

# The Reliability and Concurrent Validity of the GMFCS for Children with Cerebral Palsy

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**Abstract.** [Purpose] To determine inter-rater and intra-rater reliability using video recordings, and the concurrent validity of the Gross Motor Function Classification System (GMFCS). [Subjects] The subjects who were assessed were 71 children with cerebral palsy (CP; 46 boys, 25 girls) who were divided into three age groups according to the GMFCS guidelines; 0–2 years, 2–4 years, and 4–6 years. [Methods] Eleven pediatric physical therapists rated 71 video recordings of children with CP to test inter-rater reliability. Two of them rescored the same video recordings to test intra-rater reliability at an interval of one month. Concurrent validity was evaluated by comparing GMFCS levels with the subscale of the Pediatric Evaluation of Disability Inventory (PEDI) such as self-care, mobility, and social ability. [Results] By age group, inter-rater reliability was high (ICC = 0.994, 0.993, and 0.996 respectively). Intra-rater reliability was also high (ICC = 0.972–0.996), and correlation was higher between GMFCS level and the mobility domain of PEDI than between GMFCS level and non-motor domains of PEDI. [Conclusion] This study confirmed the reliability and validity of the GMFCS, supporting its use in clinical practice and research.

**Key words:** Cerebral palsy, GMFCS, PEDI

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## INTRODUCTION

The Gross Motor Function Classification System (GMFCS), developed by Palisano et al. in 1997<sup>1)</sup> provides an alternative approach to the classification of cerebral palsy (CP). Based upon the concepts of disability and functional limitation as laid out by the World Health Organization, it classifies children by the level of their motor ability. It is presented as a 5-point ordinal scale in which the higher the level, the less able the child<sup>2)</sup>. Formal CP classification methods, such as the GMFCS, have been developed in order to standardize the clinical variability, which is one of the major characteristics of CP<sup>3)</sup>. In addition, the GMFCS is now extensively used in developmental research and clinical practice<sup>4)</sup>, and its relation with measures of gait<sup>5)</sup>, energy efficacy<sup>6)</sup>, participation restriction<sup>7)</sup>, and health-related quality of life<sup>8)</sup> in the population with CP has been explored. It has been noted that traditional classification systems describing CP type by limb distribution (hemiplegia, diplegia, and quadriplegia), albeit useful for clinical and epidemiological purposes, have limited value as indicators of mobility. Description of CP type by limb distribution does not indicate severity level and very often does not offer prognostic utility<sup>9)</sup>.

Several previous studies have demonstrated the reliability of the GMFCS. Palisano et al.<sup>1)</sup> reported moderate inter-rater reliability in children with CP who were younger

than two years old ( $k=0.55$ ) and excellent reliability in children from two to 12 years old ( $k=0.75$ ) whose motor performances were rated by two physical and occupational therapists who were familiar with the child. The inter-rater reliability in assessing the GMFCS level of children from ages 1 to 12 years using medical records was also high ( $G = 0.93$ )<sup>10)</sup>. Also, Bodkin et al.<sup>11)</sup> reported high inter-rater reliability ( $k=0.84$ ) of the GMFCS for children with CP and Down syndrome using 30 video clips.

Establishing the validity of a new instrument is challenging, and multiple aspects of validity need to be evaluated, including concurrent validity. Concurrent validity, one type of criterion-related validity, is defined as agreement between new and accepted instruments administered in the same period<sup>11)</sup>.

To our knowledge, inter-rater and intra-rater reliability using video clips and the concurrent validity of a Korean version of the GMFCS have never been investigated. Therefore, the objectives of this study were to test the inter-rater and intra-rater reliability and to measure the concurrent validity of Korean version of the GMFCS for children with CP.

