ORIGINAL ARTICLE

Aspects of reliability and validity of the TGMD-3 in 7-10 year old children with intellectual disability in Belgium

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Abstract

The Test of Gross Motor Development (TGMD) developed by Ulrich (1985) is one of the widely known test instruments for assessing fundamental movement skills in children. Changes were made to the new TGMD-3. A total of 19 participants (boys = 14 and girls =5) were recruited for the study from ages 7-10 years old in a special school in Belgium. The results showed an acceptable level of Cronbach's alpha internal consistency for locomotor subtest $\alpha = 0.76$, but not for ball skills subtest $\alpha = 0.60$. Spearman's rho correlations for both inter and intrarater reliability was found to be 0.85. Aspect of content validity was demonstrated using Krushkal-Wallis and it revealed age differentiation in the locomotor subtest (X^2 (df=3) = 9.401, $p < 0.05$) but not for the ball skills subtest (X^2 (df= 3) = 0.661, $p > 0.05$) and the total scale raw score (X^2 (df=3) = 7.12, p=0.07). The Spearman's rho statistics revealed acceptable value for subtest correlation with total scale raw score for the locomotor subtest (rs=0.85) and ball skill subtest (rs=0.70). In conclusion, the TGMD-3 demonstrated acceptable level of interrater and intrarater reliability and some content validity aspects. However, cautioned is needed in generalizing the results.

Key Words: Fundamental movement skills, Test of Gross Motor Development (TGMD-3), reliability, validity.

Fundamental movement skills (FMS) are common motor activities with specific observable patterns. According to Burton and Muller (1998), most skills used in sports and movement activities are the advanced version of FMS. Fundamental Movement skills are of crucial importance in the early phases of the motor learning process (Gallahue & Ozmun, 2002). Evidence supports the association between FMS competence and physical activity (Okely, Booth, & Patterson, 2001; Fisher et al. 2005; Williams et al. 2008; Houwen Hartman, Jonker & Visscher 2010; Robinson, Wadsworth & Peoples 2012). The development of FMS is not a naturally occurring process and requires sufficient time, instruction, and reinforcement by educators, parents and health professionals to ensure children are appropriately engaging in movement skills that build FMS (Stodden, Goodway, Langerdorfer, Roberton, Rudisill, Garcia & Garcia, 2008). In view of the importance of FMS in early childhood, assessment of motor

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abilities at this stage is essential for children with intellectual disability in order to monitor developmental progress and to identify obvious developmental delays, (Gallahue & Ozum, 2002), which can be use for subsequent individual educational program (IEPs; Jansma & French, 1994; Sherrill, 1986).

Researchers use a variety of motor assessment batteries in evaluating motor development in children (Zittel, 1994). Evaluation of motor skills can be performed either quantitatively or qualitatively (Goshi, Demura, Kasugu, Sato & Minami 1999; Mazzone, Mugno & Mazzone 2004). Quantitative evaluation measures speed, distance, time and frequency of movement, such as standing on one leg for 10s. Qualitative evaluation measures movement quality using a pre-set criterion such as postural alignment or stability while in single leg standing for instance (Kokubun, Haishi, Okuzumi, Hosobuchi & Koike, 1996; Largo et al 2001a, 2001b). The Test of Gross Motor Development (TGMD) evaluates children's basic motor skills from 3 to 10 years old based on specific qualitative performance criteria representing the mature pattern of each skill rather than the performance outcome, it has two domains which are the locomotor and object control (Goodway & Branta, 2003; Goodway, Crowe, & Ward, 2003; Ulrich 2000). The first edition of TGMD was originally developed and validated in the United States (Ulrich, 1985), since then it has been shown to be among the most frequently used tools in the field of adapted physical education (Burton & Muller, 1998). It has also been used for children without disabilities (Kim & Yun, 2009; Woodard & Surburg, 2001) as well as children with mild intellectual disability (Burton & Muller, 1998; Evaggelino, Tsigilis, & Papa, 2002; Simons et al, 2008). The test underwent a revision that gave birth to the TGMD-2 (Ulrich, 2000). The second edition was re-normed with 1208 American children, and validity was assessed using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Other norm studies were conducted in countries like China, Taiwan and Brazil using typical developing children that shows positive support for it validity and reliability across culture (Jing & Hong-Xia, 2007**;** Liang & Li, 2005; Wong & Cheung, 2010; Sun et al 2010; Valentini, et al. 2008). Validity and reliability of the TGMD-2 has also been reported in children with intellectual disabilities and visual disabilities (Houwen et al., 2009; Simons et al., 2008). Some studies have discovered performance differences in FMS based on gender in typically developing children with boys having higher score in object control skills than girls (Aponte, French & Sherrill, 1990; Malina

& Bouchard, 1991; Nelson, Thomas, & Abraham, 1986; Haubenstricker & Seefeldt, 1986; Langendorfer, 1986; Woodard & Surburg, 2001; Krebs, 2000; Ulrich 2000).

