Research article

Ecological validity of the PERF-FIT: correlates of active play, motor performance and motor skill-related physical fitness

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ABSTRACT

Background: Active games are important health enhancing physical activities in children with and without developmental disorders and will help children to develop fundamental motor skills, while inactivity exacerbates coordination difficulties and increases the risk of obesity. Regular engagement in active play promotes physical, social and cognitive development. It is therefore important to know if children have the capabilities for healthy behavior. Motor skills and muscular fitness are both important components to participate in play, sport and leisure. The Performance and Fitness (PERF-FIT) test battery integrates motor skills (running, jumping, hopping, catching, bouncing, throwing, balance) and muscular fitness (explosive power and muscular endurance) needed in many forms of active play.
Aim: To test the ecological validity of the PERF-FIT test battery; a field-based test integrating motor skill proficiency and muscular fitness.
Methods: Seventy-five children were assessed on the PERF-FIT, Movement Assessment Battery for Children (MABC)-2 and performance in 6 active games was scored. Of these children, 52 children scored in the normal range and 23 (or 30.3%) below the 16th percentile of the MABC-2. Association between the outcomes of the two tests and the 6 games was calculated.
Results: High to moderate associations were found between game scores and PERF-FIT items; moderate to low associations between game scores and MABC-2 items. Principle axes factor analysis with oblique rotation revealed communalities between the explosive power and agility items of the PERF-FIT and the running and ball catching games but not between the games and the balance items.
Conclusions and implications: Scores on the PERF-FIT are significantly related to performance in active play. The tool is able to measure aspects of motor skills, muscle endurance and explosive power needed in children's active games and could be used as an additional tool to measure requirements for participation in everyday physical activity in children with and without developmental disorders.

1. Introduction

Active play involves whole body movement resulting in energy expenditure above resting levels (Alexander et al., 2014). Regular engagement in active play (running, jumping, throwing and catching, and hopping) promotes physical, social and cognitive development (Fisher et al., 2008; Moore and Lynch, 2018; Truelove et al., 2017). Active play also increases physical activity and fitness in children (Janssen, 2014; Sattelmair and Ratey, 2009). Motor skill proficiency and physical fitness are both dimensions of active play.

Physical fitness is usually divided into two broad categories: i) health-related and ii) motor skill-related components. *Health-related physical fitness* refers to those aspects of fitness that have close relationship with positive health outcomes and include body composition, cardiovascular endurance, flexibility, muscular strength and endurance (Corbin et al., 2000; Utesch et al., 2018b). Strong evidence demonstrates that, in children, higher amounts of physical activity are associated with more favorable status for multiple health indicators, including cardiorespiratory and muscular fitness, and weight status (Chaput et al., 2020). Many well researched test batteries are available to examine health-related

physical fitness in children (e.g., the Shuttle Run test or Progressive Aerobic Cardiovascular Endurance Run (PACER) developed by the Cooper institute and included in the FITNESSGRAM and Assessing Levels of Physical Activity (ALPHA) health-related fitness test battery (Ruiz et al., 2011; Meredith and Welk (2007)). Reduced physical fitness is well documented in children with poor motor coordination in both high and low-income countries (Farhat et al., 2015; Faught et al., 2005; Ferguson et al., 2014; Lifshitz et al., 2014; Rivilis et al., 2011; Tsiotra et al., 2009).

Motor skill-related physical fitness (Caspersen et al., 1985) is made up of aspects of physical fitness and motor skills that facilitate performance in sports and active games (agility, balance, coordination, power, speed and reaction time; For detailed description see Table 1.

Motor skill competency is critical for participation in active play (Robinson, 2011). Poor motor skill competence limits children's ability to participate in everyday activities and sports. Furthermore, it also diminishes children's motivation and engagement in physical activities, which may have significant health implications (Livesey et al., 2011; Stodden et al., 2008). Children with Developmental Coordination Disorder (DCD), a common neurodevelopmental disorder, were consistently found to have lower levels of motor skill-related fitness compared to typically developing children (Smits-Engelsman et al., 2020a, b; Rivilis et al., 2011). Therefore, it is important for clinicians seeing children with lower levels of motor skills, to follow up on motor skill-related fitness to address potential adverse health effects in this group. Equally, children who have poor anaerobic capacity underperform in gross motor skills compared with their peers and lower levels of anaerobic fitness can impede further development of motor skills, like jumping or hopping and

participation in active games (e.g., hopscotch or rope jumping) (Aertssen et al., 2018). If children have lower perceptions of their athletic abilities, they are more likely to be socially isolated as a result (Noordstar and Volman, 2020; Utesch et al., 2018a). Additionally, the avoidance of physical activity can impair the child's opportunities to develop motor skills and can limit optimal performance, and will increase the risk of children with poor motor skills to become overweight and obese (Cairney et al., 2015; Muntaner-Mas et al., 2017; Ortega et al., 2008). Because higher amounts of physical activity are associated with beneficial health outcomes in children with and without motor problems, there is a critical need to find children with lower motor skill related fitness early.

