for GMFM and PEDI self-care and mobility scaled scores to obtain more useful information. The GMFM total score cut-off values for GMFCS levels I–IV were 81.48, 75.98, 53.33, and 40.92, respectively. The PEDI self-care scaled score cut-off values for GMFCS levels I–IV were 55.48, 50.00, 48.64, and 34.94, respectively. The PEDI mobility scaled score cut-off values for GMFCS levels I–IV were 75.43, 72.04, 38.14, and 33.05, respectively. The AUC is an overall indication of the discrimination accuracy of an ROC curve. The AUC values range from 0–1, 0.5 or less of the AUC represents a worthless test. All of the AUC in this study were > 0.8 . The AUC value for both GMFM and PEDI mobility was excellent and that for PEDI self-care was good. The sensitivity and specificity were also high.

Although this study was limited by the fact that 46% of our participants were belonged to GMFCS level V, we were able to obtain important information about the relationship between the GMFCS level and functional outcomes. The GMFCS level was strongly correlated with functional outcomes including GMFM and PEDI functional skills. The use of the GMFCS can make a better interaction among parents and therapists and influence rehabilitation service choices corresponding to a child's current functional level, because it can be easily applied by health-related professionals and parents and has high reliability. Information regarding the cut-off values for the GMFM and PEDI functional skills according to the GMFCS level may help facilitate communication among clinicians and help them interpret the functional status of children with CP.

5. Acknowledgment

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6. References

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