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Original Article

Fundamental motor skill proficiency among 7- to 10-year-old children with Down syndrome

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Abstract. [Purpose] The purposes of this study were to assess the fundamental motor skill (FMS) of children with Down syndrome (DS) and to compare their FMS proficiencies to those of chronological age-matched and gender-matched typically developing children (TDC). [Participants and Methods] This cross-sectional study involved a total of 60 participants (30 children with DS and 30 TDC). The FMS proficiency of participants was assessed by using the test of gross motor development, second edition (TGMD-2). The data were analyzed using independent samples t-tests to verify the differences between the two groups and gender. The effect size of Cohen's d was also determined for comparing the two groups. [Results] The results showed that there were significant differences between children with DS and the TDC on locomotor and object control standard scores, and the gross motor quotient (GMQ). However, there were no significant gender-based differences in the locomotor and object control standard scores and the GMQ in both groups. [Conclusion] Based on the current results, the FMS proficiency of children with DS is lower than the TDC. Therefore, a therapeutic intervention program is necessary for children with DS to improve their FMS proficiency.

Key words: Fundamental motor skill proficiency, Test of gross motor development second edition, Children with Down syndrome

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INTRODUCTION

One of the most common chromosomal disorders all over the world is Down syndrome (DS) which can occur in all countries, all races, genders, different cultural backgrounds, and all socioeconomic statuses[1, 2)]. It is caused by an extra copy of one chromosome in chromosome number 21, therefore, it is also known as trisomy 21 and the estimated global incidence is around 0.1% of live births[3)]. The chromosomal abnormalities result in the typical phenotypes impairments, such as low muscle tone, joint hyperextensibility, poor postural control, poor balance, and congenital heart disease and obesity[2, 3)]. These impairments may be associated with the acquisition of fundamental motor skills (FMS) with compensatory movements of children with DS[4, 5)].

Proficiency in the FMS are building blocks for the movement that require the activation of muscles or muscle groups and include stability skills, object control skills, and locomotor skills[6)]. Object control skills are the transferring, catching, or propelling of objects, consisting of throwing, catching, dribbling, kicking, underhand rolling, striking, and so on. Locomotor skills are different movements to transport the body from one location to another including running, jumping, hopping, leaping, galloping, sliding, and so on[6)].

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Proficiency in the FMS is a critical factor for achieving and conserving physical activity[7] and physical fitness[8], healthier weight[9], and emerging more complex motor skills for current and later age[10]. Moreover, the FMS must have suitable proficiency to enhance the children's holistic development including cognitive, social, and psychological development[11]. Thus, the proficiency of FMS is important for every child. Even so, the number of FMS deficient children was still increasing[12].

The FMS proficiency of children from developing countries may occur differently[13]. Thus, it should be assessed with valid and reliable tools in these countries because there are socio-cultural, economic, and environmental differences[13]. Standardized FMS assessment methods for children with DS are necessary to provide detailed pieces of evidence for intervention plans[14]. There are numerous assessment tools to measure the FMS proficiency of children with or without disabilities[11].

The assessment tools can be separated into standardized (set protocol) and non-standardized (therapist selects relevant items) types[11]. The standardized assessment tools have prescribed guidelines for administration which must be followed to ensure reliability. Moreover, assessment tools can also be categorized as process-oriented or product-oriented. The FMS can be assessed using standardized process-oriented or product-oriented approaches[11, 15]. Process-oriented tools assess the quality of movements performed (e.g., demonstration of behavioral components of a skill), whereas product-oriented methods measure quantitative performance outcomes (e.g., velocity, distance)[11, 15]. Process-oriented assessments also evaluate movement skills based on anticipated patterns at each stage of development[11]. Within the discipline of motor development, the most widely used assessment tools are process-oriented assessments[11].

The standardized assessment tools also have two major types, norm-referenced type and criterion-referenced type[11, 15–17]. The norm-referenced tests are quantitative evaluations designed to compare individual values with the norm values of a representative group[11, 15–17]. The norm-referenced tests are similar to the product-oriented assessments[11]. The criterion-referenced tests are qualitative evaluations designed to compare the individuals to themselves over time[11].

There are several standardized assessment tools to assess the FMS of children with or without disabilities. Among them, the test of gross motor development, second edition (TGMD-2) (Pro-ed Inc, Austin, TX, USA) is commonly used because this tool has excellent psychometric properties and the norms values as well as easy application[6, 11, 16, 17]. The TGMD-2 is a process-oriented assessment and it can be used as a norm-referenced or criterion-referenced test[6, 11, 16, 17]. The TGMD-2 can be used to identify the individual's FMS delay or not, develop instructional/ interventional programs, evaluate the program, and research tools[6]. It has been proved that this tool has excellent reliability (α>0.80) and good content validity[6].