Recently the TGMD-2 has been revised into its third edition and therefore the aim of this present study was to investigate some of its psychometric properties. It is hypothesized that TGMD-3 (Ulrich, 2014, personal communication) would demonstrate acceptable level of acceptable level of reliability based on internal consistency, intra rater and inter rater reliability, and validity based on age differential, subtest correlation with total raw scale scores and item correlation with subtest to display acceptable content validity.

Method

Participants

A convenience sampling method was employed to recruit participants for the study. Nineteen elementary school children from ages 7 to 10 years old with intellectual disability participated in the study. Criteria for inclusion included (1) cognitive impairments (2) no physical disabilities hindering the ability to carry out the test. Basically, schools are categorized in Belgium into 8 types. In which type one is mainly for children with light intellectual disability, which makes the screening of participants somewhat easier. No information was gathered about the IQ score of each participating child as the child guidance center was not willing to communicate those due to their discretion. The participating special school where the pupils were recruited agreed to take part in the study. The children's parents were also given written informed consent, which they signed and returned back to us. The mean age of the participants was 8 years, 7 month (SD= 9 months). The mean age of the boys (n=14) is 8 years and 6 months (SD= 1 year) and for the girls (n=5), mean age is 9 years (SD= 7 months). There were 14 males and 5 females in total. Table 1 shows the summary distribution of the sample size.

Instrument

The TGMD-3 (Ulrich, 2014, personal communication) is meant for assessing FMS in children between the ages of three and ten years. In developing the TGMD-3, the following changes were made; (1) total test items are now 13, (2) change of names form object control to ball skills and one of the subtest item under ball skill was change from underhand roll to underhand throw, (3) six locomotion skills and seven ball skills, (4) inclusion of one hand strike under the ball skills subtest, exclusion of subtest item leap and inclusion of skip in the locomotor motor skills. (5) Some specific items criteria were adjusted.

The locomotor part has six-subtest item, which are run, gallop, hop, skip, horizontal jump, and slide. The ball skill contains seven subtest items namely; two-hand strike, one-hand strike, one-hand stationary dribble, two-hand catch, stationary kick, overhand throw and underhand throw. There are three performance criteria for subtest items skip, one-hand stationary dribble, two-hand strike and five performance criteria only for two-hand strike while all other subtest items has four performance criteria each. There are two trials for each skill performed by each participant's while a single researcher score their performance as 1 if performed properly or 0 if not performed according to the criterion. The scores from both trials of each criterion were added to get that criterion score and the overall criterion score for each skill were added to get each skill score. Then the score from each skill in the locomotor subtest were added to obtain the locomotor subtest raw score and the score for each skill in the ball skills subtest were added to get the ball skills subtest raw score, lastly both the total locomotor (maximum= 46) and ball skills (maximum=54)subtest raw score were added together to obtain the total scale raw score (maximum= 100).

Procedure

Two specialists in Adapted Physical Activity administered the test. They had received prior training from the test battery inventor and have been certified capable of administering it. The assessment was carried out in the school gym and a Canon G12 video camera was used to record the participants while they perform the task to enable re-assessment of their performance and reduce the frequency of contact with participants. Each child was assigned an identification number to assist with data entry as well as maintaining anonymity of the participants. Verbal instruction and demonstration were provided prior to testing but not while the testing was being carried out. As the children were performing the test, one rater was giving the verbal instruction while another rater was recording all proceedings of the test. All scoring were done by analyzing the video after the whole assessment. Each rater viewed and scores the video individually for each participant independently. For estimating intrarater reliability, one rater watched and re-scored the video recording again for each participant after at least a week interval from the initial scoring.

