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Concurrent validity of Preschooler Gross Motor Quality Scale with Test of Gross Motor Development-2

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ABSTRACT

Preschooler Gross Motor Quality Scale (PGMQ) was recently developed to evaluate motor skill quality of preschoolers. The purpose of this study was to establish the concurrent validity of PGMQ using Test of Gross Motor Development-2 (TGMD-2) as the gold standard. One hundred and thirty five preschool children aged from three to six years were recruited from three kindergartens in central Taiwan. Two independent evaluators who were unaware of each other's results evaluated all the children separately in their kindergartens using standardized setting and procedures. Concurrent validity was examined using correlation analysis with Pearson-Production Moment correlation coefficient. The results show that the total scores ($r = .86$, $p < .001$) and subscale total scores ($r = .82$ for locomotion, $r = .76$ for object manipulation, $p < .001$) of the two tests correlated well. Analysis of similar items in the locomotion subscale found significant but weak correlations in the running, jumping and galloping items of the two tests ($r = .23$–$.25$, $p < .001$). There were moderate to high correlations in hopping, sliding and leaping between the two tests ($r = .52$–$.70$, $p < .001$). Low to moderate correlations ($r = .37$–$.54$, $p < .001$) were found between the similar items in the object manipulation subscale of PGMQ and TGMD-2. Total scores of TGMD-2 also showed a high relation between the sum of the locomotion and object manipulation scores of PGMQ ($r = .83$, $p < .001$). The total scores of similar items in the locomotion subscale of PGMQ and TGMD-2 showed a similar high relation ($r = .79$, $p < .001$) likewise in the object manipulation subscale ($r = .75$, $p < .001$) The PGMQ proved to have adequate concurrent validity with TGMD-2.

1. Introduction

Motor skills are the foundation of human behavior and help children to learn new skills in other fields (Haywood, Brooks & Burns, 1986; Larkin & Rose, 2005). Inadequate motor skill proficiency at an early stage can negatively influence competence in physical and motor activities in later life (Gallahue & Ozmun, 2006). Motor disability impedes child development in other fields such as cognition and social interaction (Gregory, Payne, & Isaacs, 2005). Gallahue and Ozmun (2006) classified fundamental movement skills into three categories according to function: stability, locomotion and object manipulation. Single leg stance and walking on a line forward are stability skills that maintain balance in a static or dynamic condition. Skills like running and jumping are locomotion skills that enable a child to move from one point to another (Loovis

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& Butterfield, 2000). Object manipulation is the motor skill that applies or receives force from an object (Butterfield & Loovis, 1994; Goodway & Branta, 2003).

Understanding how children perform motor skills helps us to assist them in development in other fields. Payne and Isaacs (1998) stated motor evaluation was necessary for preschoolers. Motor development of preschoolers can be evaluated quantitatively or qualitatively (Mazzone, Mugno & Mazzone, 2004). Quantitative measurements evaluate distance, speed, time or frequency of motor skills. Qualitative evaluation is scored according to the criteria set for the motor skill. During qualitative evaluation, the focus is on how children perform the motor skills (Piercy & Thomas, 1998). The performance is scored according to a set of criteria that describe the mature pattern or components of the skills.

Preschooler Gross Motor Quality Scale (PGMQ) was recently developed to evaluate motor skill quality of preschoolers (Sun, Zhu, Shih, Lin & Wu, 2010). Initial validation studies show satisfactory construct validity and concurrent validity with the Peabody Developmental Motor Scale-II (PDMS-II). Moderate to high level of correlation has been found between three corresponding subscales of PGMQ and PDMS-II ($r = .605–.868$, $p < .01$) (Sun et al., 2010). PDMS-II is a comprehensive tool used in the evaluation of motor development of children (Folio & Fewell, 2000). However, only some of the items in PDMS-II evaluate quality of motor skills. For children aged from three to six years old, only one out of 11 balance skills, three out of 30 locomotion skills and three out of 16 object manipulation skills evaluate quality of performance. Therefore, it is necessary to choose a tool that mainly evaluates quality of motor skills as the gold standard to further study the concurrent validity of PGMQ.

There are only limited assessment tools available to evaluate the development and performance of motor quality for children. Most of these tools emphasize outcome and neglect the process of motor performance (Gard & Rösblad, 2009). The Alberta Infant Motor Scale (AIMS) was designed according to quality components of motor skills; nevertheless, this tool is only appropriate for infants under 18 months. The Test of Gross Motor Development-2 (TGMD-2) is a criterion- and norm-referenced instrument designed to assess gross motor development among children aged between three and 10 years of age. TGMD-2 measures how children coordinate their trunk and limbs during performance of a movement task rather than assessing the end result (for example how fast they ran, how far they threw the ball) (Ulrich, 2000).

