CONCURRENT VALIDITY OF TGMD-2 AND TGMD-3
IN CHILDREN WITH DOWN SYNDROME

by

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ABSTRACT

The purpose of this study was to test the concurrent validity of the Test of Gross Motor Development-3 (TGMD-3) in comparison to the Test of Gross Motor Development-2 (TGMD-2) in children with Down syndrome. Motor skills of 13 children (7 with Down syndrome: 3 female, 4 male; 6 typically developing: 2 female, 4 males) were compared using the TGMD-2 and TGMD-3. Children ranged in chronological age from three to seven years (4.97 ± 1.24). Children with Down syndrome were recruited from a comprehensive early childhood program and typically developing children were recruited from a community preschool. There were no significant differences between the TGMD-2 and TGMD-3 in either locomotor (p = 0.791) or object control (p = 0.761) skills. Results from this study support the validity of the TGMD-3 in comparison to the TGMD-2.
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INTRODUCTION

Motor Development

Motor development refers to the sequential, continuous, age-related process involving both change in motor patterns and the interactions with factors, including the individual’s inherent characteristics, environment, or tasks, that underlie and cause these changes to the individual’s motor pattern (Haywood & Getchell, 2009). The contemporary view of motor development assesses motor development as an interaction between one’s genetics and the state of the environment where he or she lives (Evaggelinou, Tsigills, & Papa, 2002). Typically, motor movements are divided into two areas – gross motor and fine motor. While fine motor skills include the coordination of small muscle movements that allow the manipulation of objects, gross motor development involves controlling the large muscles of the body that help humans move within their environment (Berk, 2012). Gross motor skills are further divided into two components – locomotor skills, defined as the skills that allow an individual to move from one location to another, and object control or ballistic skills, which are skills that require an individual to apply a force to a ball or object that causes it to be projected (Rintala & Loovis, 2013; Haywood & Getchell, 2009). The acquisition of these skills is typically referred to as motor milestones. Motor milestones are fundamental skills that are evaluated based on their attainment, which allows for the achievement of later motor movements (Haywood & Getchell, 2009). These skills are typically acquired in a consistent order, though the timing may differ for each individual. Nonetheless, the skills should be attained within an average time frame, which is used as an indicator of typical development for a particular skill. In order to comprehensively determine typical
development, motor skill tests have been created to look at a child’s ability to perform a variety of locomotor and object control skills.

This understanding of motor milestones allows motor development to be viewed as a sequential process, where the acquisition of motor skills are interrelated with one another – one motor skill is the product of earlier motor achievements which then contributes to the production of new skills (Berk, 2012). Due to this relation, it is therefore vital to ensure that children acquire the motor skills they need. These skills are the foundation of human movement and interaction, as their mastery serves as building blocks for children and adolescents to participate in physical activities, including sports and games, which are fun and satisfying to an individual and allow for socialization with peers (Sun, Sun, Zhu, Huang, & Hsieh, 2011; Pang & Fong, 2009). Fundamental motor skill development has also been found to enrich an individual’s cognitive, social, and emotional development (Pang & Fong, 2009). In a similar vein, when motor skill attainment is not achieved, there are consequences across these developmental domains, which is most prominent in the motor domain. As discussed earlier, motor skills build upon one another; therefore, if a child is behind in motor skill development at an early stage, as he or she grows older, this inadequate development will continue to negatively influence his or her competence in motor activities (Sun et al., 2011). Less intuitive are the other impediments that motor delays may cause. Gross motor disabilities have been linked with impairments in cognition and social and emotional domains of development (Sun et al., 2011). In a study by Piek, Dawson, Smith, and Gasson (2008), it was found that working memory and processing speed were projected by early gross motor development, while Lopes, Santos, Pereira, and Lopes (2013) found a positive
relationship between gross motor function and academic achievement. These studies show the significance of motor performance. If a child is lagging in motor development, their learning in school may be impaired. In addition, a child’s self-esteem and self-worth may also be diminished, as Skinner and Piek (2001) found both children and adolescents with delayed motor development to have lower global self-worth than their typically developing peers. These findings show the wide effect that motor development may have on a child; too many areas of a child’s life may be comprised for the progress of a child’s motor development to be neglected.