Table 1. Summary frequency statistics

Group	N	(%)	M in years	SD in years	Min years	Max years
Gender						
Boys	14	73.70	8.64	1.08	7	10
Girls	5	26.30	9.00	0.71	8	10
Total	19	100.00	8.73	0.23	7	10
Age (years)						
7	2	10.50	7.00	0.00		
8	6	31.60	8	0.00		
9	6	31.60	9	0.00		
10	5	26.30	10	0.00		

Note. M = mean, F = frequency, SD = standard deviation

Data Analysis

Data was analyzed using the Statistical Package for Social Sciences (SPSS version 22.0, 2013) and summarized using descriptive statistics of Mean values and Standard Deviation for gender and Age. Normality was checked with the Kolmogorov-Smirnov test. Cronbach's alpha was use to determine the degree of homogeneity of the 13 items on the TGMD-3.

Spearman rho's correlation was used to determine the degree of consistency and agreement for inter-rater and intra-rater correlation. Correlation between chronological age and subtest score and the total scale score as well as each item and its subtest score were calculated using Spearman rho correlation coefficient. The designated cut off point adopted for this study were those proposed by Fleiss (1981) and Cicchetti, Koenig, Klin, Volkmar, et al. (2011) where r is <0.40 = poor, 0.40-0.59 = fair, 0.60-0.74=good and > 0.74 = excellent.

The Kruskal-Wallis one way analysis of variance was used to determined chronological age differentiation within locomotor, ball skill subtest and total scale raw score. The Mann-Whitey-U test was done for pairwise comparison between the ages. The designated level of significance was set at $p < 0.05$ for the statistical test.

Result

Normality was checked with the Kolmogorov-Smirnov test for the subtest items and the result was considered not normally distributed and hence, non-parametric statistics was adopted.

Aspects of reliability

Internal consistency was checked by calculating the Cronbach's alpha coefficient for the TGMD-3. The result showed a fairly high alpha value for the locomotor subtest α=.76, for the ball skill subtest it was moderate α=.60, and for total scale it was also fairly high α=.76. The spearman correlation coefficient was used to calculate the inter rater and intra rater reliability.

Table 2. Spearman's rho correlation for interrater and intrarater reliability

	Inter rater		Intrarater	
	R	p	R	p
Locomotor Skill	.91	<.05	.99	<.05
Ball Skill	.83	<.05	.85	<.05
Total raw scale score	.93	<.05	.88	<.05

The above table showed the Spearman's rho correlation coefficient for the interrater and intrarater respectively. Although both reliability were excellent (Fleiss, 1981; Cicchetti, Koenig, Klin, Volkmar, Paul & Sparrow, 2011), but in most cases the intrarater reliability tends to be higher.

Aspects of content validity

A significant fair correlations were detected between chronological age and the locomotor (rs = .69, p = .01) and total raw scale score (rs = .61, p = .05) but not for ball skill subtest (rs = .20, p = .43). The chronological age differentiation were calculated using Kruskal-Wallis test and it was significant for locomotor subtests (X^2 (df=3) = 9.40, p = 0.02), but not for ball skill subtest (X^2 (df=3) = 0.66, p = 0.88) and the total raw scale score (χ^2 (df=3) = 7.12, p = 0.07).

Mann-Whitney-U pair wise comparison between ages with adjusted Bonferroni for post hoc test showed that the higher age ones performed better motor skill ability than the lower age ones for the locomotor subtest but not much age difference in ball skill subtest, see table 3.

Table 3. Mean, standard deviation, Kruskal-Wallis one-way ANOVA and post hoc across the ages

	Age 7 (n =2)		Age 8 (n=6)		Age 9 (n=6)		Age10(n=5)		X^2	p	Post hoc
	M	SD	M	SD	M	SD	M	SD			
Locomotor subtest	24.50	4.94	32.60	3.72	37.80	8.13	40.60	4.44	9.40	.02	10>9>8>7
Ball skills subtest	36.50	19.09	43.83	4.75	44.66	5.16	46.00	3.93	0.66	.88	10,9,8, >7
Total raw scale	61.00	24.04	76.50	7.42	82.50	9.37	86.60	6.30	7.12	.07	10,9,8, >7

Note. M = mean; SD = standard deviation.

The above table explained the average scores across the ages which showed that the locomotor subtest is statistically significant p < 05. This indicated that there is a difference in the locomotor score and each age category. Likewise, from the locomotor subtest mean score, it is somewhat obvious that the mean score increases as the age increased. The post hoc analysis revealed that difference exists between the locomotor scores and ages. The ball skills subtest and the total raw scale scores were not significant p > .05, so the null hypothesis of no difference is accepted in this case respectively. However, the post hoc test for ball skills subtest and total raw scale score revealed no difference exist from ages 8 to 10 years but not for age 7 years.