A considerable number of research studies have been published on the assessment of FMS in TDC and children with special needs in different countries across the globe. Deficiency in FMS development has been found in Canadian children with autism spectrum disorder (ASD)[18], children with intellectual disabilities (ID) from Finland[19], Korea[20], and Turkey[21], Singaporean children with mild learning disabilities[22], children with visual impairments (VI) from the United States[23], Netherlands[24], obese children from Iran[25], children with DS from Hong Kong[26] and children with special needs from Myanmar[27]. In all of these studies, the proficiency of FMS was measured by using TGMD-2 and all children with special needs show significantly deprived in FMS.

The FMS proficiency of the TDC was assessed by using the TGMD-2 in cross-cultural studies worldwide such as in Belgium[13], China[28], England[29], Indonesia[30], Ireland[31, 32], Japan[33], Malaysia[34], Myanmar[35], Singapore[36], South Africa[37] and so on. Particular studies focusing on the assessment of the FMS development with standardized FMS assessment tools in children with DS has still limitations. There were limited studies that have been conducted to determine the mastery level of the FMS among children with DS. Moreover, there is still a lack of facts about the standardized assessment of the FMS level in children with DS in Myanmar. The researchers hypothesized that the FMS proficiency of children with DS was different from that of TDC. Therefore, the purposes of this study were to assess the FMS of children with DS and to compare their FMS proficiencies to those of chronological age-matched and gender-matched TDC.

PARTICIPANTS AND METHODS

This cross-sectional study was conducted at the School for Disabled Children (SDC), Yangon, and No. (4) Basic Education Middle School (BEMS), Mingaladon, Yangon. A total of 60 participants (30 in each group) with a mean age of 9.20 ± 1.06 years participated in this study to investigate the differences in FMS proficiency between children with DS and TDC. There were 22 boys and 8 girls in each group. The study was conducted during a period from December 2021 to the end of January 2022. Children with DS who could follow two-step commands and who had independent walking were selected as participants. Inclusion criteria for TDC were healthy medical status certified by the official school health team and chronological age-matched (age-matched was assumed to have no more than five-month age differences) and gender-matched with children with DS. The matching ratio for children with DS and TDC was set at 1:1 to achieve 30 pair-matched TDC (chronological age-matched and gender-matched with children with DS). The participants and parents/guardians have explained the purpose, procedures, benefits, and safety measures of the study through verbal explanation and written explanation form. The written informed consent of all parents/guardians and verbal assent of all participants were taken. They all had the right to refuse participation in this study. They also had the right to withdraw from this study at any time after participation. Ethical approval for the study was obtained from the institutional review board of the University of Medical Technology, Yangon (IRB Approval No. IRB/UMTY/3-2020/004 on 20 November 2020).

The TGMD-2 was used to assess the FMS (both locomotor and object control skills) of the participants. The assessment procedure was done according to the standardized guidelines of the TGMD-2[6)]. The participants were explained and demonstrated each FMS by the researchers. They were provided one test trial before starting the assessment. They had to perform each FMS twice. The assessment of the TGMD-2 was taken at 10–20 minutes per participant and a rest period was provided between each FMS test. The FMS of the participant was assessed by watching video recordings by the two physiotherapists. The inter-rater reliability of the TGMD-2 was examined before the data collection for this study. The intraclass correlation coefficients for the TGMD-2 scores were excellent between those two physiotherapists. One physiotherapist was responsible for scoring the TGMD-2 for the TDC and the other was responsible for scoring the TGMD-2 for the children with DS. The TGMD-2 consists of 12 skills (six locomotor skills: run, gallop, hop, leap, horizontal jump, and slide and six object control skills: striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll) and the performance criteria were 3–5 criteria. If the participant could perform the skill, he/she obtained a score of 1, and if he could not perform a score of 0. The total criterion scores of performance criteria were summed to obtain a skill score. Six skill scores were summed to obtain subtest raw scores. The maximum subtest raw score was 48 for locomotor and object control skills. The subtest raw score was converted to standard scores (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 subtest raw scores were also converted to age equivalents.

The height and weight of the participants were also assessed using a stadiometer (Krups AL3, New Delhi, India) and a weighing machine (9815 V 04; Flipkart Internet Pvt Ltd, Bengaluru, Karnataka, India) in this study. Height was recorded to the nearest 0.1 cm using a stadiometer. Weight was recorded to the nearest 0.1 kg using the weighing machine. Participants wear minimal clothing (school uniform) and no shoes or slippers for the weight and height measurements. Participants were instructed to stand still in the center of the scale platform with their hands at their sides for each measurement. Participants were also instructed to stand up "tall" and to "look straight ahead". After measuring the height in centimeters and weight in kilograms, the BMI for age and the BMI percentiles for all participants were calculated in the BMI Group Calculator Metric version of the center for disease control and prevention (CDC)[38)].

