

Assessment of Fundamental Movement Skills in Australian Children: The Validation of a Fundamental Motor Skills Quotient (FMSQ)

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Abstract

Objectives: The development of proficient fundamental movement skills (FMS) in children is important for physical, cognitive and social development, and to establish a foundation for an active lifestyle. Many teachers, coaches and physical activity program deliverers use real time observation of individual skill performances during physical activities to assess proficiency in young children. However, a valid method to quantify these observations to provide an overall motor competence is not available. *Design:* A small pilot validation study using the Bland Altman method to compare scores on the McCarron Assessment of Neuromuscular Development (MAND) and a Fundamental Movement Skill Quotient (FMSQ) ($M = 100$, $SD = 15$) derived from a composite score for the observed mastery of 4 skills. *Methods:* Motor competence in 50 children aged between 7 and 8 years was determined using the MAND. These scores were compared to a FMSQ derived from observation scores for the run, hop, overhand throw and jump. *Results:* The correlation between the two scores was moderate ($r = .35$, $p = .013$) and the level of agreement using the Bland Altman method was acceptable. *Conclusions:* The FMSQ is a valid measure of motor competence when observing and teaching fundamental motor skills in young children.

Key words: FMS, children, outcome assessment, motor skills, Bland Altman, motor competence, motor skill assessment

Introduction

The development of proficient fundamental movement skills (FMS), the basic building blocks for more complex and specialized movement skills and patterns, are important for children's physical, cognitive and social development, and for establishing a foundation for an active and healthy lifestyle (Booth et al., 2006; Fisher et al., 2005; Stodden et al., 2008). Competency in FMS interacts with self-perceptions of motor competence and physical fitness to predict physical activity levels and also obesity from childhood to adulthood (Barnett, Morgan, Beurden, & Beard, 2008; Stodden et al., 2008). In contrast, individuals with movement difficulties are less likely to participate in movement opportunities due to lack of enjoyment, skill and confidence (Bouffard, Watkinson, Thompson, Dunn, & Romanow, 1996), resulting in lower physical fitness (Hands & Larkin, 2006) and ultimately poorer health outcomes (Bouffard et al., 1996; Cantell, Crawford, & Doyle-Baker, 2008). Consequently, the assessment and teaching of FMS in young children is an important core component of many early childhood physical activity interventions. However, the consistent assessment of skill level by teachers and exercise professionals between

same-aged children and across time is challenging as there are few suitable tests (Hands & Larkin, 1998).

Several methods are used to assess children's performance of FMS based on either quantitative, qualitative or combined approaches. Each one has advantages and disadvantages (Hands, 2002) so the decision on how to measure children's FMS performance is best guided by the purpose of assessment. For example, FMS competence levels may be used to appropriately group a class of children, to identify children with poor skills, to plan a physical activity program, to monitor change over time, to provide feedback to the performer or to predict performance in the future (Burton & Miller, 1998).

Quantitative assessment involves measuring the product or outcome of the performance, for example the time in seconds to run 50 meters. Time is then compared to the performance of a normative group and the scores converted or transformed into relative scores such as standard scores or percentiles. This information enables the comparison of a child's performance to their chronological peers and can be used to screen for children with movement difficulties or to select participants eligible for a movement program. The objective nature of the measures generally ensures a high level of reliability over time and between raters (Spray, 1987). Further, most tests can be completed quickly with large numbers. However, the results do not inform a movement intervention or teaching program as they do not provide specific information about the proficiency of the performance (Branta, Haubenstricker, & Seefeldt, 1984). For example, if a child's 50 meter run time places them below the 10th percentile for their age, the tester may not know why. Is the slow run time due to low fitness, a short stride length, erratic arms, low knee lift or all of the above? An example of this approach is the Australian Fitness Education Award (ACHPER, 1996) and the Stay in Step screening test (Larkin & Revie, 1994).

