

Reliability of the Test of Gross Motor Development Second Edition for Children with Down Syndrome

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Objectives: To investigate the test of gross motor development second edition (TGMD-2) test-retest, inter-rater, and intra-rater reliability for children with Down syndrome (DS).

Materials and Methods: Fifty children with DS from the School for Disabled Children, Yangon were participated in this reliability research. Before the assessment, all participants received an explanation of the TGMD-2 and saw all the skills in action. Each FMS had to be used twice for actual scoring, and each participant received one practice trial. The principal researcher videotaped and documented each participant's performance. The three raters watched and independently rated the recorded videos to assess inter-rater reliability. Test-retest reliability was assessed a second time two weeks later. For intra-rater reliability, the principal researcher reevaluated the identical video recordings from the initial evaluation four weeks later. Reliability was assessed using intraclass correlation coefficients (ICC) and Cronbach's alpha.

Results: The gross motor quotient, object control raw scores, and locomotor raw scores showed high reliability coefficients.

Conclusion: The TGMD-2 is an appropriate and highly reliable method to measure the FMS of children with DS, it can be inferred from the current findings.

Keywords: Children with Down syndrome; Reliability; TGMD-2


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INTRODUCTION

The fundamental motor skills (FMS), which include stability skills, object control skills, and locomotor skills, are the building blocks for movement and sophisticated sports and leisure activities that include the activation of muscles or muscle groups [1-5]. The FMS must possess the necessary expertise to promote the individual's holistic development, including their cognitive, social, and psychological growth [5-7]. The children's sociocultural, physical, and racial backgrounds all have

an impact on their FMS development [8-10]. Children from developing countries may have a different level of FMS proficiency [10, 11]. Because there are sociocultural, economic, and environmental differences in these countries, it should be evaluated using standardized, valid, and reliable tools [11, 12].

To evaluate a child's FMS, whether they have proficiency or not, a variety of tools are available. Among these, the test of gross motor development second edition (TGMD-2) is frequently utilized because of its

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superior psychometric features, normative values, and simplicity of use [1-5, 13]. The TGMD-2 is a process-oriented test that can be utilized as a criterion- or norm-referenced test [1]. The TGMD-2 can be used to determine whether an individual has FMS delay and to create interventional programs as well as to evaluate them [1]. Additionally, the TGMD-2 is a trustworthy, accurate, and well-standardized assessment tool to evaluate the FMS proficiency of children with and without disabilities [14]. However, without enough confirmation through other sociocultural activities, such as traditional games, cultural dances, and sports, the results from the TGMD-2 may not be suitable. Therefore, reliability and validity should be researched in emerging countries.

Several cross-cultural studies were conducted in Australia [15], Belgium [16], Brazil [17], Netherlands [18], Myanmar [19], Portugal [20], Philippines [21], and South Korea [22], to support the evidence that the TGMD-2 was a reliable tool for children with or without disabilities. According to the research that is currently available for children with Down syndrome (DS), the reliability of TGMD-2 appears to have minimal evidence.

Pediatric physiotherapists frequently face DS, the most prevalent chromosomal condition caused by an extra copy of chromosome 21 rather than chromosome 46 [23, 24]. Approximately 0.1% of live births are thought to be affected globally, and it can have an impact on people of various races, ethnicities, and socioeconomic classes [24, 25]. Children with DS and typically developing children (TDC) differed slightly in how their motor skills developed [26, 27]. Children with DS have delayed motor skill development that has been linked to phenotypic impairments like low muscle tone, hyperextensibility of the joints, poor postural control, poor balance, congenital heart disease, and obesity [24, 28]. Additionally, FMS acquired by children with DS through compensatory movements was connected to these deficits [29, 30]. The FMS proficiency level of children with DS should be assessed with standardized and reliable assessment tools. Therefore, reliability tools to assess the FMS level of children with DS were needed.