Outdoor play and sport-like games in young children are characterized by short periods of intensive physical activity, interspersed with short periods of reduced or less intensive activity (Rowland, 2005; Faigenbaum et al., 2020). Both motor skills and anaerobic capacity are of importance in these activities such as throwing balls to the other end of the field or playing hopscotch (Holm et al., 2008; Rivilis et al., 2011). Children with low motor competency reportedly have lower levels of explosive muscle power and anaerobic capacity, which will lead to restrictions in participation (Aertssen et al., 2016; Hassani et al., 2014). Therefore, the EACD guideline for DCD states that assessment instruments should be used to investigate daily activities and involvement in play/leisure activities, also in natural settings (Blank et al., 2019).

Testing of anaerobic capacity in children has not received the same attention from researchers as aerobic fitness (Van Praagh and Doré, 2002). Anaerobic power and sprinting are important for functional independence in childhood but research investigating these variables is limited, particularly among pediatric populations (e.g., DCD, Attention Deficit Hyperactivity Disorder (ADHD), Fetal Alcohol Syndrome (FAS) and Learning Disabilities (LD), Pervasive Developmental Disorder (PDD); Smits-Engelsman and Bonney, 2019). This is surprising, considering that high-intensity exercises, lasting only a few seconds, represent a more "natural" pattern during active play in children than prolonged low-intensity exercises (Van Praagh, 2007; Faigenbaum et al., 2020). The motor skill and fitness gap in children with lower levels of motor skills compared to their peers is likely to increase over time and warrants intervention to help prevent health consequences. In order to help find children that do not master the foundations of physical activity, valid tools to measure integrated fundamental motor skills and anaerobic fitness are needed.

Although in most daily tasks children are primarily involved in activities that require short-term high-intensity, most of the scientific literature is devoted to the study of maximal aerobic power (Van Praagh, 2007). In a recent review, Aertssen and colleagues stated that there is limited evidence about the psychometric properties from field-based tests regarding anaerobic fitness and functional strength for children with DCD and typically developing children (Aertssen et al., 2020). This hinders physical therapists, occupational therapists, physical education teachers, and researchers in choosing the appropriate anaerobic fitness and functional strength tests for these groups of children. Furthermore, inclusion of children living in low resourced areas is rare in developmental motor skill studies. One of challenges in developing countries was that no valid and reliable motor performance tests existed that had norms for these populations. The PERF-FIT was recently developed for health and teaching professionals to measure motor skill-related physical fitness. Consistent with the World Health Organization's (WHO, 2007) International Classification of Functioning, Health and Disability, the tool was developed to measure the *"activity"* component of the WHO framework rather than the *"body structure and function"*. The rationale for this focus is the desire to detect deviations in the development of fundamental motor skills that have a functional impact in the day-to-day activities of children. The benefit of such a tool is early identification of children with deficits in fundamental movement skills and muscular fitness, as these components show a moderate to large positive relationship that strengthens with increasing age (Utesch et al., 2019). The PERF-FIT is a feasible, reliable and valid tool that measures integrated

Table 1. Definitions used for the domains of skill-related physical fitness (adapted from Caspersen et al., 1985).

Domain	Theoretical definitions	Examples of operational definitions
Agility	The ability to rapidly change the position of the entire body in space, with speed and accuracy.	The child is asked to jump side to side at high speed and with great efficiency.
Balance	The maintenance of equilibrium while stationary or in motion.	The child is asked to stand on one leg while holding on to his free foot for an extended period of time (static). The child is asked to grasp his/her unsupported foot while making slow steps in the agility ladder (dynamic) The child is asked to move his arms and trunk forward to pick up a can while standing on one leg.
Coordination	The ability to use the senses, such as sight and hearing, together with moving body parts, in performing motor tasks smoothly and accurately.	The child is asked to time arm and leg movements to perform a catch or to make consecutive jumps smoothly within borders of squares of the agility ladder.
Power	The rate at which a person can perform work (strength over time).	The child is asked to apply great force to a heavy object to make a throw or propel the whole body forwards to make a long jump.
Speed	The ability to perform a movement within a short period of time.	Running speed is tested in the agility ladder where the child is moving forward from the start line quickly to the end of the ladder, turn and run back.
Reaction time	The time elapsed between a stimulus and the beginning of the reaction to it.	Most items have a start signal to which the child has to respond; many adaptations to make a movement successful, are based on rapidly responding to a stimulus and adapt the movement to that stimulus to avoid stepping on a bar (agility items) or estimate the trajectory of a bouncing or thrown ball.