Some FMS assessment tools use qualitative or competency-based measures which focus on the form or technique of the movement. Knudson and Morrison (1997, p. 4) define this type of assessment as "the systematic observation and introspective judgment of the quality of human movement for the purpose of providing the most appropriate intervention to improve performance." The most common approach is the 'mastery' or 'proficiency criteria' model (Clark & Phillips, 1985; Halverson & Williams, 1985; Langendorfer, 1987) where a person's performance is compared against criteria describing the proficient form of a skill. For example, noting whether the arms move in opposition to the legs, the head is stable, or the knees are lifted high while running. Such assessments can be undertaken in relatively informal and changeable settings compared to standardized tests, such as during free play, a game or a class activity. The components of the movement that are demonstrated and noted, provide useful information for a coach or teacher. However, this information does not provide an overall comparative measure of the child's motor competence as there are no normative data.

Australian researchers have used qualitative techniques to report on FMS development in children for many years (Booth et al., 1997; Booth et al., 2006; Cooley, Oakman, McNaughton, & Ryska, 1997; Walkley, Holland, Treloar, & Probyn-Smith, 1993). A range of approaches are used to interpret information collected using observation records. Some simply report the percentage of the skill criteria not observed (Booth et al., 1997) others use a 'rule of thumb' based on the number of mastered skill criteria to categorize a child's performance into a proficiency level such as beginning, developing, consolidating and generalizing (Western Australian Ministry for Education, 2004). Another approach requires assessors to use their professional judgment to identify children whose FMS performance is 'progressing towards', 'achieved' or 'working beyond' their expected level (New South Wales Department of Education

and Training, 2000). Within the 'progressing towards' category children could be identified as beginning, developing or consolidating. Finally, Walkey and colleagues (1993) and the NSW Schools Fitness and Physical Activity Survey (Booth et al., 1997) rated children as achieving mastery of a skill if all components were demonstrated or near mastery if only one component was not observed.

To the authors' knowledge, none of the approaches described above have been validated, therefore a validated test that quantifies these qualitative FMS observations would be useful (Stodden et al., 2008). Another alternative is to use an existing validated formal test such as the Test of Gross Motor Development (Ulrich, 2000) which requires more time to administer and score. One solution is to derive a composite score based on demonstrated skill criteria listed in the widely used movement observation records (Western Australian Ministry for Education, 2004; Walkley et al., 1993). Some studies have already used this approach to determine motor competence (McIntyre, 2009; Okely, Booth, & Patterson, 2001a, 2001b). McIntyre (2000) created a composite score (0 to 26) from skill observations of the run, overarm throw, standing broad jump and line walk using the Western Australian Fundamental Movement Skills Teacher Resource (Western Australian Ministry for Education, 2004). Okely et al. (2001b) summed the observed skill criteria from the Victorian Fundamental Movement Skills Manual (Victorian Department of Education, 1996) for 6 FMS; the run, vertical jump, catch, overhand throw, forehand strike and kick. As the number of criteria for each skill varied between 5 and 7, a skills index was created by standardizing each skill to a score of 5 and then summing these scores. The resultant scale could hypothetically range from 0 to 30. While both studies used the scores as a measure of motor proficiency, neither validated the process nor interpretation of the final score.

The purpose of this paper is to report the concurrent validity of a Fundamental Movement Skills Quotient (FMSQ) derived from the composite score of movement observations of four FMS, the run, overhand throw, standing broad jump and hop to measure motor competence in a small group of same-aged children. The criterion measure of motor competence was the McCarron Assessment of Neuromuscular Development (MAND)(McCarron, 1997) which is used by many Australian researchers to measure motor competence in children and adolescents (Caeyenberghs, Tsoupas, Wilson, & Smits-Engelsman, 2009; Chia, Guelfi, & Licari, 2010; Hands, Larkin, Parker, Straker, & Perry, 2009; O'Beirne, Larkin, & Cable, 1994; Piek, Dawson, Smith, & Gasson, 2008; Raynor, 2001; Rose, Larkin, & Berger, 1997). If shown to be valid, the FMSQ may be a simple and quick tool to measure movement competence in 7- to 8-year-old Australian boys and girls.