A number of studies on the reliability of the TGMD-2 in children with special needs, such as intellectual and visual impairments, have also been conducted [16, 18, 21]. Furthermore, the reliability of the TGMD-2 for Myanmar's healthy children has been investigated, while the reliability of the TGMD-2 for Myanmar's DS children has not been evaluated. Only an interrater reliability study of the children with DS was conducted as a pilot study in Myanmar [31]. Therefore, the FMS proficiency level of children with DS should be assessed with

standardized and reliable assessment tools. For children with special needs, the TGMD-2's reliability and validity were outstanding, and it has received approval in a number of nations. Although the TGMD-2 has been shown to be reliable throughout the globe, socioeconomic and cultural differences in children should be considered when using this test. Additionally, a recent systematic review advised that it was crucial to look at the reliability of TGMD for children with special needs [14]. Therefore, it is essential to look into the TGMD-2's reliability for children with DS. Thus, this study aimed to determine the inter-rater reliability, test-retest reliability, and intra-rater reliability of the children with DS in Myanmar.

MATERIALS AND METHODS

The School for Disabled Children (SDC), Yangon, served as the study area for the institutional-based observational (reliability) study. Fifty children with DS between the ages of 7 and 10 years (35 boys, 15 girls) were included in this study. Participants who could exhibit all 12 of the TGMD-2 items and who could follow two-step commands were considered for inclusion. Participants with serious neurological or medical illnesses or musculoskeletal issues were not allowed to participate. Participants who met inclusion criteria were chosen with a simple random sampling method to participate in this study. Prior to data collection, the Institutional Review Board of the University of Medical Technology, Yangon, granted the study ethical approval after taking participants' human values into account. Additionally, formal approval was also gotten from the research area's authorities. Moreover, verbal consent was obtained from the children with DS, and written informed consent was obtained from their parents or guardians.

The evaluation process for the FMS was carried out in accordance with the TGMD-2's standard operating procedures [1]. The principal researcher clarified and showed each FMS to the participants. Before beginning the evaluation, participants were given one practice trial, and they had to complete each FMS twice after that. Each FMS test was followed by a brief period of relaxation. For an accurate evaluation of all performance parameters, each child's performance was videotaped. To be able to adjust the camera's angle and orientation while recording the complete FMS performance for the assessment of locomotor skills, the camera was fixed to a tripod. The camera was placed where it would record the child's performance for the evaluation of object control skills. The principal researcher observed each

participant's FMS performance in the study area and documented it. Each participant was given 10 to 20 minutes to complete the TGMD-2 assessment.

The performance requirements for the TGMD-2 were 3-5 criteria, and it comprises 12 skills (six locomotor skills and six object control skills). The participant received a score of 1 if they were successful in doing the skill, and a score of 0 if they were unsuccessful. A skill score was calculated by adding the sum of the performance criteria's total criteria scores. Six skill scores were summed to obtain subtest raw scores. The maximum raw score for the locomotor and object control abilities subtest was 48. Standard scores were generated from the subtest's raw score (locomotor and object control standard scores). The subtest standard scores were also summed and converted to the gross motor quotient (GMQ), and the maximum GMQ was 160.

The participant's performance in this study was evaluated by three raters (physiotherapists) individually. The TGMD-2 was administered and scored by one rater who had more than seven years of experience doing it, and the other two raters were the principal researcher and another novice physiotherapist. The principal researcher had little prior experience of how to administer the TGMD-2 (having conducted pilot studies as well as having already finished training for the TGMD-2). The novice physiotherapist had already completed the TGMD-2 course but had no prior experience administering the test. For inter-rater reliability, the three raters watched and evaluated the video recordings separately. The participants performed all 12 motor skills for the second time two weeks after the first assessment. The second performance of each youngster was again captured on camera, and the principal researcher only evaluated it for test-retest reliability. After four weeks had passed since the initial evaluation, the principal researcher re-watched the identical video recordings and rated them in order to determine the intra-rater reliability.

Statistical analysis was performed by utilizing the Statistical Package for the Social Sciences (SPSS) software version (22.0) for Windows. Normality was checked by utilizing the Kolmogorov-Smirnov test. The reliability was calculated using the intra-class correlation coefficients (ICC) and Cronbach's alpha. The GMQ and locomotor and object control raw scores were calculated for the reliability testing. The significance level of 0.05 was approved. The reliability coefficient criteria were taken from Portney and Watkin, who said that ICCs of less than 0.50, between 0.50 and 0.75, and greater than 0.75 were categorized as low reliability, moderate reliability, and good reliability, respectively [32].