Although TGMD-2 only contains two domains (locomotion and object manipulation) and lacks a balance aspect, TGMD-2 is preferred as the gold standard in this study because it is one of the few established instruments that use "process" characteristics of movement performance as a basis for assessing gross motor skills in preschoolers. Furthermore, TGMD-2 has been widely used in evaluating fundamental movement skills among typically developing children (Evaggelinou, Tsigilis, & Papa, 2002; Hardy, King, Farrell, Macniven, & Howlett, 2010; Williams, Pfeiffer, Dowda, Jeter, Jones, & Pate, 2009), children with intellectual disability (Hartman, Houwen, Scherder, & Visscher, 2010; Simons, Daly, Theodorou, Caron, Simons, & Andoniadou, 2007), children with developmental language disorders (Visscher, Houwen, Moolenaar, Lyons, Scherder, & Hartmen, 2010) and children with autism spectrum disorders (Staples & Reid, 2010).

The purpose of this study was to establish the concurrent validity of PGMQ and TGMD-2 in preschoolers.

2. Methods

2.1. Participants and procedures

A convenient sampling method was used to recruit participants for this study. One hundred and thirty-five preschool children (69 boys and 66 girls) aged from three to six years (mean age = 60.15 months, SD = 12.66 months) were recruited from three kindergartens in central Taiwan. Children with developmental delay or any disability that affected their motor performance were excluded from the study. Parents of participants were sent a letter explaining the study and had to sign an informed consent before their children could participate. Date of birth, gender, date of evaluation, and raw PGMQ and TGMD-2 scores of each child were collected for data analysis. Two independent evaluators who were unaware of each other's results evaluated all the children separately in the three kindergartens using PGMQ and TGMD-2 standardized setting and procedures. One evaluator administered PGMQ. This evaluator was a licensed physical therapist with four years of clinical experience in pediatric physical therapy. The other evaluator administered TGMD-2. This evaluator was a master's program student in the Graduate Institute of Rehabilitation Science at China Medical University. Both received 12 h of training and took part in practice sessions in the administration of PGMQ and TGMD-2 according to standardized procedures. Children were evaluated while playing, and positive reinforcement was used to encourage good performance. This study was approved by the Institutional Review Board of the China Medical University Hospital (DMR99-IRB-082).

To determine intra-rater reliability, four children were videotaped by one of the evaluators during the administration of the PGMQ and TGMD-2. The other evaluator viewed and scored the videotapes separately in random order. The Intra-class Correlation Coefficients (ICCs) of intra-rater reliability for both evaluators ranged from .52 to 1.00.

2.2. Materials

2.2.1. Preschooler Gross Motor Quality Scale (PGMQ)

PGMQ consists of 17 items in three subscales. The locomotion subscale consists of eight items: down stairs, running, horizontal jumping, hopping, sliding, galloping, leaping, and jumping from side to side. The object manipulation subscale consists of five items: overhand throwing, catching, kicking, ball bouncing, and striking a stationary ball. The balance subscale contains four items: single leg standing, tandem standing, walking line forward, and walking line backward. In each

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case the evaluator demonstrated how to perform the motor task first. Then the child was asked to perform the task demonstrated by the evaluator. The evaluator did not emphasize or teach the skills required for scoring the criteria, and rated the child's performance in each item according to the criteria after performance of the motor task by the child. Each criterion was scored 1 if the child demonstrated a quality component described in it, otherwise the criterion was scored 0. The total scores for PGMQ were 84, 41 in the locomotion subscale, 25 in the object manipulation subscale, and 18 in the balance subscale. A higher score represented better motor skill quality. Cronbach's alpha coefficient of PGMQ was .866. The ICCs for inter-rater and intra-rater reliability ranged from .41 to 1.00 and from .60 to 1.00, respectively (Sun et al., 2010).

2.2.2. The Test of Gross Motor Development-2 (TGMD-2)

TGMD-2 measures 12 fundamental movement skills divided evenly into locomotor (run, gallop, hop, leap, jump, and slide) and object control subtests (strike, dribble, catch, kick, throw, and roll). Each skill includes three to five performance criteria. Multiple performance criteria allow children to receive credit for any aspect of the movement skill they are able to perform. This approach provides more detailed understanding of the movement patterns children use. Scoring is based on the presence (1) or absence (0) of each performance criteria. Two trials of each skill are scored. The sum of these scores for the six skills in each subtest is the raw score, which ranges from 0 to 48 for each subtest with a higher score indicating greater proficiency. Test–retest reliability and average alpha coefficients for the locomotor subtest were $r = .88$ and $\alpha = .85$ and for the object control subtest $r = .93$ and $\alpha = .88$, respectively (Ulrich, 2000).