motor skills, power and muscular fitness (Smits-Engelsman et al., 2020a; Smits-Engelsman, Bonney, Neto and Jelsma, 2020b). The items of this test encompass fundamental motor skills, which gradually increase in the task demands of the tested motor skill. For instance, jumping, a common childhood activity used to assess motor development, is tested in different ways: i) as a long jump to measure power; ii) as a 30 s side jump to measure agility and muscular endurance; iii) as hopscotch jumping into squares to measure accuracy and iiii) as jumping over 4 consecutive obstacles, which not only requires muscle power but also adequate timing and accuracy.

The International Classification of Functioning, Disability and Health defines *"participation"* as 'involvement in life situations', and views participation as resulting from the interaction of individuals with their social and physical environments (WHO, 2007). In this study, we used the PERF-FIT, to measure how well the test performance relates to behavior in real-world settings, also called ecological validity (Chaytor and Schmitter-Edgecombe, 2003). In this study we compared performance of the children on meaningful active games in their current everyday environment (school play hall with other children looking and playing) to performance scores on the PERF-FIT and Movement Assessment Battery for Children test (MABC-2) (Henderson et al., 2007). The PERF-FIT items were chosen because they are close to the ones used in play and recreational activities. However, association between active play and the PERF-FIT has not been evaluated. It was hypothesized that the outcomes of active play would be related to motor skill related fitness (moderate to strong correlation) and less to items of the MABC-2 (weak to moderate correlations) since the latter instrument has been shown to be a valid tool for identifying children with motor coordination impairments (Brown and Lalor, 2009) and not for quantifying motor skill related fitness like running speed or explosive power in jumping or throwing. To gain insight into whether the PERF-FIT and active games measure comparable constructs, principle axes factor analysis was performed.

2. Methods

2.1. Study design and setting

This cross-sectional study was conducted to further validate the recently developed test battery; PERF-FIT (Smits-Engelsman, 2018). For this study, an ecological design for participation was developed, using a context that is representative for the situations where tasks are to be performed. Participants included a convenience sample of children attending mainstream elementary school in a low-income area. Because of the limited resources, structured physical education is less frequent in most schools, safe playgrounds and organized sports are hardly available in these settings.

2.2. Participants

Participants were recruited from grades 1–3 from a local primary school. Eligibility criteria were specified to include learners aged 6–9 years, and willingness to participate in the study. Children were excluded if they had any injury or physical disability that made it difficult to cope with testing procedures. Written informed consent was obtained from parents and each child provided written assent before involvement. A total of seventy–five children (36/39 boys/girls; mean age 7.2 ± 1.0 years; BMI 15.7 ± 2.3; MABC-2 9.3 ± 3.1 (range 0.5[th] - 98th percentile) volunteered for this study. Of the 75 children, 23 (30.6%) scored below the 16th percentile of the MABC-2 and the teachers reported that more than half of the children may have motor problems. No formal neurodevelopmental diagnosis was available for any of the children. Twenty percent of the children was underweight and fifteen percent overweight. For details on demographic background information see Table 2.

Table 2. Demographic background information.

Variables	Total 75 children
Boys/Girls *(n/n)*	36/39
Age (years) *Mean (SD)*	7.2 (1.0)
Weight (kg) *Mean (SD)*	24.4 (5.6)
Height (cm) *Mean (SD)*	124.2 (8.2)
Waist (cm) *Mean (SD)*	58.1 (6.2)
BMI (kg/m^2) *Mean (SD)*	15.7 (2.3)
BMI Classification *(n)* Underweight/Normal weight/Overweight	15/49/11
Waist-to-Height ratio *Mean (SD)*	0.46 (0.04)
Waist-to-Height Classification *(n)* Normal weight/Overweight	65/10
MABC-2 (standard score) *Mean (SD)*	9.33 (3.1)
Age band 1/Age band 2	27/48
MABC-2 Classification >16/≤ P16/≤ P5	52/13/10
Traffic light classification (teachers) *(n)* No motor problems/Maybe motor problems/Motor problems	35/34/6