Cronbach's alpha was classified by George and Malery as follows: >0.9 - Excellent, >0.8 - Good, >0.7 - Acceptable, >0.6 - Questionable, >0.5 - Poor, and 0.5 - Unacceptable for the coefficient alpha size [33]. George and Malery's coefficient alpha size criterion were used in the current investigation. This manuscript follows the GRRAS guidelines [34].

RESULTS

Seventy percent of the participants were boys, accounting up the majority of the study's participants. The participants' average age was 9.44 ± 0.92 years. Almost half of the individuals (48%) were overweight.

Inter-rater reliability

Three raters evaluated the TGMD-2 for children with DS's inter-rater reliability. The inter-rater reliability statistics of the TGMD-2 are summarized in Table 1. For TGMD-2, the Cronbach's alpha and ICC values indicated excellent inter-rater reliability. The ICC for the GMQ was 0.96, the locomotor raw scores were 0.97, and the object control raw scores were 0.97. These findings showed "high" reliability when compared to the adopted criteria.

Test-retest reliability

After two weeks following the initial evaluation, the principal researcher evaluated the TGMD-2 for children with DS for test-retest reliability. Table 2 presents the data of the raw scores of the locomotor and object control skills, and the GMQ, Cronbach's alpha, and ICC for the test-retest reliability. The test-retest reliability findings showed excellent Cronbach's alpha values and good ICC values for agreement between Day 1 and Day 2 assessments.

Intra-rater reliability

After 4 weeks of initial assessment, the principal researcher evaluated the TGMD-2's intra-rater reliability for children with DS. Table 3 presents the data for the GMQ, Cronbach's alpha, and ICC for the test-retest reliability as well as the raw scores of the locomotor and object control skills as well as the mean values for these variables. The intra-rater reliability result showed strong agreement values for ICC between Assessments 1 and 2, as well as high Cronbach's alpha values. These results demonstrate "high" reliability when measured against the established standards.

Table 1. Results of inter-rater reliability test (Cronbach's alpha and ICC) n=50

FMS	Rater A	Rater B	Rater C	Cronbach's alpha	ICC	95% CI		p-value
	Mean \pm SD	Mean \pm SD	Mean \pm SD			Lower bound	Upper bound	
LRS	17.7 \pm 11.1	18.8 \pm 10.0	17.0 \pm 10.5	0.98	0.97	0.96	0.98	<0.001
OCRS	22.1 \pm 9.9	23.3 \pm 8.44	21.1 \pm 9.10	0.98	0.97	0.95	0.98	<0.001
GMQ	53.6 \pm 11.0	53.3 \pm 10.1	52.0 \pm 9.60	0.96	0.96	0.94	0.98	<0.001

FMS: Fundamental Motor Skills, ICC: Intraclass Correlation Coefficient, CI: Confidence Interval, LRS: Locomotor Raw Scores, OCRS: Object Control Raw Scores, GMQ: Gross Motor Quotient

Table 2. Results of test-retest reliability (Cronbach's alpha and ICC) n=50

FMS	Day 1	Day 2	Cronbach's alpha	ICC	95% CI		p-value
	Mean \pm SD	Mean \pm SD			Lower bound	Upper bound	
LRS	18.9 \pm 10.0	24.9 \pm 7.70	0.94	0.92	0.90	0.96	<0.001
OCRS	23.3 \pm 8.44	27.6 \pm 6.79	0.95	0.94	0.91	0.97	<0.001
GMQ	53.3 \pm 10.1	57.3 \pm 11.1	0.95	0.94	0.90	0.96	<0.001

FMS: Fundamental Motor Skills, ICC: Intraclass Correlation Coefficient, CI: Confidence Interval, LRS: Locomotor Raw Scores, OCRS: Object Control Raw Scores, GMQ: Gross Motor Quotient

Table 3 Results of intra-rater reliability (Cronbach's alpha and ICC) n=50

FMS	Assessment 1	Assessment 2	Cronbach's alpha	ICC	95% CI		p-value
	Mean \pm SD	Mean \pm SD			Lower bound	Upper bound	
LRS	18.9 \pm 10.0	24.7 \pm 7.80	0.85	0.87	0.73	0.91	<0.001
OCRS	23.3 \pm 8.44	20.7 \pm 9.93	0.84	0.86	0.73	0.91	<0.001
GMQ	53.3 \pm 10.1	53.7 \pm 10.2	0.99	0.99	0.98	0.99	<0.001