The Kolmogorov–Smirnov test for normal data was used to test whether the data were normally distributed. The data were normally distributed therefore, descriptive statistics and independent samples t-tests were used to verify the differences between the two groups as well as gender. The effect size of Cohen's d was also determined for comparing the two groups. Statistical analysis was performed by using a statistical package for the social science (SPSS) software version (22.0) for Windows. The significance level was accepted as $p<0.05$.

RESULTS

The mean BMI scores (21.6 ± 2.9 kg/m^2) and BMI percentiles (91.1 ± 15.4) of children in the DS group were significantly higher than the mean BMI scores (15.9 ± 2.5 kg/m^2) and BMI percentiles (33.9 ± 28.8) of the TDC group ($p<0.001$). More than half of the TDC was healthy weight (73.3%) whereas almost all children with DS were overweight (46.7%) or obese (50%).

Table 1 displays the differences in FMS proficiency between children with DS and TDC. The statistically significant differences in the locomotor and object control raw scores, locomotor and object control standard scores, and GMQ between the two groups, were evident. Since the GMQ is an estimate of an individual's overall performance on the TGMD–2, the results ($t=-31.11$, $p<0.001$, the effect size=8.04) of the comparison of the DS and matched samples TDC are significant. The effect sizes for GMQ, locomotor, and object control standard scores were considered large effect sizes when compared with the adopted criteria[39)]. Moreover, the age equivalents for the mean locomotor and object control raw scores were between three and four years in the DS group. The age equivalents were younger than the chronological age in the DS group. The age equivalents for the mean locomotor and object control raw scores were between seven and ten years in the TDC group.

Table 1. Differences in FMS proficiency between children with DS and TDC

FMS	DS (n=30)	TDC (n=30)	95% CI		Cohen's d
			Lower bound	Upper bound	
LRS	13.2 ± 9.2	46.3 ± 2.0***	−36.6	−29.5	4.8
LSS	1.4 ± 1.0	12.1 ± 1.4***	−11.3	−10.0	8.2
OCRS	18.7 ± 9.5	44.9 ± 3.1***	−29.9	−22.4	3.6
OCSS	1.8 ± 1.4	11.3 ± 2.1***	−10.4	−8.51	5.1
GMQ	49.7 ± 6.0	110.3 ± 8.7***	−64.4	−56.6	8.0

***$p<0.001$ Significant difference tested by independent sample t-test.
Mean ± SD. FMS: Fundamental Motor Skills; DS: Down Syndrome; TDC: Typically Developing Children; CI: Confidence Interval; LRS: Locomotor Raw Score; LSS: Locomotor Standard Score; OCRS: Object Control Raw Score; OCSS: Object Control Standard Score; GMQ: Gross Motor Quotient.

Table 2 shows the results of mean FMS between the boys and the girls in children with DS and TDC groups. There were no significant differences in the locomotor standard score, object control standard score, and GMQ between the two genders in either group.

DISCUSSION

The role of physiotherapy in the management of children with DS is essential. One of the most essential aims of physiotherapy treatment for children with DS is to promote motor skills that enhance the improvement in quality of life and also allow them to participate in social life. To implement the proper therapy program, the FMS assessment is essential for these populations. All 12 FMS of TGMD-2 were assessed that skills were essential for fundamental motor function in everyday life.

The FMS levels of children with DS in this study were lower when compared with Ulrich's TGMD-2 normative data as well as with the TDC group in this study. There were significantly lower FMS (locomotor standard scores, object control standard scores, and GMQ of the TGMD-2) in the children with DS than in the TDC groups in this study. Additionally, the locomotor and object control subtest raw scores in the children with DS were less than those of the TDC. Thus, the FMS level of children with DS was poorer than that of TDC in the current study. All children with DS in this present study demonstrated a "very poor" level of FMS rank according to the GMQ of TGMD-2. However, the majority of the TDC group in this study demonstrated an "average" level and an "above average" level of FMS rank when categorized according to the descriptive ratings of TGMD-2. Moreover, the age equivalents were significantly lower than the actual chronological age in the DS group. The findings highlighted that the FMS proficiency in the children with DS was lower than their chronological ages in this study.