Assessing a child’s motor development as he or she ages presents information that allows for the identification of motor deficits (Evaggelinou et al., 2002). The detection of these delays allows for an expert to plan and implement a motor program that helps improve a child’s motor ability (Wiart & Darrah, 2001). Intervention is a key way to help improve poor motor skills (Robinson, Goodway, Dunn, Johnson, & Devins, 2007). Robinson et al. (2007) performed a study which showed that preschoolers from poor, urban, and disadvantaged environments typically have low motor skill competence within both object control and locomotor skills. The study put a nine week object control intervention program into effect with this population, and after nine weeks found that these children improved in their object control skills. This study helped show the need for a way to determine if a child is developmentally delayed within the motor domain so that mediation could occur, allowing the child to improve their motor skills. Identification and intervention is, therefore, extremely important as it allows for both improved physical activity and fitness as a person grows up and ages and the ability to learn advanced motor skills (Evaggelinou et al., 2002).
Motor Development in Down Syndrome

A population that experiences these motor delays is individuals with Down syndrome. Down syndrome was first described by Dr. John Langdon Down in 1866, making it the oldest form of an intellectual disability (Tiernan, 2012). Down syndrome is the result of having an extra copy of chromosome 21, called trisomy 21, and affects about 1 out of every 733 live births, making it the most common developmental disability (Fidler, 2005; Russell, Palisano, Walter, & Rosenbaum, 2008). This high incidence may be attributed to the ability to screen for Down syndrome while the woman is still pregnant, utilizing a process known as amniocentesis which tests a small amount of amniotic fluid for chromosomal abnormalities (Fidler, 2005). This early identification allows for the tracking of development for these children over the first few years of life, which is different from other genetic disorders that are not able to be diagnosed as early.

