# Inter-Rater and Intra-Rater Reliability of the Gross Motor Function Measure (GMFM-66) by Thai Pediatric Physical Therapists

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***Objective:*** *The present study aimed to determine inter-rater reliability and intra-rater reliability of the 66-item version of the Gross Motor Function Measure (GMFM-66) in assessing motor ability of Thai children with cerebral palsy.*
***Material and Method:*** *Ten children, aged 2-10 years, were recruited in the present study. Eight children with spastic diplegia from an outpatient department of Thammasat University Hospital, and two normal children were recruited. The motor abilities of the subjects were recorded on a video camera. Three pediatric physical therapists independently watched the video recordings and scored each child according to the GMFM assessment. The video clips of ten children were assessed on two occasions at an interval of one week by the same therapists. The inter-rater and intra-rater reliability were analyzed using an intraclass correlation coefficient (ICC).*
***Results:*** *The inter-rater reliability and intra-rater reliability of the GMFM-66 were both high. The ICC for inter-rater reliability was 0.93 and for intra-rater reliability were 0.99-1.00 for the total scores.*
***Conclusion:*** *The present study confirms high inter-rater and intra-rater reliability of the GMFM-66 measured by Thai pediatric physical therapists. Therefore, in clinical practice, we recommend Thai pediatric physical therapists to use the GMFM-66 in assessing motor ability of cerebral palsy patients.*

***Keywords:*** *Cerebral Palsy, Gross Motor Function Measure, Inter-rater reliability, Intra-rater reliability*

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Cerebral palsy (CP) is a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances of developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbance of sensation, perception, cognition, communication, and behavior, by epilepsy, and by secondary musculoskeletal problems[1]. Cerebral palsy can be classified by clinical characteristics as spastic, dyskinetic, ataxia and hypotonic types or classified by Gross Motor Function Classification System (GMFCS)[2,3]. Accurate measurement of motor function change in children with cerebral palsy is essential in order to follow their motor function ability as a clinical outcome. The Gross Motor Function Measure (GMFM) is a standard criterion tool for evaluating change of gross motor function over time in children with cerebral palsy[4]. The original GMFM measure consisting of 88-items, GMFM-88, has been reported of having good psychometric properties as high inter-rater reliability, intra-rater reliability and responsiveness of motor function change[5-8]. It contains five dimensions of motor function measure including lying/rolling (17 items), sitting (20 items), crawling/kneeling (14 items), standing (13 items) and walking/running/jumping (24 items). However, the GMFM-88 was modified into GMFM-66 consisting of 66 items by statistical method of Rasch analysis[9]. Twenty two items that were excluded from the GMFM-88 are from 13 items of lying and rolling dimension, 5 items of sitting dimension and 4 items of kneeling and crawling dimension. The rest items were re-arranged

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and re-scaled to be a more precise measure of changes of gross motor function[10]. The GMFM-66 was reported of better psychometric property as its higher intra-rater reliability (ICC = 0.99), higher responsiveness and more consistency compare to the GMFM-88[9].

Presently, the GMFM-66 is frequently used as a clinical outcome measure by Thai pediatric physical therapists to follow their children with cerebral palsy. However, the reliability of using this instrument among Thai children with cerebral palsy has not been reported. The aim of the present study was to examine inter-rater reliability and intra-rater reliability of the GMFM-66 in Thai children with cerebral palsy using video clips.

## Material and Method

Ten children, aged 2-10 years, were recruited in the present study. Eight children with spastic diplegia from an outpatient department of Thammasat University Hospital and two normal children were recruited. The present study was approved by the ethics committee of Thammasat University. Informed consent was obtained from the subjects' parents before participation in the present study.

Three well-experienced pediatric physical therapists, with 5-15 years of experience in pediatrics, participated in patient assessment. One of the three is a pediatric physical therapist who had training on using a GMFM assessment. The other two pediatric physical therapists studied the GMFM and learned from the trained therapist before an actual GMFM assessment was conducted. The motor abilities of the subjects were recorded on a video camera. Each subject was recorded for about 30 minutes each performing motor abilities of each dimension including lying and rolling (4 movements), sitting (15 movements), crawling (10 movements), standing (13 movements) and walking, running and jumping (24 movements). Each child was stimulated to perform each movement in the dimensions by an experienced pediatric physical therapist, while another pediatric physical therapist videotaped the children's performance. Thereafter, the three pediatric physical therapists independently watched the video recordings and scored each child according to the GMFM assessment. The video clips of ten children were assessed on two occasions at an interval of one week by the same therapists. The scores of both assessments were calculated by using the WINSTEPS Rasch Analysis software, which converts the data from a categorical scale to a continuous scale to give a more precise score. The converted data is then used to calculate the inter-rater and intra-rater reliability to find the intraclass correlation coefficient.