FMS: Fundamental Motor Skills, ICC: Intraclass Correlation Coefficient, CI: Confidence Interval, LRS: Locomotor Raw Scores, OCRS: Object Control Raw Scores, GMQ: Gross Motor Quotient

DISCUSSION

The TGMD-2 is one of the most widely used process-oriented, norm-referenced, as well as criterion-referenced tools for assessing the FMS proficiency of children, whether they have disabilities or not [1-5, 35]. Moreover, the TGMD-2 is only evaluating the children's gross motor skills between the ages of 3 and 10 years. It consists of six locomotor skills and six object control skills. Clinicians, physiotherapists, physical educators, and scholars needed reliable, valid, and practical FMS competency evaluation tools to give valuable evidence for clinical, educational, and research objectives [1, 14, 36]. Reliability is the core of measurement, or the measurement is how much error- and consistency-free [32]. Determining the reliability (inter-rater, intra-rater,

and test-retest reliability) of the TGMD-2 for children with DS aged 7 to 10 years old was the study's main goal.

Inter-rater reliability

Inter-rater reliability is known as the consistency or agreement in measuring scores between two or more raters of an identical group of individuals examined in similar situations [14, 32]. For evaluating the children's motor skill proficiency, the TGMD-2's inter-rater reliability was an essential psychometric property [15]. In the current study's evaluation of inter-rater reliability, the raw scores of the TGMD-2 locomotor and object control were found to have high or excellent ICC values among the three raters. The TGMD-2 was a good-to-excellent reliable tool to assess the FMS proficiency of children

with DS in Myanmar since Cronbach's Alpha for all individual TGMD-2 skills and subtest raw scores remained above 0.8. For both the locomotor and object control raw scores in the current study, the inter-rater reliability coefficient was 0.98, indicating high or excellent reliability.

The results of this study were in line with those of other previous studies, which showed good to excellent ICC values and satisfactory inter-rater reliability for the TGMD-2 in TDC or children with special needs such as VI, and ID [15, 16, 18, 19, 21, 31, 37].

Simons and colleagues discovered that the locomotor and object control subtests had excellent inter-rater reliability and agreement between two raters in their study on Flemish children with ID [16]. For Dutch children with VI, Houwen and associates reported a comparable result. They stated that the inter-rater reliability of the locomotor subtest and the object control subtest was 0.93 [18]. Additionally, Capio and coworkers showed that in the locomotor and object control subtests of Filipino children with ID, the inter-rater reliability was 0.99, which was similar to the results of the current study [21]. In addition, the results of the current study were in keeping with the previous reliability study [19]. In a study of Myanmar kindergarten children, Aye and colleagues found that the inter-rater reliability for locomotor raw scores was 0.95 and for object control raw scores was 0.88 [19].

The results of the current study were consistent with the results of the pilot study, which assessed the TGMD-2's inter-rater reliability (between two raters) in children with DS ($n = 41$), and that study was conducted at the SDC in 2019 [31]. Additionally, a recent systematic review found that in 19 out of 23 studies that evaluated the TGMD's inter-rater reliability, the raw scores of locomotor and object control as well as the GMQ showed good-to-excellent levels [14]. The results of the current study are in line with those of other investigations on children with or without disabilities because all of the studies had excellent inter-rater reliability.

Test-retest reliability

The temporal stability scores of assessment tools between two measures obtained by the same assessment tool on the same participant under the same circumstances are used to determine test-retest reliability [20, 32, 38]. It means that the test results and the retest results agree. Repeated testing will produce the same results when using a reliable tool [32].

Over time, the durability of TGMD-2 was evaluated (test-retest). For the GMQ, the raw scores of locomotor

and object control had ICC values > 0.8 , indicating high reliability. These results were similar to previous research, which showed high test-retest reliability in a variety of study populations, including TDC, children with ID, and VI [16, 18–20, 22].

According to Simon and colleagues, test-retest reliability in Flemish children with ID was 0.98 for the GMQ, 0.90 for the locomotor subset, and 0.92 for the object control subset [16]. The subjects in their study, which had a two-week test-retest reliability interval, ranged in age from 7 to 10 years old. Eight randomly selected children with ID participated in their study [16].