Methods

In order to establish the concurrent validity of the FMSQ, the derived quotient was compared to the score of a previously validated test of motor competence, the MAND (McCarron, 1997) in a sample of 7 - 8 year old children.

The criterion measure of motor competence, the MAND (McCarron, 1997), was developed in the United States in 1982 as a screening and evaluation tool and is suitable for children aged 3.5 years to young adults. The raw scores for each of the 10 items are converted to scaled scores ($M = 10$, $SD = 3$) according to the participant's age. The scaled scores are summed and converted to the Neuromuscular Developmental Index (NDI) which has a normal distribution ($M = 100$, $SD = 15$) (McCarron, 1997). Evidence of the content, construct, predictive and concurrent validity of the MAND is provided for this age group (McCarron,

1997). Concurrent validity of the test with the Bruininks-Oserestky Test of Motor Proficiency (Bruininks, 1978) was established by an Australian research team (Tan, Parker, & Larkin, 2001) with children aged 5 to 11 years. Several other Australian studies have validated the appropriateness of the MAND as a motor assessment tool with children (O'Beirne et al., 1994; Raynor, 2001).

The data used to derive the FMSQ were gathered using four observation records provided in the Western Australian Fundamental Movement Skills Teacher Resource (Western Australian Ministry for Education, 2004). Each skill observation record comprises a number of criteria that are considered important to perform the skill proficiently. A score of 1 is recorded for each criterion successfully demonstrated and a 0 recorded if mastery of the criterion was not displayed. The four chosen skills represent the three FMS categories of body management (hop), locomotor (run and jump) and object control (throw). The observation record for the run comprised six criteria, the overarm throw seven criteria, the standing broad jump eight criteria, and the hop eleven criteria (Figure 1). Therefore, a maximum score of 32 was possible from the sum of scores for all 4 skills.

<p>Hop (Right and left leg) = 11</p> <ol style="list-style-type: none"> 1. Support leg bends on landing then straightens to push off (R & L) 2. Takes off and lands on forefoot (R & L) 3. Swing leg moves in rhythm with support leg (R & L) 4. Able to hop on both right and left leg 5. Head and trunk stable with eyes focused forward (R & L) 6. Arms bent and move to assist leg action (R & L) 	<p>Overhand throw = 7</p> <ol style="list-style-type: none"> 1. Stands side on to directions of throw 2. Throwing arm moves in a downward and backward arc 3. Opposite foot to the throwing arm steps forward 4. Hips then shoulders rotate forward 5. Elbow bends as throwing arm moves behind the head 6. Forearm and hand lag behind upper head 7. Throwing arm follows through across body
<p>Jump for distance = 7</p> <ol style="list-style-type: none"> 1. Ankles knees and hips bend 2. Eyes focused forward 3. Arms swing behind body 4. Legs straighten 5. Both feet leave ground together 6. Arms swing forward and upward 7. Lands on both feet at same time 	<p>Sprint run = 6</p> <ol style="list-style-type: none"> 1. Feet land along a narrow path 2. Foot close to buttocks and high knee lift 3. Head and trunk stable 4. Eyes focused forward 5. Elbows bent at 90 degrees 6. Arms drive vigorously forward and backward

Figure 1: Skill criteria from observation records for each FMS. R = right L = left

A small pilot study, involving twelve 6- to 9-year-old children, was undertaken in order to refine the test protocol and the suitability of the selected skills (McIntyre, 2009). The participants were videoed performing three of the final four skills (run, jump, throw) and a line walk, as well as completed the MAND. However, when the video footage was analyzed, the line-walk failed to discriminate between performances as almost all participants' demonstrated

mastery on all skill criteria. In the subsequent phase of data collection, this task was replaced with a 5 meter hop for both right and left legs.

The participants for the main study (N = 50) were recruited from Year 2 classes from three Perth metropolitan primary schools. The sample comprised 21 males and 29 females with a mean age of 7.24 years (*SD* = .43). Ethical approval was granted for the study by the Institution’s Human Research Ethics Committee. Parental permission was received for all participants to complete the motor competency assessment for the validation study. Testing was completed by three trained researchers at the each participant’s school.