2.3. Assessment tools

2.3.1. PERF-FIT

Given the importance of motor skill related fitness for children's future physical activity, an international group of academics developed a standardized test battery, the PERF-FIT, to assess motor skill related fitness worldwide in low resourced areas (Smits-Engelsman et al., 2018). In this tool, the most developmentally appropriate and natural ways for children to test motor skill related fitness were selected. Items in the PERF-FIT test battery were selected because no expensive materials were needed and it uses increasing levels of skills making it possible to apply the same test to all ages. The PERF-FIT comprises of various fundamental movement skills (locomotor, stability, and object control) and combines motor coordination and power and muscular endurance aspects. The test has two subscales: a Performance part with the five motor skills and a Fitness part with five *Agility and Power* items. (For item description see Table 3).

Motor Skill Performance subscale: This subscale contains five Skill Item Series of increasing difficulty. All children start at the easiest level of a Skill Item Series and a series is terminated when they do not reach the criterion number of points for the item after two trials.

Agility and power *subscale:* Children perform two trials for each item and get 15 s rest between the two trials.

Based on a feasibility study in Brazil it was concluded that the PERF-FIT test battery was easy to administer and suitable for measuring skill-related physical fitness in school-aged children living in low-income settings. It was also determined that the PERF-FIT had excellent content validity, good structural validity, excellent inter-rater reliability (ICC, 0.99) and good test-retest reliability (ICC, ≥ 0.80) (Smits-Engelsman et al., 2020a, 2020b, 2021). In a comparison study, all PERF-FIT balance tasks were significantly correlated with the MABC-2 balance sub score. The Throwing and Bouncing item series are moderately related to the MABC-2 Aiming and Catching cluster score, while the Overhand throw of the heavy bag of the PERF-FIT was not. As expected correlations of MABC-2 items were found to be moderate to low with PERF-FIT power and agility sub scale items (Smits-Engelsman et al., 2020b).

2.3.2. Movement Assessment Battery for Children test-2 (MABC-2 test)

All children completed the MABC-2 test (Henderson et al., 2007) either in age band 1 or 2. The test is divided into three components; manual dexterity, ball skills and balance tasks. Items of two age bands [i.e. *age band 1* (6-year-old children) and *age band 2* (7 to 9-year-old children)] were used, which were instructed and scored according to the MABC-2 test manual. Items of the two age bands are intended to measure the same constructs. The raw item scores were converted to

Table 3. Description of the items of the PERF-FIT.

PERF-FIT	
Items	Description
Performance subscale	
Bouncing and Catching (#)	Children bounce a tennis ball to the floor and catch it. This series involves five bouncing and catching items of increasing skill difficulty.
Throwing and Catching (#)	Children throw tennis ball in the air to at least eye level height and catch it. This series involves five throwing and catching items of increasing skill difficulty.
Jump (cm)	Children are asked to jump inside an agility ladder. This series involves four jumping items of increasing difficulty.
Hop (#)	Children are asked to hop inside an agility ladder. This series involves four hopping items of increasing difficulty for each leg.
Balance (s/#)	Children are asked to perform two static balance tasks for each leg and three dynamic balance tasks. Tasks involve knee hugging, grasping the foot and picking up cans from the floor.
Agility and Power Subscale	
Running (s)	Children are asked to run (one foot per square) in 3.5m agility ladder and run around a bottle placed at a distance of 50cm and back.
Stepping (s)	Children step with two feet in each square of a 3.5m agility ladder and run around a bottle placed at a distance of 50cm and back.
Side Jump (#)	Children are required to jump sideways in the agility ladder. The total number of correct landings in 15s is recorded.
Long Jump (cm)	Children are asked to jump forward as far as possible and land on their feet with a balanced landing.
Overhead Throw (cm)	Children kneel just behind a starting line and throw a sandbag (2kg) forward as far as possible.

standard scores for the *MABC-2 total score, manual dexterity, aiming and catching, and balance subscale scores,* to classify motor performance for the participants. The MABC-2 test is considered to have excellent psychometric properties (Brown and Lalor, 2009; Ellinoudis et al., 2011; Henderson et al., 2007; Perenboom and Chorus, 2003; Smits-Engelsman, 2010).

2.3.3. Active games

Six active games were developed for this study: *Obstacle race* and *Slalom, Sack race, Foam pad race, Cup ping pong, Flip and catch,* (For

Table 4. Description of the active games.