## Results

Of the ten children in the present study, including eight spastic diplegia children and two normal children, aged between 2-10 years, with a mean age was 5.3 $\pm$ 2.2 years, were given a GMFCS score between 1-5. Both of the two normal children scored a GMFCS I, while there were one, two, four and one spastic diplegia children with GMFCS II, III, IV and V, respectively, as shown in Table 1.

Correlations of the total score for the five dimensions of GMFM-66 had a high inter-rater reliability with ICC = 0.93 (Table 2). Correlations of each dimension had the inter-rater reliability of between ICC = 0.19-0.94. Correlation for the lying and rolling dimension was 0.19 (ICC = 0.19); correlation for the sitting dimension was 0.72 (ICC = 0.72); correlation for the crawling and kneeling dimension was 0.85 (ICC = 0.85);

**Table 1.** Participant characteristics

| Characteristics | Spastic diplegia (n = 8) | Normal (n = 2) | Total |
|---|---|---|---|
| Age in years (Mean $\pm$ SD) | 5.5 $\pm$ 2.4 | 4.5 $\pm$ 0.3 | 5.3 $\pm$ 2.2 |
| Sex | | | |
| Boy | 2 | 1 | 3 |
| Girl | 6 | 1 | 7 |
| GMFCS level* | | | |
| Level I | 0 | 2 | 2 |
| Level II | 1 | 0 | 1 |
| Level III | 2 | 0 | 2 |
| Level IV | 4 | 0 | 4 |
| Level V | 1 | 0 | 1 |

*GMFCS = Gross Motor Function Classification System

correlation for the standing dimension was 0.90 (ICC = 0.90); correlation for the walking, running and jumping dimension was 0.94 (ICC = 0.94), which are considered good (Table 3). The intra-rater reliability of the total scores of GMFM-66 is considered excellent with ICC = 0.99-1.00. The ICC score was 0.99 (ICC = 0.99) for evaluators numbers 1 and 2 and the ICC was 1.00 (ICC = 1.00) for evaluator number 3 (Table 4).

## Discussion

The present study demonstrated that the GMFM-66 has good psychometric properties. The inter-rater reliability and intra-rater reliability of GMFM-66 were both high with ICC scores of 0.93 and 0.99-1.00, respectively, which were satisfactory high and were in line with previous studies of Nordmark E et al[7]. Their study analyzed inter-rater and intra-rater

**Table 2.** Total scores of the Gross Motor Function Measure (GMFM-66) by three independent assessors in evaluating the first video clips of cerebral palsy children and their inter-rater reliabilities

| Subjects | Total scores of the GMFM-66 | | | ICC* |
|---|---|---|---|---|
| | Assessor 1 | Assessor 2 | Assessor 3 | |
| 1 | 32.4 | 34.0 | 28.0 | |
| 2 | 53.9 | 55.2 | 49.1 | |
| 3 | 41.1 | 40.3 | 40.5 | |
| 4 | 49.7 | 51.7 | 48.9 | |
| 5 | 44.3 | 43.1 | 41.3 | |
| 6 | 41.3 | 40.8 | 37.6 | 0.93 |
| 7 | 62.5 | 60.8 | 59.5 | |
| 8 | 53.7 | 51.5 | 58.1 | |
| 9 | 31.8 | 26.2 | 34.7 | |
| 10 | 46.2 | 46.5 | 41.3 | |

* Intraclass correlation coefficients

**Table 3.** The Gross Motor Function Measure (GMFM-66) scales of each dimension by three independent assessors in evaluating the first video clips of cerebral palsy children and their inter-rater reliabilities