Due to this early diagnosis, it is known that development in these individuals is negatively affected across all domains, including cognitive, physical, motor, and social-emotional (Connolly, Morgan, Russell, & Fulliton, 1993). It has been found that health, structural, and cognitive features in children with Down syndrome impedes their motor development (Jobling, 1998). Muscle hypotonia (low muscle tone), increased joint flexibility, decreased strength, short arms and legs, and ligamentous laxity (loose ligaments) are structural characteristics common in children with Down syndrome that have been found to contribute to the delayed acquisition of early motor milestones when compared with their chronologically-aged matched peers (Lauteslager, Vermeer, & Holders, 1998; Fidler, 2005). Studies have shown that even before six months of age developmental differences are noted, particularly in regards to postural control; when
postural development occurred at a slower rate, other motor milestones were achieved at a delayed rate when compared to infants and children without a developmental disability (Block, 1991; Lauteslager et al., 1998). In terms of motor milestones, walking is the skill that has been evaluated most extensively. For children with typical development, walking emerges between the ages of 9 and 17 months with an average age of 11 months, 3 weeks (Berk, 2014). However, research has shown that walking does not even emerge until as early as 15 months and as late as 74 months, with a mean age between 24 and 28 months in children with Down syndrome (Palisano et al., 2001). Even more shocking is that Palisano et al. (2001) found that only 14% of children with Down syndrome are walking by 18 months and 40% by 24 months of age (two years). In addition, health impairments, including congenital heart defects, chronic upper respiratory infections, and ear infections, have been linked to delayed physical development, specifically in regards to decreased endurance and balance (Gémus et al., 2001). This slow motor development affects children’s engagement in physical activity, which is a concern as existing research indicates that those with Down syndrome have a greater prevalence of being overweight or obese (Pitetti, Baynard, Agiovlasitis, 2013; Russell et al., 2008). Also as a result of impaired motor skills, children with Down syndrome may experience a lack of self-confidence (Jobling, 1998). Therefore, interventions to assist children with Down syndrome are essential in order to help them procure and improve gross motor skills so they can increase their independence in movement and their involvement in physical activity (Gémus et al., 2001). Tests and assessments are necessary in order to evaluate these interventions and to track the impact they have on motor function (Connolly et al., 1993).
These motor development tests and assessments are also a vital component in testing whether or not there are motor development delays. Due to the nature of Down syndrome and the impacts on physical and motor development, children with Down syndrome typically score poorly on these assessments. Simons, Daly, Theodorou, Caron, Simons, and Andoniadou (2008) reviewed the validity and reliability of the Test of Gross Motor Development, Second Edition (TGMD-2) in Flemish children with and without intellectual disabilities. Simons et al. (2008) found a significant difference, where children without an intellectual disability scored better in terms of motor development, than did the children with an intellectual disability. In another study, Hartman, Houwen, Scherder, and Visscher (2010) analyzed the gross motor ability of children with an intellectual disability in comparison to a control group which consisted of typically developing children, by utilizing the TGMD-2. This study also saw that the children with an intellectual disability scored lower on the TGMD-2 than the control group on both the locomotor and object control subtests, which are the two components that define gross motor skills. Rintala and Loovis (2013) have also confirmed this finding; in their study, their results found that on the TGMD-2 children with an intellectual disability significantly lag in motor development in comparison of their peers with typical development. The motor development of children with an intellectual disability lags so much that Rintala and Loovis found these children to earn a rating of “very poor” on the TGMD-2. In this population, children typically score lower on ball skills than in locomotor skills (Hartman et al., 2010). This may be due to the intricacy of object control skills as well as a lack of an opportunity to practice these skills; object control skills are normally practiced and involved in sports or games, which children with an
intellectual disability are less likely to participate in than their typically developing peers (Hartman et al., 2010). Overall, locomotor and object control skills are delayed in development in children with an intellectual disability.

**Motor Development Measures**

There are a variety of movement skill assessments that have been published and utilized when determining a child’s motor development progress. Cools et al. (2009) reviewed seven movement skills assessments, each of which typically target a specific group or set of skills, that is either norm- or criterion-referenced. Within the United States, four of these tests are regularly used to evaluate motor development. One of these tests, the Movement Assessment Battery for Children-2 (MABC-2), is a validated, norm-referenced, product-oriented tool, that assesses the ability of a child between the ages of three and sixteen to either complete a certain number of successful trials or complete a single task in a certain amount of time (Logan, Robinson, & Getchell, 2011). The focus of this test is to determine if an individual has a motor delay or deficiency. Another assessment, the Peabody Developmental Motor Scales – Second Edition (PDMS-2), is a norm- and criterion-referenced test that can be used as a research tool as it evaluates a child’s motor progress relative to peers, determines both fine and gross motor skills, and evaluates the progress of a child through retesting. The Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) is a norm-referenced tool used to evaluate fine and gross motor skill development in order to detect children with motor coordination deficits. The fourth assessment, the Test of Gross Motor Development, Second Edition (TGMD-2) was developed to assess and evaluate the gross motor skills of children between the ages of three and ten years (Ulrich, 2000). The TGMD-2 is a
validated, criterion- and norm-referenced test that measures gross motor development through a process-orientation (Logan et al., 2007). This test allows motor skills to be judged qualitatively based on performance criteria and not strictly based on whether or not a skill as a whole is performed correctly.

While the different motor assessments have varying strengths, the TGMD-2 is known within the motor development community as a respected instrument in the understanding of motor development, due to its ability to expose motor delays within children (Ulrich, 2000; Valentini, 2012). This test allows motor skills to be judged qualitatively by the administrator based on multiple performance criterions for each skill as laid out on a scoring form. By using this format, motor skills are not strictly judged on whether or not the skill is performed correctly as a whole; instead, each performance criterion (3-5 for each skill), which represents the process necessary to complete a skill, is individually evaluated to better determine motor development as a whole. The TGMD-2 has been extensively tested and found to be a reliable and valid instrument, as well as a norm and criterion-referenced test (Valentini, 2012). These features make the TGMD-2 one of the most frequently used tests in research within the United States, being used in a broad array of situations which includes research and clinical settings (Evaggelinou et al., 2002; Valentini 2012).