2.3. Statistics

Statistical analysis was performed using SPSS version 13.0 for Windows. Concurrent validity was examined using correlation analysis with Pearson-Production Moment correlation coefficient. The magnitude of each correlation analysis was interpreted using descriptive terms for the strength of correlation coefficients with correlations of .00–.25 indicating that little, if any correlation exists, whereas .26–.49, .50–.69, .70–.89, and .90–1.00 indicate a low, moderate, high and very high correlation (Domholdt, 2000). In this study p value less than .05 was set as the minimum threshold for statistical significance.

3. Results

Table 1 shows the correlations between all items of PGMQ and TGMD-2. The total scores ($r = .86$, $p < .001$) and subscale total scores ($r = .82$ for locomotion, $r = .76$ for object manipulation, $p < .001$) of the two tests correlated well.

Analysis of similar items in the locomotion subscale found significant but weak correlations in the running, jumping and galloping items of the two tests ($r = .23$–$.25$, $p < .001$). There were moderate to high correlations in hopping, sliding and

Table 1
Correlations between PGMQ and TGMD-2.

PGMQ	TGMD-2		
	Locomotion	Objection manipulation	Total score
Locomotion	.82***	.65***	.79***
Objection manipulation	.55***	.76***	.71***
Balance	.68***	.56***	.67***
Total score	.83***	.78***	.86***

*** $p < .001$.

Table 2
Correlations between the similar items in locomotion and objection manipulation subscale of PGMQ and TGMD-2.

Subscale	Correlation coefficients (r)	Number of criteria PGMQ	Number of criteria TGMD-2
Locomotion			
Running	.23**	6	4
Horizontal jumping	.23**	6	4
Hopping	.62***	5	5
Sliding	.70***	5	4
Galloping	.25**	5	4
Leaping	.52***	5	3
Objection manipulation			
Overhand throwing	.54***	5	4
Catching	.52***	6	3
Kicking	.54***	4	4
Ball bouncing	.52***	4	4
Striking a stationary ball	.37***	5	5

** $p < .01$.
*** $p < .001$.

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Table 3
Correlations between the similar items of PGMQ and TGMD-2.

PGMQ	TGMD-2		
	Locomotion (6 items)	Objection manipulation (5 items)	Total score (11 items)
Locomotion (6 items)	.79***	.59***	.76***
Objection manipulation (5 items)	.55***	.75***	.70***
Total score (11 items)	.78***	.75***	.83***

*** $p < .001$.

leaping between the two tests ($r = .52–.70$, $p < .001$). We found low to moderate correlations ($r = .37–.54$, $p < .001$) between the similar items in the object manipulation subscale of PGMQ and TGMD-2 (Table 2).

Total scores of TGMD-2 also showed a high relation between the sum of the locomotion and object manipulation scores of PGMQ ($r = .83$, $p < .001$). The total scores of similar items in the locomotion subscale of PGMQ and TGMD-2 showed a similar high relation ($r = .79$, $p < .001$) likewise in the object manipulation subscale ($r = .75$, $p < .001$) (Table 3).

4. Discussion

Concurrent validity is an important psychometric property of an assessment tool and represents the capability of a new assessment tool to evaluate the same trait as a gold standard tool. Computing the correlation of the scores of the two tools validates the correlation (Anastasi & Urbina, 1997). The total scores of PGMQ and TGMD-2 were highly correlated ($r = .86$, $p < .001$, see Table 1). The correlation of the sum score of similar items of PGMQ and TGMD-2 also reached a high level of correlation ($r = .83$, $p < .001$, see Table 3). Since TGMD-2 mainly evaluates movement quality for children aged from three to 10 years old and was used as a gold standard tool in this study, the results support our finding that PGMQ has the same capacity as TGMD-2 to evaluate the quality of movement in preschoolers.

On further examination of the correlation between subscales, locomotion of TGMD-2 correlated highest with locomotion of PGMQ ($r = .82$, $p < .001$) among the three subscales (see Table 1). The sum of the six similar items in the locomotion subscale of the two tools also reached a high level of correlation ($r = .79$, $p < .001$). This result was reasonable because locomotion subscales of the two tools were designed to gauge the same movement skills–locomotion. Object manipulation subscale of the two tools also showed the same tendency. This result again proves that the locomotion and object manipulation subscales of PGMQ assess similar movement abilities of a child as the two subscales of TGMD-2.

A previous study shows that PGMQ has satisfactory concurrent validity with PDMS-2 (Sun et al., 2010). That study verified that PGMQ was appropriate to evaluate motor development and performance in the same way as PDMS-2. The results of our study further establish the usability of PGMQ to assess the quality of motor skills.

Eleven out of 17 items in PGMQ are similar to TGMD-2. The correlations of these items between the two tools ranged from .23 to .70 (see Table 2). Significant but weak correlation between the two tools was found in running, jumping and galloping ($r = .23–.25$, $p < .001$). Only hopping, leaping and sliding reached a moderate to high level of correlation (see Table 2). After analyzing the differences between the two tools, several factors may account for the low level of correlation between them.