## SUBJECTS AND METHODS

The Gross Motor Function Classification System (GMFCS) is a standardized classification of functional

**Table 1.** Summary of sample characteristics

|                              | > 2 years (n=17) | 2–4 years (n=31) | 4–6 years (n=23) |
|------------------------------|------------------|------------------|------------------|
| Gender                       |                  |                  |                  |
| Boys                         | 12 (70.6)        | 19 (61.3)        | 15 (65.2)        |
| Girls                        | 5 (29.4)         | 12 (38.7)        | 8 (34.8)         |
| Mean age (yrs)               | 16.35 ± 4.86     | 36.87 ± 6.08     | 59.04 ± 7.57     |
| CP type by tones             |                  |                  |                  |
| Spastic                      | 12 (70.6)        | 22 (71.0)        | 19 (82.6)        |
| Athetoid                     | 3 (17.6)         | 6 (19.4)         | 3 (13.0)         |
| Hypotonia                    | 1 (5.9)          | 1 (3.2)          | 1 (4.3)          |
| Ataxia                       | 1 (5.9)          | 2 (6.5)          | 0 (0.0)          |
| CP type by limb distribution |                  |                  |                  |
| Hemiplegia                   | 1 (5.9)          | 5 (16.1)         | 1 (4.3)          |
| Diplegia                     | 6 (35.3)         | 12 (38.7)        | 10 (43.5)        |
| Quadriplegia                 | 10 (58.8)        | 14 (45.2)        | 12 (52.2)        |

Values are n (%) or Values are mean ± SD.

motor abilities of children with CP. The emphasis in GMFCS design was on making distinctions between different levels that are clinically meaningful and as a result the classification system focuses on functional limitations and the need for assistive devices. Children are assigned a GMFCS level of I–V according to motor functioning abilities. Level I, the highest functional level in the GMFCS, describes children with CP who have the ability to participate in community settings with minimal functional deficits. On the opposite end of the spectrum, children classified as level V are typically fully dependent, have great difficulty with voluntary movements and are transported in wheelchairs<sup>1)</sup>. In this study, the Korean version of GMFCS was used.

The Pediatric Evaluation of Disability Inventory (PEDI) is a comprehensive standardized measure of functional capabilities and performance across three domains, self-care, mobility and social function, of children with disabilities aged between 6 months and 7.5 years<sup>12)</sup>. We used the Korean version of PEDI to measure self-care, mobility, and social function which were determined from interviews with the subjects' parents. The scaled scores used in this study reflect a child's functional skills on a continuum from 0 to 100, where 0 presents no ability and 100 represents full capability to perform the functional skill items in a particular domain.

The subjects were 71 children with CP (46 boys and 25 girls) and their mothers who gave their written consent to participation in this study (Table 1). The children with CP were recruited mainly from a CP clinic in Gyeonggi-do, South Korea. The CP subjects had no history of newly developed neurological problems, musculoskeletal disorders, or botulinum toxin injections within the previous six months.

All the CP subjects were divided into three age groups according to the GMFCS guidelines; 0–2 years, 2–4 years, and 4–6 years. Their ages ranged from 6 months to 6 years (mean age 3.6 ± 1.52 years). Eleven pediatric physical therapists (rater A, B, C, D, E, F, G, H, I, J, and K) served as the GMFCS raters.

Video recordings of the subjects were made by two assistants who also worked in a CP clinic and provided pediatric physical therapy every day. It took about 15 minutes to record the subject's functional abilities and limitations based on their self-initiated movement with particular emphasis on sitting, walking, and wheeled mobility.

The raters of GMFCS were 11 pediatric physical therapists who had 8 months to 12 years of experience (mean experience 5.6 years) in the evaluation and treatment of children with CP. All raters independently viewed and scored the 10 videotaped test sessions within one week of their training session.

To assess inter-rater reliability of the GMFCS, the raters scored the same video recording of the subjects in the therapy room. To determine intra-rater reliability, we followed the method of Jeng et al.<sup>13)</sup>. One month after the first assessment, two raters (B and K) rescored the same video recordings. Rater B had 8 months of experience in the evaluation and treatment of children with CP (the newly trained PT), while rater K had 12 years of experience in pediatric physical therapy (the Expert PT). A number of studies<sup>14–16)</sup> have used videotapes of patients to permit multiple raters to observe the same performance. According to Gross and Conrad<sup>17)</sup>, videotaping permits less biased estimates of reliability. It is also facilitates scheduling of patient evaluations when the inter-rater reliability of several raters is involved. In order to examine concurrent validity, the GMFCS was compared with PEDI. PEDI data was collected by interviews with mothers which were conducted by two assistants who were experienced in the use of the PEDI.