Sun, Sun, Zhu, Huang, & Hsieh (2011) used the TGMD-2 as the gold standard to establish the concurrent validity of a motor assessment, the Preschooler Gross Motor Quality Scale (PGMQ). Previously the PGMQ had shown satisfactory validity when compared with the Peabody Developmental Motor Scale-2. However, the Peabody is not a comprehensive scale when evaluating the quality of motor skills. Therefore, Sun et al.
conducted this study to evaluate the PGMQ against a gold standard of motor development. The TGMD-2 was chosen as this gold standard since it evaluates how children coordinate movement and grade based on criterion, instead of only appraising the end result; the TGMD-2 is one of the few tests that actually uses process criteria. In addition, the TGMD-2 has been used in numerous studies to assess gross motor skills in typically developing children, children with an intellectual disability, and children with Autism, making it a versatile tool.

**Project Significance**

While the TGMD-2 is currently a valid and reliable measure of motor development, it has been 15 years since the test was normed. Therefore, the developer of the test believes it needs to be updated by collecting data throughout the United States, including in Fort Worth, to represent the current population and motor development of children. Updating the TGMD-2 will allow for the third edition of the Test of Gross Motor Development (TGMD-3) to be normed and the motor development age equivalents that are produced from this test to be appraised. The objective of this study is to collect a sample of data to be contributed with the data from the rest of the United States while also answering our own research question of the concurrent validity of the TGMD-3 in comparison to the TGMD-2 in children with Down syndrome. Concurrent validity is an important aspect of an assessment tool as it exemplifies the proficiency of the new assessment (TGMD-3) to appraise the same qualities as the gold standard (TGMD-2) (Sun et al., 2011).
Purpose and Hypothesis

The purpose of this study is to test the concurrent validity of the TGMD-3 in comparison to the TGMD-2 in children with Down syndrome. It is hypothesized that the TGMD-3 will not be significantly different for children with typical development and for children with Down syndrome when compared with the TGMD-2, even with the addition and subtraction of skills on the third edition, signifying that the TGMD-3 is a valid assessment.

METHODS

Participants

Six children (4 males and 2 females) with typical development and 7 children (4 males and 3 females) with Down syndrome between the ages of three and seven years old (4.97 ± 1.24) participated in the study. Typically developing children were healthy and ambulatory, with no known physical or intellectual delay/disability. Children with Down syndrome had a formal diagnosis. Exclusion criteria included having a physical disability that limited their ability to engage in physical activity and/or an intellectual disability that limited their ability to comprehend or understand what was being asked of them.

Participants were recruited from the Fort Worth/Dallas metroplex through parent letters, word of mouth, and existing contacts. Each child gave verbal assent to participate after receiving an explanation of the study. The child gave assent by saying or expressing “yes” in some form when asked if they wanted to participate in the study; the child was also asked if he or she had any questions about the research. In addition, each child’s
parent/guardian signed a university approved consent form before beginning participation in the study.

**Instruments**

**TGMD-2**

The Test of Gross Motor Development, second edition (TGMD-2), is a standardized test that evaluates gross motor abilities that develop early in life. The test has multiple purposes: to recognize children, between the ages of three and ten, that lag considerably in gross motor development in relation to their peers; to construct a program that teaches gross motor development; to quantify the advancement of the child in motor skill development; to examine the effectiveness of the created development program; and to function as a gross motor development measure in both teaching and research scenarios (Ulrich, 2000).