There are several possible explanations for these results. Malak and associates reported that children with DS were delayed in motor development due to the reduced size of the cerebrum, disorders of central nervous system (CNS) maturation, and pathophysiological process[5)]. Cognitive and structural features such as hypotonia, ligament laxity, hypermobility, and obesity in children with DS may also lead to delays in the acquisition of motor skills[3)].

The results of the present study were in agreement with those obtained by Capio and associates[26)] and Alesi and colleagues[40)] findings which showed the locomotor and object control standard scores of children with DS were lower. Capio and coworkers reported that there was a significant difference between the children with DS and TDC groups in locomotor standard scores and object control standard scores[26)]. Alesi and associates stated that the TGMD locomotor standard scores, object control standard scores, and GMQ were significant differences between the children with DS and TDC groups in Italy[40)]. Klotzbier and colleagues reported that children with DS showed lower performance in all motor dimensions of a movement assessment battery for children second edition (MABC-2) compared to TDC-mental age and TDC-same chronological age children. Significant group differences in the motor dimension of MABC-2 were found in Klotzbier and colleagues' study[41)].

Several studies explored the gender-based FMS proficiency level in different study populations that children with or without disabilities. Some studies had found that FMS did not affect boys and girls differently in this measure[26, 30, 34)]. Some studies had found no significant differences between the locomotor skills of boys and girls[35, 42)]. On the other hand, some studies had found girls to be outperformed in locomotor skills compared to boys[33, 43)] and some studies had found that the object control skills were significantly better in the boys[33, 35)]. Erign and Ozbek had found that locomotor skills, object control skills, and GMQ were significantly better in the boys[21)].

This finding was consistent with that of Bakhtiar who found that there were no gender differences in both locomotor and object control skills in Indonesian first-grade elementary students[30)]. Additionally, these results reflect those of Noordin and coworkers who found that there was no significant difference between boys and girls in both locomotor and object control skills except for overhand throw in 7 to 9 years old Malaysian TDC[34)].

Table 2. The mean FMS proficiency scores between children with DS and TDC regarding genders

FMS	DS (n=30)			TDC (n=30)		
	Boy (n=22)	Girl (n=8)	Cohen's d	Boy (n=22)	Girl (n=8)	Cohen's d
LRS	14.7 ± 9.8	9.0 ± 7.1	0.6	46.0 ± 2.1	47.0 ± 1.5	0.5
LSS	1.5 ± 1.2	1.1 ± 0.3	0.4	12.0 ± 1.6	12.5 ± 1.0	0.3
OCRS	20.4 ± 9.9	13.9 ± 6.8	0.7	44.6 ± 3.5	45.6 ± 1.6	0.3
OCSS	1.9 ± 1.6	1.5 ± 0.9	0.3	11.1 ± 2.2	11.6 ± 1.8	0.2
GMQ	50.4 ± 6.6	47.9 ± 3.5	0.4	109.5 ± 9.6	112.4 ± 5.9	0.3

Mean ± SD. FMS: Fundamental Motor Skills; DS: Down Syndrome; TDC: Typically Developing Children; LRS: Locomotor Raw Score; LSS: Locomotor Standard Score; OCRS: Object Control Raw Score; OCSS: Object Control Standard Score; GMQ: Gross Motor Quotient.

In the current study, all the children with DS were obese and overweight. Therefore, it could be assumed that the BMI status of the children with DS negatively impacted their FMS level. The results of the present study were broadly supported that the findings from previous systematic reviews and studies. A systematic review conducted by Lubans and associates reported that six of the nine studies highlighted a significant negative association between weight status and FMS proficiency in healthy children or adolescents (aged 3–18 years)[44]. Similarly, another systematic review conducted by Slotte and colleagues reported that seven of the twelve studies highlighted a significant negative association between BMI and FMS proficiency in aged 3–12 years old children[45].

Some limitations to the present study need to be acknowledged. So, the researcher would like to acknowledge a few limitations of this study. In this study, the study population was DS who attended the SDC, Yangon. It may not represent the whole DS population of Myanmar, thereby limiting the generalization of the results. Therefore, further studies are needed to investigate the FMS proficiency of the children with DS in different settings or other special education centers with a larger sample to establish the normative samples of the FMS level of Myanmar DS children. Moreover, other children with special needs such as ASD, VI, ID, and hearing impairments should also be investigated for FMS proficiency in Myanmar. In conclusion, the development of FMS in 7- to 10-year-old children with DS and TDC in Myanmar had differences in both locomotor and object control skills. The result of the current study has revealed that both boys and girls with DS could not perform FMS at the proficiency levels. It pointed out that there was a need for motor skills training, structured exercises, and practice opportunities in educational settings.

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