| Subjects | Dimension score of GMFM-66 | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lying and rolling | | | Sitting | | | Crawling and kneeling | | | Standing | | | Walking, running and jumping | | |
| | Assessor | | | Assessor | | | Assessor | | | Assessor | | | Assessor | | |
| | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| 1 | 63.4 | 63.4 | 45.8 | 33.5 | 39.0 | 30.9 | 38.1 | 39.6 | 26.4 | 10.5 | 10.5 | 10.5 | 3.6 | 3.6 | 3.6 |
| 2 | 99.0 | 81.7 | 63.4 | 58.7 | 70.3 | 47.3 | 61.1 | 63.4 | 54.2 | 50.9 | 51.7 | 47.7 | 47.3 | 47.3 | 46.3 |
| 3 | 81.7 | 81.7 | 63.4 | 44.0 | 46.3 | 47.3 | 49.9 | 48.4 | 49.9 | 28.8 | 10.5 | 10.5 | 3.6 | 3.6 | 3.6 |
| 4 | 99.0 | 99.0 | 63.4 | 51.4 | 57.5 | 52.4 | 51.5 | 51.5 | 41.9 | 45.9 | 49.3 | 54.9 | 47.3 | 47.3 | 47.3 |
| 5 | 99.0 | 52.1 | 81.7 | 52.4 | 52.4 | 46.3 | 48.4 | 48.4 | 48.4 | 35.7 | 35.7 | 31.5 | 18.6 | 18.6 | 3.6 |
| 6 | 99.0 | 81.7 | 63.4 | 46.3 | 45.2 | 37.4 | 46.1 | 44.5 | 43.7 | 28.8 | 33.7 | 28.8 | 18.6 | 18.6 | 18.6 |
| 7 | 99.0 | 99.0 | 63.4 | 61.7 | 61.7 | 57.5 | 63.4 | 56.5 | 57.8 | 60.6 | 59.5 | 58.5 | 62.2 | 61.5 | 62.2 |
| 8 | 99.0 | 69.9 | 99.0 | 61.7 | 57.5 | 70.3 | 57.8 | 54.2 | 57.8 | 64.8 | 60.6 | 91.5 | 18.6 | 18.6 | 44.2 |
| 9 | 69.9 | 30.3 | 63.4 | 35.6 | 35.6 | 45.2 | 26.4 | 26.4 | 26.4 | 10.5 | 10.5 | 10.5 | 3.6 | 3.6 | 3.6 |
| 10 | 63.4 | 45.8 | 81.7 | 55.3 | 50.4 | 45.2 | 55.3 | 57.8 | 52.4 | 35.7 | 45.0 | 37.5 | 21.5 | 21.5 | 21.5 |
| | ICC* = 0.19 | | | ICC* = 0.72 | | | ICC* = 0.85 | | | ICC* = 0.90 | | | ICC* = 0.94 | | |

* Intraclass correlation coefficients

**Table 4.** Total scores of the Gross Motor Function Measure (GMFM-66) by three independent assessors in evaluating the video clips of cerebral palsy children twicely and their intra-rater reliabilities

| Subjects | Total scores of GMFM-66 | | | | | |
|---|---|---|---|---|---|---|
| | Assessor 1 | | Assessor 2 | | Assessor 3 | |
| | 1st scoring | 2nd scoring | 1st scoring | 2nd scoring | 1st scoring | 2nd scoring |
| 1 | 32.4 | 32.4 | 34.0 | 32.9 | 28.0 | 28.0 |
| 2 | 53.9 | 53.3 | 55.2 | 55.2 | 49.1 | 49.1 |
| 3 | 41.1 | 39.4 | 40.3 | 40.3 | 40.5 | 40.5 |
| 4 | 49.7 | 49.9 | 51.7 | 48.5 | 48.9 | 48.9 |
| 5 | 44.3 | 43.3 | 43.1 | 41.9 | 41.3 | 41.3 |
| 6 | 41.3 | 41.9 | 40.8 | 40.0 | 37.6 | 37.6 |
| 7 | 62.5 | 62.5 | 60.8 | 59.8 | 59.5 | 59.5 |
| 8 | 53.7 | 52.5 | 51.5 | 50.7 | 58.1 | 58.1 |
| 9 | 31.8 | 32.4 | 26.2 | 31.3 | 34.7 | 34.7 |
| 10 | 46.2 | 46.2 | 46.5 | 47.5 | 41.3 | 41.3 |
| | ICC* = 0.99 | | ICC* = 0.99 | | ICC* = 1.00 | |

* Intraclass correlation coefficients

reliability of GMFM-88, which involved 15 physical therapists evaluating the video recordings of the motor abilities of three children with cerebral palsy twice, with an interval of six months. The evaluators studied the GMFM manual without training prior to the study. Both inter-and intra-rater reliability was considered good, with inter-rater reliability of 0.77 and 0.88 for the first and second assessments, respectively. The intra-rater reliability was at 0.68 on the second assessment. Russell DJ et al[5] developed the GMFM-66 from the original GMFM-88 by using the statistical method of Rasch analysis and determined test-retest reliability of the GMFM-66 from 19 children with cerebral palsy. The children were assessed twice, 1 week apart, by the same therapist. Their study showed test-retest reliability was high (ICC = 0.99). Shi Wei et al[10] examined the inter-rater and intra-rater reliability of GMFM-66 from 171 children with cerebral palsy. The results indicated the inter-rater and intra-rater reliability were 0.98 and 0.97, respectively. Ruck-Gibis J et al analyzed intra-rater and inter-rater reliabilities of the GMFM from 19 children with osteogenesis imperfecta, who were watched and scored via video recordings by five physical therapists. The ICC for intra-rater reliability and for inter-rater reliability was 0.99 was 0.99, respectively[11]. A recent study about inter-rater reliability in Thai children with cerebral palsy was done by Piyapa Keawutan et al. They determined the inter-rater reliability of GMFM-88 Thai version from six children with cerebral palsies with two physical therapists, separately. The results showed an inter-rater reliability of GMFM-88 Thai version at high (ICC = 0.96)[12]. The results of the present study also revealed high inter-rater and intra-rater reliability of GMFM-66, which is in line with many previous studies. As such, GMFM-66 is a practical clinical assessment of Thai children with cerebral palsy, but the pediatric physical therapists should study the details and guidelines of the assessment in its manual before implementing the assessment.