Inter-item correlation with subtest and subtest correlation with total raw scale score was calculated using Spearman's correlation coefficient. A good positive correlation was observed for ball skill subtest and total raw scale score (rs = .70, p = .02) and locomotor subtest and total raw scale score (rs = .84, p = .00) but not for ball skill subtest and locomotor subtest (rs = .22, p = .368), see table 4 below. The correlation between locomotor subtest and locomotor items showed that not all items correlated significantly with each other and its subtest. Likewise ball skills subtest with ball skill subtest items revealed also that not all items correlated significantly.

Table 4. Spearman's correlation between total raw score and subtest total scores

	Locomotor total	Ball skill total
Locomotor total		
Ball skill total	0.22	
Total raw scale score	0.84*	0.70*

*p<0.05

Table 5. Spearman’s correlation between locomotor total raw score and subtest total scores

	Run	Gallop	Hop	Skip	Horizontal jump	Slide
Run						
Gallop	0.57*					
Hop	0.69*	0.62*				
Skip	0.22	0.30	0.69*			
Horizontal jump	0.14	0.35	0.28	0.33		
Slide	0.61*	0.38	0.35	-0.25	-1.20	
Locomotor total	0.63*	0.74*	0.90*	0.67*	0.60*	0.34

*p<0.05

Table 6 . Spearman’s correlation between ball skills total raw score and subtest total scores

	Two hand strike	One hand strike	One hand dribble	Two hand catch	Kick	Overhand throw	Underhand throw
Two hand strike							
One hand strike	-0.20						
One hand dribble	-0.14	0.19					
Two hand catch	-0.66 *	0.16	0.33				
Kick	-0.22	-0.30	0.95*	-0.22			
Overhand throw	0.67*	0.44	0.30	-0.08	0.40		
Underhand throw	0.00	0.38	0.39	0.15	0.33	0.33	
Ball skills total	0.17	0.69*	0.34	0.51*	0.20	0.69*	0.68*

*p<0.05

The table 4 revealed that the subtest item correlation with total raw scale score were measuring the gross motor skills due to their good positive values (Fleiss, 1981), which was significant. Locomotor subtest and ball skills subtest were not significantly correlated, though it was a poor positive correlation. The poor positive value revealed that both subtest are measuring different aspects of gross motor skills.

Discussion

In this study, some psychometric properties of the TGMD-3 were examined to establish its suitability to assess fundamental movement skills in elementary school children with intellectual disability.

Findings from internal consistency of the TGMD-3 revealed acceptable alpha value for total raw scale score (α =0.77) and locomotor subtest (α = 0.76) but were low for ball skill subtest (α = 0.60). Excellent correlations were reveled for both subtest and total raw scale score with correlation higher than (α = 0.8) for interrater and intrarater reliability. According to Portney and Watkins (1993), it is more likely that an individual rater will agree consistently with him or herself than with any other rater. Our findings aligned with disposition by Portney and Watkins (1993) as the intrarater reliability were somewhat higher compared to the inter rater reliability. The rater's variability in their agreement could be attributed to individual differences in interpretation of the items scoring criteria and instruction (Parkkinen & Rintala, 2004). This result showed that the TGMD-3 is to certain extent reliable for examining fundamental movement skills in children with intellectual disability. Comparison of these results with other studies is however not possible at this time as there are no published studies yet on TGMD-3. Nevertheless, Houwen et al. (2010) and Simons et al. (2008), did a similar studies with the previous version, TGMD-2, in a similar population and reported an overall satisfactory reliability of the TGMD-2. For instance, Simons et al. (2008) reported an excellent level of interrater reliability coefficients (r = 1.00) for the TGMD-2 version in Flemish children with intellectual disabilities using Pearson's correlation coefficients.