The participants completed the MAND assessment in a quiet classroom with one of the chief investigators. Each participant was individually videoed performing each of the 4 FMS on the school oval. They rotated between 4 stations (one for each skill) in small groups of 3-4. (Booth et al., 2006; Hardy, King, Espinel, Cosgrove, & Bauman, 2010) To maximize reliability, one researcher with extensive training and previous research experience in the qualitative assessment of motor skills reviewed and scored each individual’s video performance for each skill.

Table 1: Age and skill performance scores for demonstrated skill criteria for total sample and for males and females

	Total N= 50	Males n = 21	Females n = 29	Gender difference p value
Age (yrs)	7.24 (.43)	7.24 (.44)	7.24 (.44)	.98 ^a
Run (/ 6)	5.58 (.57)	5.67 (.58)	5.52(.57)	.29 ^b
Jump (/ 8)	7.32 (.89)	7.29(.96)	7.34 (.86)	.89 ^b
Throw (/7)	4.34 (1.62)	5.24 (1.58)	3.69 (1.34)	.001 ^b
Hop (/11)*	9.61 (1.75)	9.67(1.40)	9.57(1.98)	.77 ^b
NDI	104.12 (11.83)	104.43 (12.19)	103.90 (11.77)	.88 ^a
FMS quotient	100.00 (8.33)	99.98 (8.12)	100.01 (8.61)	.99 ^a

^a t-test ^b Mann-Whitney U test *n = 44

In order to increase the sample size, the data for the six children (3 boys and 3 girls) in the pilot study aged 7 and 8 years were included in the validation analysis. They did not have scores for the 5 meter hop and so they were allocated the mean score for their age and sex.

Data Analysis

The data were examined for normality using the Kolmogorov-Smirnoff test, and non-parametric tests used where appropriate to identify sex differences and the relationship between test item scores. Concurrent validity of the derived FMSQ with the NDI was examined using Pearson Product Moment Correlations and Bland Altman method (Bland & Altman, 1986). The level of significance was set at .05.

Results

Scores for both the MAND and FMS performances were available for 50 children aged 7 and 8 years. Hop data were not available for the 6 children who participated in the pilot study. The mean age, raw scores, NDI and final FMSQ are reported in Table 1 for the total sample and for males and females. There were no significant differences between males and females except for the raw score of the overhand throw ($p < .001$). Boys demonstrated mastery of more skill criteria for the throw than the girls.

To create the FMSQ, a z-score was first derived for each skill. Several methods were examined to identify the most valid process for deriving the quotient. These included examining the correlations between the MAND and the FMSQ based on z-scores for all skills ($r = .18, p = .34$), sex-specific z-scores for all skills ($r = .28, p = .046$) or a combination of both ($r = .35, p = .013$). The scores derived from the latter combination using sex-specific z-scores for the throw and run, and non sex-specific z-scores for the jump and hop were most strongly correlated with the NDI (Figure 2). This final combination accounted for 12% of the variance. A mean overall Z score was then derived from the z-scores for the 4 skills and then normalised around a mean of 100 and SD of 15 similar to an intelligence quotient or the NDI, this was called the FMSQ.

Correlations between the raw score for each FMS, the NDI and the final FMSQ are reported in Table 2. Fair to moderate positive and significant correlations were found between all FMS skills and the FMSQ but not with the NDI.

Table 2: Correlations (Spearman’s rho) between FMS raw scores, NDI and FMSQ

Item	FMSQ	Run	Throw	Jump	Hop
NDI	.348*	.096	.129	.334	.148
FMSQ		.562**	.529**	.692**	.301*
Run			.207	.264	-.174
Throw				.212	-.001
Jump					.077