Active Games	
Obstacle course (s)	Running 10 m while jumping over four 15 cm high obstacles without touching them, get a ball from a cone and put it in a bucket and run back.
Slalom (s)	Running over a 5-meter super curvy slalom trajectory, using colored bottles to make narrow gates the children had to run through and at the end they had to put a ball in the bucket and run back the same slalom trajectory.
Sack race (s)	Children got inside a large burlap sack before the starting signal and had to jump over a 10-meter trajectory as fast as possible without falling.
Platform Foam (s)	Children had to cover a 10-meter distance towards a ball on a cone next to a bucket while staying on two thick closed cell foam pads, normally used for balance testing, without touching the floor with their feet. When they reached their target, they had to put a ball in the bucket to end the timing.
Flip and catch (#)	A bean bag had to be caught (10 times) after it was propelled in the air by the child firmly stepping on a small seesaw and then trying to catch it. Number of beanbags caught was counted.
Cup Ping-Pong (#)	The children had to throw a Ping-Pong ball (10 times) against the wall and catch it in a plastic beer cup in the other hand. Number of balls caught was counted.

s: measured in 0.1 seconds; # measured in number of times.

description of the games see Table 4). Games were chosen based similarities with known games and on the spread of required fundamental skills (Running and Agility, Dynamic balance, and Catching). Children were provided with verbal encouragement by the therapists and other children during the games. All games were played two times and time needed to finish a game, or the number of catches was used for the analysis. The best score of the 2 repetitions of each game was used for the analysis.

2.4. Procedure

The protocol received ethical approval from the Human Research Ethics Committee of the University of Cape Town (HREC #: 209/2018). Permission was also obtained from the principal of the school and designated education authorities in the Western Cape Province of South Africa. The PERF-FIT and MABC-2 were administered in two sessions by four trained assessors (physical and occupational therapy postgraduate students, all with at least three years working experience with children). The assessors had received a half-day training on the tests, and they practiced in small groups to obtain a solid routine. Each child received verbal instructions, demonstrations and practice trials before the actual tests were performed. This was done to ensure that participants understood the requirements of the tests.

The active games were performed in a large hall at the school in small groups (2–4 children) supervised by two physical therapists, not involved in administering the MABC-2 or PERF-FIT or the data analysis. The games were set up before the children arrived and each game was explained and practiced. All games were played two times per session and the games were divided over two sessions of 30 min each. Children were provided with verbal encouragement by the therapists and other children during the games.

2.5. Data analysis

Descriptive statistics were calculated to describe anthropometric data including age, MABC-2- and BMI classification. The data were checked for normality with the Shapiro-Wilk test. Because data on some items were skewed, relationships between the different variables were investigated with Spearman's Rank-order correlation coefficients. Relationships were calculated between the active game scores and outcomes of the PERF-FIT and MABC-2. The PERF-FIT items do not change with age, but the MABC-2 items do. To make comparison over age groups possible, the manual provides standard scores that can be compiled to subscale scores and total scores, which are corrected for age. Because game scores and PERF-FIT score were the same for all ages, the raw MABC-2 items scores (not corrected for age) were used for the correlational analysis.

To gain insight into whether the PERF-FIT and active games measure comparable constructs, principle axes factor analysis (with oblique rotation) and Kaiser-Meyer-Olkin (KMO) test was performed. The eigenvalue for extraction was set at 1. Minimum loadings of 0.4 per item were considered relevant. Data analyses were performed using SPSS (version 27.0. SPSS Inc., Chicago, IL, USA). Level of significance was established at $p \leq 0.05$.

3. Results

3.1. Associations between PERF-FIT and games

To confirm to what degree the PERF-FIT was measuring the requirements needed in active games, we compared the scores on the eleven PERF-FIT items to those on the six games. Of the 66 comparisons, 49 showed moderate and 9 showed strong associations. All items of the *Motor skill performance subscale* of the PERF-FIT, except *Jump and Static balance* items, correlated significantly with the active games. *Agility and power subscale* items correlated significantly (moderately or highly) with results on all active games. As expected, the highest associations with the

games were found with the *Throw and Catch* items of the PERF-FIT and the *Cup Ping Pong* and *Flip and Catch* games. Results are shown in Table 5.