The test-retest reliability of the locomotor raw scores and the object control raw scores (ICC = 0.86 and 0.87, respectively) in children with VI in the Netherlands was reported by Houwen et al. [18]. Twenty-three children (6–12 years old) took part in the study, and there was a 2-week interval between the first and second assessments [18]. The results of the current study also reflected those of Aye and coworkers, who also found high test-retest reliability for the TGMD-2 for kindergarten children in Myanmar. They described that the ICC for all the FMS in their study was more than 0.75, which indicated high reliability in the test-retest reliability for Myanmar TDC [19].

Before measuring their performance, each participant should be familiar with the assessment procedures, as these could affect the validity and reliability of the results [39]. Children must first do familiarization trials for each skill before assessment trials, according to the TGMD-2 examiner's manual [1]. These results revealed that the TGMD-2's test-retest reliability was temporally stable despite various research populations and a short familiarization interval [14].

Additionally, 10 out of 15 studies that tested the TGMD-2's test-retest reliability were included in a recent systematic review. The TGMD-2 verified good to excellent test-retest reliability in their systematic review for the overall score, object control skills scores, and GMQ, and moderate to excellent test-retest reliability for the locomotor skills scores [14]. As a result, the TGMD-2 test-retest reliability values obtained in the current study were comparable to those found in other previous studies.

Intra-rater reliability

The degree of agreement measured by the same rater across two or more subsequent trials conducted under the same conditions is known as intra-rater reliability [14, 38]. Inter-rater reliability testing will improve measurement instrument accuracy and research conclusions [32]. For the raw scores of both locomotor

and object control, the ICC values of intra-rater reliability were higher than 0.8 and at acceptable levels in the current study. These findings were consistent with other research studies that were carried out on several study populations, including TDC, children with ID, and VI. These results of high intra-rater reliability are in line with previous studies that investigated the reliability of TGMD-2 in children with and without disabilities. High or excellent intra-rater reliability was present in each of these studies [14, 18, 19, 21].

The results of this study supported those of Houwen and colleagues, who found that the TGMD-2 had good intra-rater reliability in Dutch children with VI. They discovered that for the locomotor subtest, the intra-rater ICC value was 0.85, for the object control subtest, it was 0.93, and for the GMQ, it was 0.95 [18]. In their investigation, one month passed between the initial test and the follow-up examination, and this period was considered sufficient to reduce the examiners' bias to favor memory [18].

The results of the current study also substantially confirmed the findings of a previous study carried out in the Philippines by Capio and colleagues [21]. In the intra-rater reliability testing of 10 children with ID, they conveyed that for the locomotor subtest, the ICC was 0.99, for the GMQ, it was 0.99, and for the object control subtest, it was 0.99, all of which show high reliability [21]. The results of the current study were also in line with a previous study conducted by Aye et al. that demonstrated high reliability in the intra-rater reliability testing of 12 kindergarten children in Myanmar. They reported that the intra-rater ICC value for the locomotor subtest was 0.98, the object control subtest was 0.95, and the GMQ was 0.97 [19]. The time interval between the test and retest in their study was six weeks [19].

Additionally, the results of the current investigation supported the conclusions of another recent systematic review [14]. Six out of the 13 studies that looked into the TGMD-2's intra-rater reliability were determined by Rey and colleagues, to have good-to-excellent intra-rater reliability [14]. Since all of the studies had strong intra-rater reliability, the results of the current study were matched with those seen in previous studies for children with or without disabilities.

The limitations of the current study were that the participants came only from one special school, and only the principal investigator tested the test-retest and intra-rater reliability. As a result, future research should be carried out with larger sample size, different special schools in Myanmar, test-retest reliability assessments, and intra-rater reliability assessments of all raters.

CONCLUSION

The findings of this study support that the TGMD-2 has a high or excellent reliability for assessing the FMS proficiency of children with DS. The TGMD-2 is an appropriate and acceptable tool for evaluating the FMS of children with DS in Myanmar, it can be deduced from this study.

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Informed Consent Statement: Each participant in the study provided informed consent, including permission for the findings to be published. Verbal consent was obtained from the children with DS, and written informed consent was obtained from their parents or guardians.

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