* $p < .05$ ** $p < .01$

A comparison of the data for the NDI and FMSQ are presented graphically in Figure 2 using the Bland Altman method. Plot A represents the relationship (correlation) between the two quotients and Plot B represents the level of agreement. The Bland Altman method plots the average of the paired values from each measure on the x-axis and the difference of each pair on the y-axis. The upper and lower lines represent the limits of agreement (or precision) of the measures, and the middle line represents the overall mean difference or bias. Three (6%) of the data points are outliers, and exceed either the upper or lower limits of agreement. The bias of the FMSQ is - 4.12 (95% CI = -7.49, -.75), SD = 11.86 (95% limits of agreement = -27.36, 19.12), indicating the FMSQ consistently yields slightly lower scores than the NDI. Although the differences are slightly skewed, the sample distribution is approximately normal as indicated by the Kolomogorov-Smirnov test for normal distribution ($p = .20$). The regression of the Bland Altman calculated bias and mean was significant ($p = .011$) which was probably due to the 3 scores outside the Confidence Intervals.

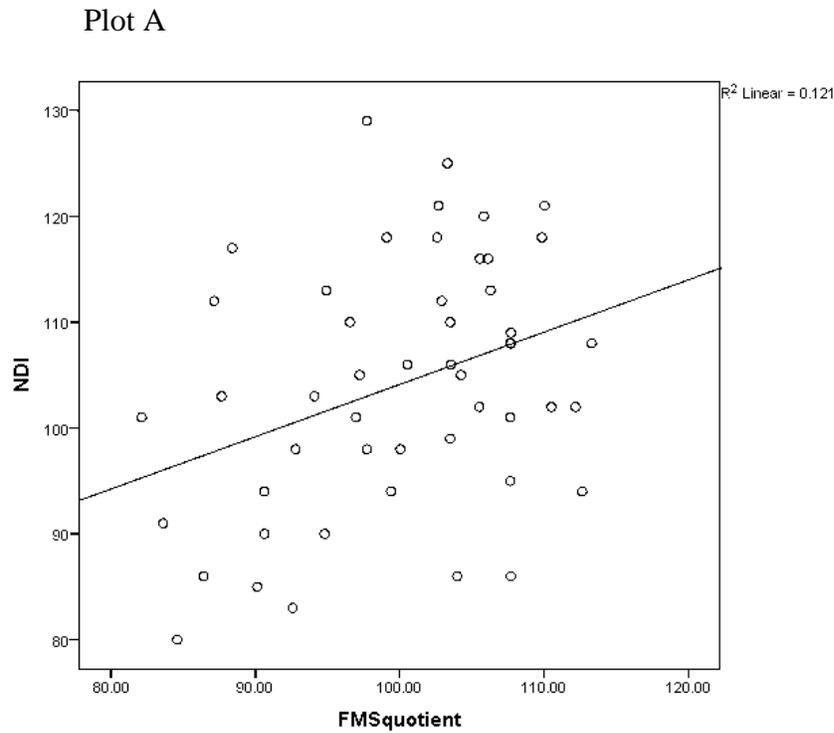


Figure 1: Skill criteria from observation records for each FMS. R = right L = left

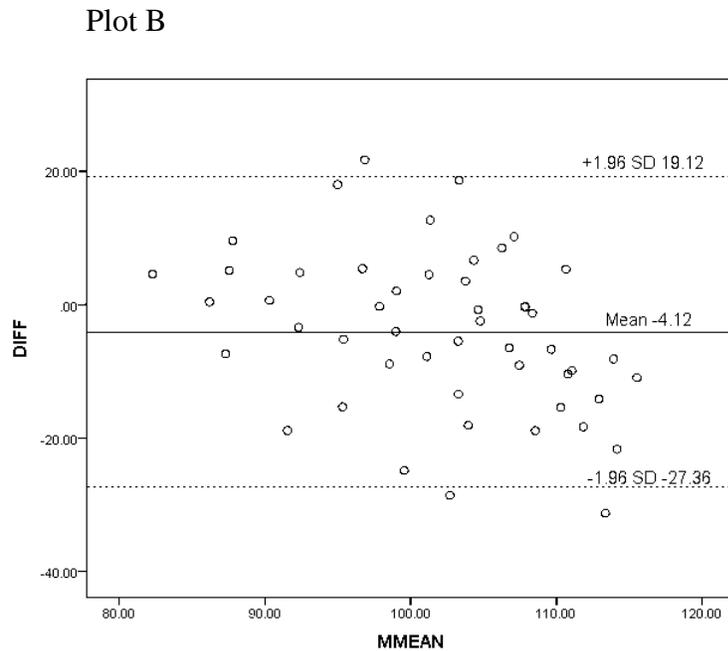


Figure 2: Correlation scatter plot with regression line fit (Plot A) and “level of agreement” between FMSQ and NDI using the Bland Altman Method (Plot B)