3.2. Factor analysis PERF-FIT and games

The PERF-FIT and games variables were entered in the principle axes factor analysis. KMO value was 0.86, indicating the sampling was adequate for the factor analysis. The three factors (power and agility, precision jumps and balance), explaining 62% of the variance, emerged and Table 6 shows the factor pattern matrix, which represents the relation between the variables and the factors. The analysis revealed communalities between the PERF-FIT explosive power and agility items (*Long Jump and Overhand Throw*), performance items (*Throw and Bounce*) and the scores on the games. Remarkably, the *Side jumping, Jumping and Hopping* in squares and *Balance* (*static* and slow *dynamic balance)* did not correlate with factor in which the games loaded, but clustered in two separate factors (precision jumps and balance).

3.3. Associations between MABC-2 and games

As hypothesized, the correlations between MABC-2 items scores and the games were moderate to low (See Table 7). For age band 1, 13 of the 60 calculated correlations were moderate and significant. Against expectations, 8 of these significant correlations were with manual dexterity items. For Age band 2, significant moderate correlations were found for 10 out of 66 tested associations. Of the manual dexterity items, the *Drawing trail* was correlated with two games (*Slalom and, Flip and Catch*) in the older children.

The other finding was that the MABC-2 items, which significantly correlated with the game scores, were different for age band 1 and 2 items, except for item 5 (*Throwing bean bag on the mat*) and the moving on *Platform foams* game, and for item 7 (*Standing on 1 leg*) and *Flip and catch*. While, in the 6-year-old children, significant correlations were found with the manual dexterity items and *Obstacles, Foam Platforms, Slalom, and Flip and Catch*. None of these associations were significant in older children.

4. Discussion

There is a paucity of literature on motor skill and fitness related prerequisites for participation in leisure activities in children with and

Table 5. Correlations between PERF-FIT items and performance scores on the active games.

PERF-FIT	Active games					
Item	Obstacle	Platform Foam	Slalom	Sack race	Ping Pong	Flip and Catch
Bouncing and catching	-.645**	-.536**	-.598**	-.491**	.631**	.720**
Throwing and catching	-.567**	-.589**	-.625**	-.484**	.563**	.608**
Jump	-.221	-.155	-.211	-.117	.162	.195
Hopping	-.502**	-.466**	-.565**	-.524**	.407**	.580**
Static Balance	-.257*	-.289*	-.203	-.260*	.412**	.259*
Dynamic Balance	-.404**	-.369**	-.453**	-.417**	.386**	.504**
Running	.511**	.465**	.451**	.231*	-.453**	-.487**
Stepping	.391**	.370**	.533**	.393**	-.425**	-.559**
Side Jump	-.400**	-.481**	-.472**	-.411**	.418**	.561**
Long jump	-.635**	-.543**	-.638**	-.671**	.479**	.523**
Overhand throw	-.442**	-.443**	-.611**	-.481**	.284*	.541**

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Table 6. Factor pattern matrix based on common factor analysis revealed 3 factors.

Factor Pattern Matrix	Agility/Explosive power	Precision jumping	Balance
Slalom game	-.846		
Obstacle	-.820		
Sack race	-.759		
Platform Foam	-.684		
Flip and catch	.572		
Ping-Pong	.442		
Long jump	.731		
Bouncing and catching	.712		
Overhand throw	.680		
Throwing and catching	.646		
Stepping	-.453		
Running	-.308		
Side Jump		.488	
Hop		.905	
Jump		.453	
Static Balance			.868
Dynamic Balance			.649

Rotation Method: Oblimin with Kaiser Normalization.
a Rotation converged in 6 iterations.

without motor coordination problems, especially from low resource areas. This study investigated the associations between active play and motor skill related fitness using the PERF–FIT and the MABC-2 as standardized tests for motor performance. We examined the ecological validity of the PERF-FIT by comparing the outcomes of this test to the results of active games obtained in a natural context. The PERF-FIT showed moderate to high correlations to the active game results and was found to be concurrent with the rarely researched dimension of participation of the ICF (Perenboom and Chorus, 2003). As stated in our hypothesis, the construct of the MABC-2 was not thought to be highly correlated to active games requiring anaerobic capacity and agility and this was what the data showed. The few studies that have investigated active play-like activities have shown components of physical fitness and motor skills to be critical for children to effectively participate in these physically active games, which is what the items on the PERF FIT are supposed to evaluate (Cermak et al., 2015; Farhat et al., 2016; Ferguson et al., 2014).

4.1. Games and PERF-FIT

The games selected combined many motor skill and agility components. Catching a propelled beanbag after giving a forceful stamp with the foot on a seesaw (while standing on the other leg) in the *Flip and catch* game, is not just a catching game but a fast-adaptive agile movement to a partly unpredictable trajectory of the bean bag.