The mean and standard deviation (SD) for each test were calculated. The intraclass correlation coefficient with 95% confidence intervals was calculated to determine inter-rater and intra-rater reliability of the GMFCS. Spearman's correlation coefficient was used to assess the relationship between PEDI and GMFCS. A p value of less than 0.05 was considered significant. All the statistical analyses were performed using the SPSS software package for Windows (ver. 12.01).

## RESULTS

The characteristics of the 71 subjects who participated in this study are shown in Table 1.

The mean scaled scores and standard deviations for the subscales of the PEDI are described in Table 2. The inter-rater reliabilities of the three age groups, represented by the ICC, were 0.994, 0.993, and 0.996 respectively (Table 3); the intra-rater reliabilities of the newly trained PT, rater B, ICC were 0.973, 0.972, and 0.988 respectively; and the intra-rater reliabilities of the expert PT, rater K, were 0.989, 0.996, and 0.995 respectively (Table 4). The GMFCS was inversely correlated with the PEDI ( $r = -0.51 \sim -0.77$ ) (Table 5).

## DISCUSSION

It is accepted practice to use standardized tools to assess disease status and some of these tools, like the GMFCS, have gained universal acceptance. Employing established instruments with well-demonstrated reliability and validity, allows interchange of findings and cross-cultural comparisons. Health professionals have used the GMFCS in research and clinical practice internationally, because it provides an accurate description of children's gross motor function<sup>18)</sup>. It has been reported to have a major effect on the care of children with CP<sup>19)</sup>.

To our knowledge, this is the first study of a population of Korean children with CP to determine the reliability and

**Table 2.** Descriptive statistics of PEDI (N=71)

|                           | > 2 years (n=17) | 2–4 years (n=31) | 4–6 years (n=23) |
|---------------------------|------------------|------------------|------------------|
| PEDI- Functional skill    |                  |                  |                  |
| Self-care                 | 22.72 ± 9.72     | 41.15 ± 13.25    | 44.44 ± 17.09    |
| Mobility                  | 11.08 ± 9.83     | 31.58 ± 23.81    | 30.76 ± 25.70    |
| Social ability            | 18.39 ± 14.42    | 42.93 ± 15.73    | 45.91 ± 22.18    |
| PEDI-Caregiver assistance |                  |                  |                  |
| Self-care                 | 0.00 ± 0.00      | 19.00 ± 21.19    | 31.51 ± 24.38    |
| Mobility                  | 0.69 ± 2.84      | 22.15 ± 24.32    | 20.45 ± 30.77    |
| Social ability            | 0.66 ± 2.74      | 23.27 ± 22.49    | 35.43 ± 28.57    |

Values are mean ± SD. PEDI: Pediatric Evaluation of Disability Inventory.

**Table 3.** Inter-rater reliability for GMFCS (N=71)

| Age groups       | N  | Inter-rater (Rater A - K) |             |
|------------------|----|---------------------------|-------------|
|                  |    | ICC                       | 95% CI      |
| > 2 years (n=17) | 17 | 0.994                     | 0.989–0.998 |
| 2–4 years (n=31) | 31 | 0.993                     | 0.989–0.996 |
| 4–6 years (n=23) | 23 | 0.996                     | 0.993–0.998 |

GMFCS: Gross Motor Function Classification. ICC: Intraclass Correlation Coefficient, CI: Confidence Interval.

**Table 4.** Intra-rater reliability for GMFCS (N=71)

| Age groups | N  | Intra-rater (Rater B) |             | Intra-rater (Rater K) |             |
|------------|----|-----------------------|-------------|-----------------------|-------------|
|            |    | ICC                   | 95% CI      | ICC                   | 95% CI      |
| > 2 years  | 17 | 0.973                 | 0.926–0.990 | 0.989                 | 0.970–0.996 |
| 2–4 years  | 31 | 0.972                 | 0.942–0.987 | 0.996                 | 0.993–0.998 |
| 4–6 years  | 23 | 0.988                 | 0.972–0.995 | 0.995                 | 0.988–0.998 |

GMFCS: Gross Motor Function Classification. ICC: Intraclass Correlation Coefficient, CI: Confidence Interval.