Within the TGMD-2 there are two subtests – locomotor skills and object control skills. The locomotor skills subtest contains six skills – run, leap, slide, gallop, hop, and jump. Four performance criteria assess run, gallop, jump, and, while five evaluate hop and only three score leap. Object control skills subtest also contains six skills; the six skills include striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll. Four performance criteria appraise stationary dribble, kick, overhand throw, and underhand roll. Five performance criteria judge striking a stationary ball, while catch only has three performance criteria.

Children performed each skill for evaluation twice. The evaluator gave a score of 1 (performed correctly) or 0 (did not perform correctly) for each performance criterion.
The examiner then totaled the score for each skill, then summed the scores to obtain raw subtest scores for the locomotor skills and the object control skills.

**TGMD-3**

The Test of Gross Motor Development, third edition (TGMD-3) has not yet been published, but is currently in the stage of collecting normative data in order for it to gain recognition as a standardized motor skill assessment. This standardization will allow for the establishment of norms so in the future the test can to assess fundamental motor skills. As with the TGMD-2, the TGMD-3 hopes to be able to use the results from the assessment to determine if a child, aged three to ten years, is notably delayed in gross motor development when compared to their peers; devise a plan to help improve gross motor development; appraise the child’s improvement in gross motor development; assess the suitability of the plan to enhance gross motor development; and serve as an instrument to quantify gross motor development in teaching and research settings (Ulrich, 2013).

As before, there are two subscales, but the second subscale has been renamed. The first subscale is still locomotor skills, but the second is now referred to as ball skills; however, for the sake of clarity and cohesiveness in this paper, both second subscales will be referred to as object control skills. The locomotor skills still consists of six skills but has experienced change within the content of the skills; the six skills that are evaluated are run, skip, slide, gallop, hop, and jump. The locomotor skills contain four performance criteria each, except for skip which only consists of three. The object control skills now has seven skills, which comprises of overhand throw, underhand throw, catch, dribble, kick, one-hand strike, and two-hand strike. There are three
performance criteria for dribble and catch, four performance criteria for one-hand strike, kick, overhand throw, and underhand throw, and five performance criteria for two-hand strike. The differences between the TGMD-3 and the TGMD-2 are that the TGMD-3 has eliminated the leap and underhand roll skills and added skip, one-handed forehand strike, and underhand throw, bringing the total skill count up to thirteen from the previous twelve.

Similar to the TGMD-2, each skill was performed and evaluated twice. The evaluator either gave a score of 1 or 0 for each performance criterion. The examiner then totaled the performance criteria, giving a raw score for each skill, and then summed each skill to obtain a raw score for the locomotor subtest and the object control subtest.

**Equipment**

Data was collected using the examination record form for the TGMD-2 and the record form for collecting norms for the TGMD-3. Both versions of the test required manipulatives, with the TGMD-2 requiring an 8-10 inch playgroup ball, a 4 inch lightweight/plastic ball, a basketball, a tennis ball, a soccer ball, a softball, a 4-5 inch square beanbag, tape, two traffic cones, a plastic bat, and a batting tee (Ulrich, 2000). The TGMD-3 required all of the same equipment but with the addition of a light plastic paddle (Ulrich, 2013).

The locomotor skills of run, gallop, hop, horizontal jump, slide, and skip only required two cones at 60 feet, 25 feet, 15 feet, 10 feet, 25 feet, and 30 feet, respectively, to mark the start and end point for each task. Leap, another locomotor skill, required a starting point marked by tape, with a beanbag placed 10 feet away for the child to leap over. The object control skills required more equipment in order to complete the
requested task. Two-hand strike of a stationary ball required a 4 inch plastic ball, a plastic bat, and a batting tee that held the ball stationary in order for the child to hit the ball. On the TGMD-3, a tennis ball, a light plastic paddle, and a wall were required for the child to complete the task of one-handed forehand strike of a self-bounced ball. An 8-10 inch playground ball for children aged 3-5 years or a basketball for children aged 6-10 years, as well as a flat surface, was needed in order to complete the skill of one-hand stationary dribble. To complete the two-handed catch, a 4 inch plastic ball and 15 feet of clear space is required. In addition, an 8-10 inch playground or soccer ball, as well as a wall and a clear area were utilized to complete the task of kicking a stationary ball. A tennis ball and wall were used for both the overhand and underhand throw, with the overhand throw requiring 20 feet of clear space and the underhand throw only needing 15 feet. Lastly, in order to complete the underhand roll on the TGMD-2, a tennis ball for the children aged 3 to 6 and a softball for the children aged 7 to 10 were used, as well as two cones to place against the wall for the child to roll the ball between from 20 feet away.