Also, the *Foam pad game* may seem a balance game, but besides stepping and moving on these large closed-cell foams, the foams needed to be picked up with two hands while crouching down and the foam needed to be positioned in a way that the child could make a step on it without touching the floor. While doing this the child needed to plan the shortest trajectory towards the ball on the cone to end the game.

Moreover, the *Sack race* may look like a jumping game, but a more detailed observation revealed that if the sack was not held firmly by children at the landing moment, the sack would drop, and the child would lose time. The repetitive jumps were very tiring, and also required quite some postural control because the movements of legs and arms were constrained by the sack.

We found a significant but moderate association between the *Foam game* score and *Throwing and catching* as well as with the *Balance and Power and agility* items of the PERF-FIT. *Jumping* on two feet showed lower association with the games probably because this item was very

Table 7. Correlations between MABC-2 items for Age band 1 and Age band 2 and Performance Scores on the Active Games.

MABC-2	Items per Age band (AB)		Obstacle#		Platform Foam#		Slalom#		Sack race#		Ping Pong$		Flip and Catch$	
	AB 1 n = 27	AB2 n = 48	AB 1	AB2	AB 1	AB2	AB 1	AB2	AB 1	AB2	AB 1	AB2	AB 1	AB2
Item1# PH	Posting coins	Placing pegs	**0.46***	-0.09	**0.50***	-0.01	**0.51****	0.02	0.25	0.02	-0.06	0.06	-0.30	0.08
Item1# NPH	Posting coins	Placing pegs	**0.47***	-0.18	**0.47***	-0.06	**0.40***	0.20	0.27	-0.07	0.01	0.07	**-0.45***	0.03
Item2#	Threading beads	Threading lace	0.11	0.03	0.31	0.13	0.17	0.27	0.02	0.37*	0.01	-0.08	-0.09	-0.02
Item3#	Drawing trail easy	Drawing trail harder	0.35	0.15	**0.48***	0.04	0.35	0.15	0.09	-0.12	-0.22	-0.36*	-0.21	**-0.40****
Item4$ Catching	Catching beanbag	Throwing and catching via wall	-0.20	**-0.44****	-0.27	-0.17	-0.32	-0.18	-0.22	-0.19	0.31	0.24	0.21	**0.53***
Item5$ Aiming	Throwing beanbag on mat	Throwing beanbag in circle	-0.28	-0.24	_**-0.42***_	_**-0.34***_	**-0.51****	-0.08	-0.20	-0.31*	0.16	0.07	0.39*	0.17
Item 6$ PL	One leg stance	One leg stance on balance board	0.04	-0.10	-0.20	-0.17	-0.03	-0.05	-0.08	-0.08	0.20	**0.44****	0.36	0.17
Item 6$ NPL	One leg stance	One leg stance on balance board	0.01	-0.03	-0.05	-0.21	-0.02	-0.06	0.05	-0.13	0.27	0.35*	0.37	0.18
Item7$	Walking on a line on toes	Walking on a line heels to toe	-0.16	-0.17	-0.31	-0.21	-0.23	-0.16	-0.03	0.04	0.13	0.21	_**0.54****_	_**0.34***_
Item8$ Both/PL	Jumping on mats	Hop on mats	-0.31	-0.04	-0.14	0.01	-0.18	-0.06	-0.25	-0.14	0.09	0.06	**0.45***	-0.06
Item8$ NPL		Hop on mats		-0.37		-0.13		-0.34		-0.28		0.11		0.22

PH: preferred hand. NPH: non-preferred hand. PL: preferred leg. NPL: non-preferred leg. AB1 = Items MABC-2 test; AB2 = Items MABC-2 Age band 2.

\# lower values indicate better performance (children needed less time); $ higher values indicate better performance (children caught more balls or maintained balance for longer time). Correlation between two # or two $ variables are expected to be positive, between one # and one $ variables negative.

*Correlation is significant at the 0.05 level and ** at the 0.01 level (2-tailed). Correlations ≥.40 are printed in bold.

Values indicating significant correlation between games and the same item in _both_ Age band 1 and 2 are underlined.

easy for most children. Additionally, *Static balance* showed lower correlations than the rest of the items, which could be attributed to the fact that none of the games required children to stand still and balance.

Data suggest that anaerobic power (*Long jump/hopping*) and running speed are prerequisites to perform well on the selected games. Interestingly, bouncing, throwing and catching of the PERF-FIT seem to have a large agility component, given the association with many of the games that do not have ball skills embedded in them. As predicted, the strength of the correlations was high between the *Bouncing, Throwing and Catching* items of the PERF-FIT and the *Flip and Catch* and the *Cup Ping Pong* games.