Discussion

Based on the results of the Pearson Product Moment Correlation and Bland Altman method, the FMSQ based on the final four skills can be considered a valid measure of motor competence when observing and teaching fundamental motor skills. The modest correlation with the MAND derived NDI was expected as the two measures, while measuring a similar construct, involve very different types of test items and assessment methodologies. The MAND is a standardized clinical test, involving both quantitative and qualitative test items, and undertaken one-on-one in a quiet indoors setting. On the other hand, the criterion-referenced movement observations of the FMS used to derive the FMSQ were undertaken outdoors, in a more informal, yet more authentic setting for teachers and coaches. Similar correlations have been reported in other studies seeking to establish concurrent validity between two different types of motor skill assessments. For example, reported correlations between parent questionnaires designed to screen children and adolescents for movement difficulties with a standardized test, the Movement ABC ranged from $r = -0.26$ (Schoemaker et al., 2006), $r = 0.34$ (Pannekoek, Rigoli, Piek, & Barrett, 2012), $r = -0.39$ (Civetta & Hillier, 2008), to $r = .59$ (Wilson, Kaplan, Crawford, Campbell, & Dewey, 2000).

The low association between test items was also confirmed with the weak correlations between the FMS raw scores and the NDI (Table 2). Further the raw scores for each skill showed weak to moderate correlations with each other, indicating a level of independence in the development of skill proficiency. This is in keeping with the understanding that simply because a child masters one motor skill, for example the run, they may not necessarily have mastered other skills. Motor competence is the ability to learn and confidently engage in a wide range of basic coordinative patterns (locomotor, object control and body management) that underpin the many sports, games and daily activities important for leading a healthy, active life (Burton & Rodgeron, 2001; Stodden et al., 2008).

The Bland Altman method revealed acceptable 'limits of agreement', although the range was quite large possibly reflecting the small sample size and great variation of the differences. Importantly, however, the differences did not vary in a systematic direction. The FMSQ could be 27 points below or 19 points above the NDI. While this range may be unacceptable for clinical purposes, in that the FMSQ should not be used to diagnose motor impairment, it is suitable as a measure of motor competence.

The FMSQ was derived using sex-specific z-scores for 2 of the 4 skills, the overhand throw and the run. Gender differences in these skills, particularly the throw, have been identified in many studies from an early age. Where the proficiency of the skill has been reported, boys have been rated as more proficient than girls for the throw (Booth et al., 2006; Hardy et al., 2010; Kelly, Reuschlein, & Haubenstricker, 1989; Nelson, Thomas, Nelson, & Abraham, 1986), and the run (Booth et al., 2006; Hardy et al., 2010).

The line walk task did not discriminate between performances among children this age, whereas the right and left leg hop task did. Young children are able to master both static and dynamic balancing tasks at a younger age than hopping tasks (Hands, Larkin, & Sheridan, 1997).

Strengths and Limitations

This is a small pilot study designed to examine the validity of a simple quotient based on movement observations derived from a widely used Australian education resource. These results provide support for the use of composite scores based on mastered skill criteria to assess motor competence. Further studies are needed to increase the sample size and the age range of the normative sample to include 6 and 9 year olds as this age range covers a crucial early childhood phase of motor development. The FMSQ is a useful measure for teachers and other professionals to assess children's motor competence in an authentic setting rather than use a formal test.

To conclude, the FMSQ has concurrent validity with the MAND and can be used as a measure of motor competence among children aged 7- to 8-years. It is an appropriate and useful method for teachers or sports coaches to determine the motor competence of their children.

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