Testing was completed in the gymnasium of the Kinderfrogs School at Texas Christian University and the gymnasium of University United Methodist Child Development Center, which both provided an area larger than 60 feet by 30 feet and a wall at which a ball was able to be thrown and kicked towards. During testing, a camera was placed to the side of the child with the entire testing field in view. This permitted scoring to occur after administration in order to allow for reliable and accurate scoring; with this procedure, the skill could be viewed multiple times, allowing for the careful evaluation of each performance criteria within a particular skill.
**Procedure**

Before beginning data collection, the investigator established reliability with an expert in this protocol. The investigator coded eight children on the TGMD-2 and four children on the TGMD-3, scoring both their locomotor and object control subscales. Testing of the children within this study did not begin until after the investigator established 80% reliability in coding for both the TGMD-2 and TGMD-3.

The TGMD-2 and TGMD-3 were administered simultaneously, by having each child perform the culmination of all 15 skills from the two tests. First the locomotor skills – run, leap, slide, skip, gallop, hop, and jump – were evaluated, followed by the object control skills – striking a stationary ball, one-hand forehand strike, stationary dribble, catch, kick, overhand throw, underhand throw, and underhand roll. All sessions were videotaped, allowing for more reliable scoring so the skills could be slowed down and viewed with more precision.

The TGMD-2 and the TGMD-3 were both administered utilizing standard protocol. For all test items, the investigator gave the child a precise demonstration of the skill in which they were being asked to perform; the demonstration included all of the performance criteria. The child was given a practice trial, followed by two scored test trials. Scoring was done using the respective criteria. Each skill has between three and five performance criteria, scored with either a 1, indicating that the child performed the skill correctly, or a 0, indicating that the child failed to correctly perform the skill for the trial. Performance criteria scores were calculated by summing the scores of trial one and two for each performance criterion. Skill scores were calculated by summing all of the performance criteria scores for each skill. The locomotor subtest raw score is calculated
by summing all locomotor skills (6 for the TGMD-2 and 6 for the TGMD-3). Likewise, the object control subtest raw score is calculated by summing all the object control skills (6 for the TGMD-2 and 7 for the TGMD-3). The raw scores were converted by using the standard scores from Appendix B of the Examiner’s Manual for the TGMD-2. The standard scores were then added for the two subtests. Appendix C was then referenced to convert the Subtest Standard Totals to the Gross Motor Quotient and Percentile (GMQ). The GMQ could convert to a range of scores from 46 to 154, and be described as very poor, poor, below average, average, above average, superior, or very superior. Lastly, Appendix D was referred to in order to determine the Age Equivalents in regards to motor development.

**Statistical Analysis**

Descriptive statistics were run for the entire sample involved in the study. An independent samples t-test was run to determine the difference between the TGMD-2 and TGMD-3. To analyze the differences between the typically developing group and children with Down syndrome, an independent samples t-test was run. In addition, we also present descriptive data to describe their performance.
RESULTS

Group statistics between the TGMD-2 and TGMD-3 for all 13 participants were analyzed, expressing mean and standard deviations for the raw score. The statistics were divided into the two distinct subtests – locomotor and object control. For locomotor skills, there were no statistical significant differences observed (p = 0.791) between the TGMD-2 (22.00 ± 8.42) and the TGMD-3 (22.92 ± 9.11), as shown in Figure 1. Object control skills also did not show a significant difference (p = 0.761) between the TGMD-2 (28.00 ± 9.50) and TGMD-3 (29.15 ± 9.60), also shown in Figure 1.