One critical element of the ICF acknowledged to be in need of better measures is the dimension of participation, particularly for children and youth (Perenboom and Chorus, 2003). Good fundamental movement skills give children the confidence to participate in different physical activities, sports, and games (Utesch et al., 2018a). The PERF-FIT measures motor skills and is made up of aspects of physical fitness that facilitate performance in active play. The tool was not primarily developed to measure participation. However, the results of this study suggest that the PERF-FIT is able to measure aspects of motor control and fitness needed in everyday active play in children over the full range of the MABC-2 (percentile 0.5–98).

4.2. Games and MABC-2

According to the MABC-2 test manual, the main purposes of the test is to identify motor development problems, evaluate the effectiveness of motor-skill intervention programs, and clinically investigate the motor skills of children (Henderson et al., 2007). The eight MABC-2 tasks were originally selected to represent aspects of motor control and coordination that underlie many (partly fine motor) activities of daily living for children. Low but significant correlations emerged between items measuring more or less similar constructs. MABC-2 catching item of age band 2 (*Throwing* against the wall and catching) revealed moderate significant associations with *Flip and Catch* but not with the *Cup Ping Pong* game where the throwing and catching has to be done with two different hands. The moving on *Foams* game correlated moderately with manual dexterity and aiming but not with MABC-2 balance, as one would expect.

However, the balance position in the foam game - turning and reaching while squatted on a wobbly surface is very different from postures (*One leg stance*) and movements (*Jumping or hopping in mat*) in the MABC-2. The highest correlation (0.54 and 0.34) of a MABC-2 item was found between *Walking on a line* and the *Flip and catch*, of age band 1 and 2, respectively.

Lastly, the different correlations of the games with the same items of the two age bands could indicate that the constructs measured in the items can differ between the age groups (Psotta and Abdollahipour, 2017; Schulz et al., 2011). Schulz et al. (2011) already showed that the correlation matrices of the MABC-2 for age band 1 and 2 were different.

4.3. Limitations

This study is not without limitations. Firstly, the tests were applied to a specifically chosen population. Since the PERF-FIT was developed and validated to be used in low resourced areas, this was where we selected the children for this study. However, the everyday movement experience of these children will differ from children in Western countries. For instance, none of these children participated in organized sports. Therefore, results should not be generalized to other populations before they are replicated in order to give a consistent result, since play activities may be influenced by culture (Bartie et al., 2016).

Secondly, although the MABC-2 is viewed as the "gold standard" test to measure motor coordination difficulties (Venetsanou et al., 2011), is not validated or normed for African children and may measure a slightly different construct because of the different movement experience in the current group compared the children in the UK. Moreover, the fact that we had to use two sets of items of the MABC-2, because of the age range in this study, complicated the comparison. An advantage of the current sample was that it included children over the full range of MABC-2 classifications (69.3% of the children in the normal range, 17.3% at risk for motor problems and 13.3% in the impaired range of motor performance).

Lastly, when children are playing games usually there is also a form of competition and social interaction. In the current study, although children were tested in small groups and cheered for by their peers, they

were not competing against each other or in teams. Therefore, this aspect of play was not part of the outcomes. More studies are needed to find out if the results of the current study can be replicated in children from other communities, different diagnostic groups (ADHD, LD, FAS, PDD) and other forms of active play.

5. Conclusion

In this study the congruency was assessed between motor skills, muscle endurance and explosive power, and scores obtained from active games in children's natural environment. As predicted, based on the intended construct to be measured, the strength of relationship between the active games scores and the PERF-FIT variables was moderate to high. Although no universally agreed-upon definition of ecological validity exists, the term often refers to the relationship between phenomena in the real world and their manifestation in a test setting. Our results indicate that the PERF-FIT has good ecological validity as the outcomes are related to meaningful active play. Although the MABC-2 will be the preferred standardized assessment tool to identify, classify and diagnose motor problems in children with coordination difficulties, healthcare professionals and researchers also require tools to evaluate integrated aspects of motor skills, muscle endurance and explosive power to measure requirements for participation in every-day physical activity. The PERF-FIT may be a tool that can be used to evaluate if poor motor competence and fitness are factors that limit children in low-resourced areas to participate in active play.

Declarations

Author contribution statement

Rosemary Xorlanyo Doe-Asinyo: Performed the experiments; Wrote the paper.

Bouwien Smits-Engelsman: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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