First of all, tasks and requirements of similar items are different. For example, the hopping item in PGMQ requires the child to hop five times within a 60 cm × 60 cm square while the hopping item in TGMD-2 requires the child to hop forward three times with either the preferred or non-preferred leg. In ball catching, PGMQ requires the child to catch the ball thrown from three meters away and TGMD-2 requires the child to catch the ball from 4.5 m. McConnell and Wade (1990) and Strohmeyer, Williams, and Schaub-George (1991) have indicated size, color, speed and trajectory of the ball, and the distance and height the ball is thrown from, will influence difficulty of ball activities.

Secondly, the equipment used by the two tools are different. For the item "Leaping", PGMQ uses a 30 cm × 60 cm mat as the target for leaping while a 12.7 cm × 12.7 cm sand bag is used in TGMD-2. We found, however, that in the TGMD-2 test children usually step over or run over the sand bag instead of leaping. Conversely, we found it is easier to facilitate a leaping movement when administering PGMQ because it is harder to step over or run over a 30 cm × 60 cm mat. For "Strike stationary ball", PGMQ uses a baseball sized plastic ball hung from a hand-held beam for striking. The evaluator could adjust the height of the ball according to the height of the child. In TGMD-2, the ball is four inches in size and placed on a T stand. Different ball size and ways to present the ball may change the striking action in this task. PGMQ used a 20 cm rubber ball for the dribbling item instead of the 8–10 in. rubber ball (3–5 year olds) or the basketball (6–10 year olds) used in TGMD-2. The weight of the ball may alter the performance of the dribbling task. In ball catching, PGMQ used a 20 cm rubber ball while TGMD-2 uses a 4 in. (10 cm) rubber ball. Our results are comparable to Yang and Jwo (1998) who found ball size changed the performance of catching. Thus instruments used in the test contribute to different performance in similar items.

Thirdly, the contents and number of scoring criteria of the two tools are different. More quality criteria are included in PGMQ. Running, horizontal jumping, sliding, galloping, leaping, overhand throwing and catching have one or two more scoring criteria in PGMQ (see Table 2). The requirements also differ. In the item "Overhand throwing", "Preferred foot steps backward before throwing" (M11) and "Hand over head before throwing" (M13) are added and modified in PGMQ. In the item "Catching", "Arms flex and hands face each other in pre-catch phase" (M21), "Distance between hands is a little bit larger than diameter of the ball" (M22) and "Arms bend after catching the ball" are different criteria when compared with the item ''Catch'' in TGMD-2. ''Ball bouncing'' (PGMQ) and ''Stationary Dribble'' (TGMD-2) both have four criteria but the criteria are different.

''Trunk leans forward'' (L24) and ''Deviated from line less than 15 cm'' (L26) are two additional criteria of ''Running'' in PGMQ. In ''Horizontal jumping'', all criteria are different except ''Both feet off the ground when jumping'' (L34). PGMQ adds ''Continuously leaps over the mat without stopping before it'' (L71) and ''Legs split in the air'' (L73) in ''Leaping''. PGMQ and TGMD-2 share the same criteria except for one additional criterion ''Does not open arms for balance'' (L53) in PGMQ.

Oslin, Mitchell, and Griffin (1998) indicated trunk stability and coordination of extremities were prerequisites for different motor skills. Movement pattern is related to the purpose and context. Although children were asked to perform similar motor skills of the two tools in this study, they would probably demonstrate different movement patterns under different requirements or conditions. This may lower the correlation of the similar items of the two tools.

Maturation may also contribute to the low level of correlation between similar items of the two tools. Since motor skills are not mature and still developing in children aged three to six years old, they may display a lot of movement variation when asked to perform similar motor skills.

Schmidt (1988) indicated practice and feedback were factors that influenced motor learning and development of motor skills. Children who received TGMD-2 first may perform better during later PGMQ evaluation. In this study, two procedures were employed to balance the learning effect. Firstly, the testing sequence was randomly assigned. Nearly half of the children received PGMQ evaluation first and the other half received TGMD-2 first. This balanced the learning effect from the evaluation of the first stage. Secondly, all children had to finish all the test items of the first tool before undergoing evaluation with the second tool.

According to the above discussion, maturation, practice, task differences, equipment and criteria may all account for the low level of correlation between similar items in this study. Nevertheless, the high level of correlation between subscales and total score of the two tools indicated that the traits inherent in PGMQ are equivalent to those in TGMD-2.

5. Conclusion

PGMQ is a standardized assessment tool with Taiwanese norms that evaluates quality of gross motor skills of preschoolers. PGMQ had adequate concurrent validity with TGMD-2.

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