**Table 5.** Correlation between GMFCS and PEDI subscale scores (N=71)

|                  | PEDI-Functional skills |          |                | PEDI-Caregiver assistance |          |                |
|------------------|------------------------|----------|----------------|---------------------------|----------|----------------|
|                  | Self-care              | Mobility | Social ability | Self-care                 | Mobility | Social ability |
| GMFCS            |                        |          |                |                           |          |                |
| 2 years > (n=17) | -0.324                 | -0.630** | -0.405         | –                         | -0.215   | 0.269          |
| 2–4 years (n=31) | -0.513**               | -0.754** | -0.396*        | -0.654**                  | -0.720** | -0.0410*       |
| 4–6 years (n=23) | -0.683**               | -0.772** | -0.665**       | -0.553**                  | -0.729** | -0.608**       |

GMFCS: Gross Motor Function Classification, PEDI: Pediatric Evaluation of Disability Inventory. \* Correlation is significant at the 0.05 level (two-tailed). \*\* Correlation is significant at the 0.01 level (two-tailed).

validity of the GMFCS. In our opinion, this paper may provide pediatric physical therapists an introduction as to how far the classification of CP has advanced.

In our study, 11 pediatric physical therapists initially examined the inter-rater reliability of the GMFCS based on video recordings. To investigate intra-rater reliability, an expert PT and a newly trained PT rescored the same video clips one month after the inter-rater reliability assessment. Watkins and Portney<sup>20)</sup> reported that an ICC  $\geq 0.90$  indicates a high reliability, 0.75–0.90 indicates good reliability, 0.50–0.75 indicates moderate reliability, and  $\leq 0.50$  indicates poor reliability. Our results indicate that the ICC for the eleven GMFCS raters was high in all age groups. The intra-rater reliability of newly trained PT, rater B, and expert PT, rater K were also high.

Previous studies have demonstrated GMFCS reliability using a review of medical records<sup>10)</sup> or therapists' knowledge of the children being rated<sup>1)</sup>. Bodkin et al.<sup>11)</sup> investigated the inter-rater reliability of the GMFCS using video recordings and the results showed very good agreement between two raters ( $k=0.84$ ). It is important to understand that video recording rating is reliable because video recordings may be a more efficient way to rate children in some clinical and research situations<sup>11)</sup>.

Several types of reliability testing are necessary, so we examined the intra-rater reliability. The ICC for intra-rater reliability was high for both the expert PT and the newly trained PT. This result indicates that even a rater, such as the newly trained PT, can rate GMFCS similar to an expert PT.

Therefore, our results demonstrate that the GMFCS can be used to reliably rate motor behavior using video recordings of children with CP.

For the concurrent validity, our results show that GMFCS demonstrated a significant negative correlation with the PEDI. Meyer<sup>21)</sup> reported that a correlation coefficient  $r \geq 0.8$  indicates a high correlation,  $r = 0.6$ – $0.8$  indicated a good correlation,  $r = 0.4$ – $0.6$  indicates a moderate correlation, and  $r \geq 0.4$  indicates a poor correlation. We compared the GMFCS level with the PEDI subscales; self-care, mobility, and social ability. In the present study, the GMFCS levels showed a moderate negative correlation with the mobility of the PEDI in 2–4-year-old and 4–6-year-old children with CP. For mobility, the GMFCS levels demonstrated a good negative correlation with the mobility in age groups of 2–4 and 4–6 years children with CP. For social ability, the GMFCS levels were inversely moderately correlated in 4–6-year-old children with CP. These findings support the concurrent validity of the GMFCS, strengthening the assumption the GMFCS level is a reflection of the subscales of the PEDI. In other words, lower GMFCS levels were associated with poorer self-care, mobility, and social ability.

Gunel et al.<sup>22)</sup> demonstrated that the Functional Independence Measure for Children (WeeFIM) can be used as concurrent validity measures of GMFCS for children with cerebral palsy. They reported that there was a negative correlation between the GMFCS and WeeFIM subscales. Therefore, the results of the present study show that GMFCS had moderate to good concurrent validity when used for children with cerebral palsy.

A limitation of this study is that the GMFCS is a 5 level classification system that describes the gross motor function of children with CP aged between 0 and 18 years. This study focused on children with CP aged 0–6 years. Further studies with inclusion of school-aged children with CP are necessary.

In conclusion, inter-rater and intra-rater reliability were high, and the concurrent validity of GMFCS with PEDI was moderate to good. Also, the level of expertise of the pediatric physical therapist did not affect the reliability of the rating.

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