Statistics were broken down further based on group – typical development or Down syndrome. In the typical development group (n = 6), there were no significant differences observed in locomotor skills (p = 0.765) between the TGMD-2 (21.50 ± 7.79) and the TGMD-3 (23.00 ± 9.06). There were also no significant differences found within the object control skills (p = 0.900) between the TGMD-2 (29.17 ± 5.71) and the TGMD-3 (29.67 ± 7.53), as seen in Figure 2. Within the group with Down syndrome (n = 7), there were no significant differences in locomotor (p = 0.935) or object control (p = 0.794) skills between the TGMD-2 (22.43 ± 9.52; 22.86 ± 9.87) and TGMD-3 (27.00 ± 12.74; 28.71±11.69, as expressed in Figure 3.

Due to this expectation of not finding any statistical significant differences, interclass correlations were run between the TGMD-2 and TGMD-3. Between the two editions, locomotor skills had a correlation of 0.833 (p < 0.01), and object control skills showed a correlation of 0.845 (p < 0.05).
DISCUSSION

Results from this study indicate that the hypothesis (TGMD-3 will not be significantly different than the TGMD-2) is accepted. There were no significant differences observed in either subtest between the TGMD-2 and TGMD-3 (p values: locomotor=0.791, object control=0.761). Further, when the results were broken down by group, typical development and Down syndrome, still no significant differences were present between the differing editions of the TGMD. The lack of differences show the validity of the TGMD-3 in comparison to the TGMD-2. The validity of the TGMD-3 is further supported through the significant differences observed by the interclass correlations, showing the similarity between the TGMD-2 and TGMD-3. The validity of the TGMD-3 is important as it allows the test to assess motor development in children, as well as expose motor development delays in children with developmental disabilities, such as children with Down syndrome.

Looking at the performance of the skills on the two tests, qualitatively some differences can be observed (Figure 4 and 5). In terms of locomotor skills, skip replaced leap on the TGMD-3. Leap was a skill that the typically developing group performed fairly high. It was however, the skill with the lowest raw score for the children with Down syndrome, as there was low performance. This skill appeared to be a strong discriminator between children with typical development and children with Down syndrome. With the new skill, skip, the typically developing children are now performing quite poorly, with a mean raw score of 2. The children with Down syndrome are performing even worse on skip, with a mean raw score of less than 1. This low score indicates that most children with Down syndrome were unable to complete any of the
performance criteria that inherently make up the movement of a skip. A reason for these differences is that skip is a skill that requires a lot of coordination between all four limbs, which can be difficult for a younger child or a child with Down syndrome to perform.

The locomotor skill hop had a change in performance criteria between the TGMD-2 and TGMD-3. On the TGMD-2, the child had to jump and land three consecutive times on his or her dominant leg. For the TGMD-3, though, the child now has to jump and land four consecutive times on his or her dominant leg. This shift in the amount of times the child had to jump posed an issue in balance with the children with typical development.

Typically developing children performed better on the hop on the TGMD-2, but on the TGMD-3, children with Down syndrome performed better on this skill. A reason for this difference could be that children with Down syndrome wear ankle foot orthotics (AFOs) that provides stability in the ankle joint, allowing them to obtain the fourth hop.