Few aspects of validity were examined due to the very limited sample size available at the time of conducting the study, which makes some statistical calculations for validity not feasible. Nonetheless, those statistics that are reasonably achievable were calculated but the results must be interpreted with caution due to the very small sample size. We hypothesized that the TGMD-3 would demonstrate reasonable level of validity based on subtest correlation with subtest items and subtest correlation with total scale raw score. The correlation between subtest and total raw scores was excellent for locomotor subtest (r_s = .85, $p < 0.05$) and good for ball skills subtest (r_s = .70, $P < .05$), which indicates both subtests assess fundamental movement skills. Correlation between locomotor subtest items with the ball skill items showed moderate correlation that ranged from (-0.12 to 0.75). However correlation between both subtests ($r = 0.22$, $p > 0.05$) was poor. This is somewhat expected as too high correlation would mean the items are measuring the same construct (Ulrich, 2000). Hence, the observed poor correlation may indicate in part that the two subtests are not mutually exclusive. Each items correlated significantly ($p < 0.05$) with total raw scale score except the horizontal jump, slide, two hand strike, two hand catch and kick. Simons et al (2008) reported similar result as all items were significantly ($p < 0.05$) correlated with their total raw sca1e scores and subtest skill score. According to Simons et al (2008), three items namely leap ($r=0.49$, $p< 0.05$), slide ($r = 0.48$, $p < 0.05$) and catching ($r = 0.36$, $p< 0.05$) were moderately correlated with their total raw scale scores. Tab1e 5 shows that the following items based on the absolute critica1 value of rs (df =17) = 0.49, correlated unsatisfactorily with their corresponding subtest; slide ($rs = 0.34$, $p > 0.05$), two-hand strike ($rs = 0.17$, $p > 0.05$), one-hand stationary dribble ($rs = 0.34$, $p > 0.05$) and kick a stationary ball ($rs = 0.20$, $p > 0.05$). This partially agrees with the hypothesis because it was expected for all items to have good correlation with its subtest. However, there were no negative correlations observed between items and their subtest as was expected. Furthermore, we posited that there would be age differentiation in performance of fundamental movement skills, as older children will demonstrate high mastery level compare to the younger children due to its developmenta1 nature. The correlation between age, and subtest score were significant for total raw scale score ($rs = 0.62$, $p < 0.05$) and locomotor subtest ($rs = 0.70$, $p < 0.05$), but not for the ball skills subtest ($rs = 0.20$, $p > 0.05$). The Kruskal-Wallis statistic revealed significant age differentiation for the locomotor subtest (X^2 (df=3) = 9.401, $p = 0.02$) but not for the ball skills subtest (X^2 (df= 3) = 0.66, p = 0, 80) and the total raw scale score (X^2 (df=3) = 7.12, $p = 0.07$).

A post-hoc test revealed significant differences between each age group and total raw scale score with higher age groups scoring better than the lower age group. Also a significant age difference in locomotor subtest was observed but not much for the ball skill subtest. Conversely, Simons et al (2008) observed a significant age effects with the TGMD-2 for the ball skills subtest but not for the locomotor skills. Moreover we understood from the literature that as typically developing children grow older, their motor abilities improves particularly from the age 7 where there is a switch from unimodal to multimodal control of balance (Gallahue & Donnelly, 2003). Having this at heart, it is normal to expect that a valid basic motor development test should be capable of detecting such developmental changes in performance, however the population focused of our study are those of intellectual disability and as such, motor skill maturation is sometimes expected to be delayed which in turn could explain the lack of significant difference in the ball skill subtest.

The results showed that locomotor skills are attained at an earlier age better than manipulation skilIs. Gender difference couldn't be examine due to fewer sample size. Furthermore exploratory factor analysis (EFA) cannot be calculated, as the sample size does not meet the conditions for it. There are several shortcomings with this study that we acknowledged. A convenience sampling technique was employed to recruits participants and the sample size was quite very small. Future study with this group should ensure larger random sample size and also minimize distractions as much as possible as children with intellectual disability often have a short period of concentration compare with typical developing children and tend to be sensitive to environmental changes that makes them easily distracted (Simonoff, Pickles, Wood, Gringras & Chadwick., 2007). This might impede their test score, as the investigator is not allowed to give another instruction for standardized testing even if it is obvious they're doing another movement entirely. This result can therefore only be compared with participants group presenting with similar characteristics.

Conclusion

This study examined aspects of reliability and validity of the test of gross motor development-3 among children ages 7 to 10 in Belgium. Based on our findings, the TGMD-3 has to certain extent acceptable reliability and validity within the sample population with intellectual disability, although caution should be exercised in generalizing the findings. Future research should focus on exploratory factor analysis with larger sample, structural validity, test-retest reliability and established norm for Belgium.

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