The limitation of the present study was the limited types of cerebral palsy involved. The samples used were not representative of all types, which do not verify the practicality of the assessment for all types of cerebral palsy. The children used in the present study were children with spastic diplegia and normal children, whose motor abilities were considered moderate to good, and were able to perform nearly all dimensions of the assessment. Further studies should verify the validity of the assessment for all types of cerebral palsy, which include increasing the number of subjects, age range, and with all levels of gross motor function classification system (GMFCS). The inter-rater and intra-rater reliability of the GMFM-66 in this study is limited to this population, and cannot yet be generalized to include all types of cerebral palsy and age ranges. Nevertheless, it is suggested that Thai pediatric physical therapists use the GMFM-66 to assess motor function in Thai children with cerebral palsy, but only

after having observed the GMFM manual closely.

**Conclusion**

The present study confirms high inter-rater and intra-rater reliability of the GMFM-66 measure among Thai children with cerebral palsy. In clinical practice, the authors' recommend Thai pediatric physical therapists to use the GMFM-66 in assessing motor ability of children with cerebral palsy after having thoroughly learning it's manual. Apart from this, Thai pediatric physical therapists must use the software that analyzed the interval level scale of the GMFM-66, such as the WINSTEPS Rasch Analysis software or the Gross Motor Ability Estimator (GMAE) software.

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**Potential conflicts of interest**

None.

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## *การศึกษาค่าความเชื่อถือได้ระหว่างบุคคลและภายในบุคคลของแบบประเมิน Gross Motor Function Measure (GMFM-66) ประเมินโดยนักกายภาพบำบัดไทย*

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***วัตถุประสงค์:*** *ศึกษาค่าความเชื่อถือได้ระหว่างบุคคลและภายในบุคคลของแบบประเมิน Gross Motor Function Measure (GMFM-66) ฉบับภาษาอังกฤษในการประเมินความสามารถด้านการเคลื่อนไหวของผู้ป่วยเด็กไทยที่มีภาวะสมองพิการ*

***วัสดุและวิธีการ:*** *คัดเลือกเด็กอายุระหว่าง 2 -10 ปี จำนวน 10 คน เป็นผู้ป่วยเด็กที่มีสมองพิการชนิด spastic diplegia ในโรงพยาบาลธรรมศาสตร์เฉลิมพระเกียรติ จำนวน 8 คน และเป็นเด็กปกติจำนวน 2 คน ความสามารถทางการเคลื่อนไหวของเด็กทั้งหมดถูกบันทึกด้วยกล้องถ่ายวิดีโอ จากนั้นนักกายภาพบำบัด 3 คน แยกกันประเมินความสามารถของเด็กจากการดูวิดีโอโดยใช้แบบประเมิน GMFM-66 เป็นจำนวน 2 ครั้ง โดยมีระยะเวลาห่างกันหนึ่งสัปดาห์ หาค่าความเชื่อถือได้ระหว่างบุคคลและภายในบุคคลโดยคำนวณค่า intraclass correlation coefficient (ICC)*

***ผลการศึกษา:*** *การศึกษานี้พบว่ามีค่าความเชื่อถือได้อยู่ในเกณฑ์สูงมากโดยค่า ICC สำหรับความเชื่อถือได้ระหว่างบุคคลเท่ากับ 0.93 และสำหรับความเชื่อถือได้ภายในบุคคลเท่ากับ 0.99-1.00*

***สรุป:*** *ค่าความเชื่อถือได้ระหว่างบุคคลและภายในบุคคลของแบบประเมิน GMFM-66 ในการประเมินความสามารถด้านการเคลื่อนไหวที่ประเมินโดยนักกายภาพบำบัดไทยอยู่ในเกณฑ์สูงมาก ดังนั้นนักกายภาพบำบัดไทยควรนำแบบประเมิน GMFM-66 มาใช้ประเมินความสามารถด้านการเคลื่อนไหวของผู้ป่วยเด็กไทยที่มีสมองพิการในทางคลินิกได้*