In regards to object control skills, on the TGMD-3, underhand roll was removed and underhand throw and one-hand strike was added. Between the throw and the roll there were not any large variable differences but a few small differences. On average, children with Down syndrome were slightly outperforming the typically developing children on underhand roll, while children with typical development barely performed better than the children with Down syndrome on underhand throw. Underhand throw is inherently going to be a skill that children with typical development perform better on as it is a more advanced motor skill than roll. Children with Down syndrome may be better performing the skill of roll as it is a less coordinated task and tends to be a common way for these children to move a ball from point A to point B. One-hand strike is worthy to note on the stark performance difference between the typical development group and the
group with Down syndrome. This skill requires a lot of coordination between the upper limbs and legs. The child must bounce the ball with their non-dominant hand, while stepping with their non-dominant foot, and then time their swing of the tennis racket to hit the ball on its upward bounce. The timing and coordination that this skill requires may pose issues for a child with Down syndrome to complete this task. As a result, this skill may be a good indicator for exposing motor delays in children.

The TGMD-2 is now 15 years old, so the TGMD-3 is an imperative new edition as it is important to re-norm data every 10-15 years. Over this time, population changes can occur to where the normative data no longer aligns with motor development patterns. For those identified with a developmental disability or delay, the creation of an intervention program can help these individuals. Early intervention programs have expanded and improved over the past 15 years, so the improvements these programs create may impair an individual from receiving the benefits they need by inflating their motor development scores. Another reason for the re-norming process is that one of the criticisms of the TGMD-2 is that it was inherently too “American.” Some of the skills were activities that American children would engage in, but children in other countries would not, thus impairing their motor development score. By switching some of the skills between the TGMD-2 and TGMD-3, the hope was to make the motor skills translate better to other countries.

**Practical Implications**

Between the TGMD-2 and TGMD-3 there were some changes in skills, such as leap to skip, and some performance criteria alterations, for example hopping changing from 3 to 4 times. These changes in skills, as evidenced in Figures 4 and 5, may alter the
motor development scores. Whether those changes overall are positive and negative cannot be determined through the scope of this project. However, those changes can have implications, especially for children with developmental disabilities and delays. With the change in scores this could affect classroom placement. If scores decrease with the TGMD-3, then children who would typically be mainstreamed in school may be placed in a more restrictive environment than their needs actually warrant. An inflation in scores, though, could cause issues in receiving a referral for services and therefore affect the benefits received by a child. If scores were to increase with the TGMD-3 then a child may not be able to receive a referral for evaluation by a physical therapist (PT) or an occupational therapist (OT), who could otherwise help them develop their motor skills as needed.

**Future Directions**

In the future, it will be imperative to test the TGMD-3 against another motor development instrument. While the TGMD-2 is currently considered the gold standard of motor development assessments and therefore can provide strong internal validity to the TGMD-3, it will strengthen the validity of the TGMD-3 to test it against other valid and reliable motor development exams. Some tests that would be appropriate to test the TGMD-3 against would be the Movement Assessment Battery for Children-2 or, specifically in children with below average motor skills, such as children with Down syndrome or cerebral palsy, the Gross Motor Function Measure.
FIGURES

Figure 1

TGMD version

![Bar chart showing comparison of Locomotor raw score and Object control raw score between TGMD version 2 and TGMD version 3.](chart.png)

- **p = 0.791** for Locomotor raw score
- **p = 0.761** for Object control raw score
Figure 2

Group: Typical development

TGMD version

- TGMD version 2
- TGMD version 3

Mean

<table>
<thead>
<tr>
<th></th>
<th>Locomotor raw score</th>
<th>Object control raw score</th>
</tr>
</thead>
<tbody>
<tr>
<td>p = 0.765</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p = 0.900</td>
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<td></td>
</tr>
</tbody>
</table>
Figure 3

Group: Down syndrome

TGMD version

<table>
<thead>
<tr>
<th>TGMD version 2</th>
<th>TGMD version 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>p = 0.935</td>
<td>p = 0.794</td>
</tr>
</tbody>
</table>

Mean

Locomotor raw score | Object control raw score
Figure 4

TGMD version: 2 (Locomotor skills)

TGMD version: 3 (Locomotor skills)
Figure 5

TGMD version: 2 (Object control skills)

Group
- Typical development
- Down syndrome

TGMD version: 3 (Object control skills)

Group
- Typical development
- Down syndrome
REFERENCES


