

Original Article

Assessing health related fitness in the pre-school setting by means of physical performance batteries: a narrative review

CARLOS AYÁN PÉREZ

Department of Special Didactics , University of Vigo, SPAIN

Published online: September 30, 2013

(Accepted for publication July 15, 2013)

DOI:10.7752/jpes.2013.03048;

Abstract:

Problem Statement: Health-related fitness assessment may be useful to promote physical activity among children under six years old. The movement skills and motor gross development assessment tools most widely used in the preschool setting have been widely reviewed. However, there is a lack of studies of this kind regarding physical fitness outcomes. Approach: Literature review. Purpose: To identify and to classify the most relevant physical performance batteries that either have been specifically designed to assess physical fitness in the pre-school setting or at least contain some fitness tests that could be useful in this regard. Results: A total of 17 batteries were found, described and later classified into “Motor Functioning” (6), “Proficiency Motor Skills” (5) and “Physical Fitness” (6) batteries. Based upon their psychometric properties, physical performance tests included, economic cost, existing normative data available for comparison and taken into account its possibilities of administration in the preschool setting, no ideal battery could be identified. Conclusions: Kindergarten and preschool teachers, as well as health professionals should know in depth the different fitness test included in the revised batteries, in order to identify those which can help them to assess physical fitness components in the kindergarten/preschool setting.

Key words: children, kindergarten, evaluation, test.

Introduction

Physical inactivity contributes to the growing prevalence of health related problems which have been observed among preschool children (Klein et al, 2010). Given that preschool age is a key time for the development of health behaviors (Hardy et al, 2011), effective preventive interventions targeting this population are needed. Consequently, nowadays the number of studies aimed at increasing physical activity level during kindergarten years is on the rise (Ward et al, 2010). Therefore, it seems that there is a need for adequate age-appropriate measures to test and evaluate motor competence improvement, in order to assess the effects of such interventions (Davis et al, 2008).

Historically, such outcome measures have been specifically designed to screen for children with suspected coordination disorders (Slater et al, 2010), as well as to identify their motor development taking into account the children age and the performance on a variety of psychomotor tasks (Baena et al, 2010). In this regard, it should be noted that motor-coordination may confound some fitness measures (Hands, 2008), implying that these measurement tools are not accurate enough to assess physical fitness in this population. This is a key issue, given that children motor competence is based upon motor skills and fitness variables.

Several studies have reviewed the characteristics and psychometric properties of some of the movement skills and motor gross development assessment tools most widely used in the preschool setting (Slater et al, 2010; Wiart and Darrah, 2001; Cools et al, 2008). The findings of these investigations allow kindergarten teachers and health professionals to accurately assess children motor skills. On the other hand, it seems that there is a lack of studies of this kind regarding physical fitness outcomes (i.e., aerobic capacity, muscular strength, flexibility, agility, speed, etc), which must be efficaciously measured in order to evaluate the little children motor competence.

Indeed, although a great amount of performance tests have been developed to evaluate physical fitness in young populations (Castro-Piñeiro et al, 2010), the existing variety of this kind of test which can be applied to children under six years old seems, in comparison, scarce. In this regard, health-related fitness batteries are of great interest since they include a variety of fitness tests, and can help to identify children at risk for major public health diseases as well as to evaluate the effects of alternative intervention strategies (Ruiz et al, 2006). Because of that, the characteristics and administration properties of this kind of batteries in the elderly (Varela, Ayán, & Cancela, 2008), adult (Sun, 2000) and young populations (Castro-Piñeiro et al, 2010) have been widely reviewed. However, to the best of the author's knowledge, no studies of this kind have been carried out regarding preschool children.

Under these circumstances, this narrative review aims to identify and classify the most relevant physical performance batteries that either have been specifically designed to assess physical fitness in children under six years old or at least contain some performance tests that could be useful in this regard.

Motor Functioning Batteries

The first physical performance batteries specifically created for the young children were originally designed to assess their fine and gross motor skills. These batteries were developed in order to help health practitioners and researchers to screen children who may have motor impairment as well as to evaluate the effects of motor interventions (tables 1 and 2). Nevertheless, some of the tests included in them can be of help when assessing fitness level or when measuring the effects of physical activity interventions on preschool children.

Table 1. Characteristics of the Motor Functioning Batteries

Battery	Age	Measures	Strong Points	Weak Points	Fitness test suggested to use in the kindergarten /preschool setting
BOTMP T	4-21	Fine motor control; Manual and body coordination; Strength; Agility.	Good psychometric properties; Normative data is available	It needs acquisition of manual; Some of its instructions are complex; Its usefulness to compare the obtained information with other populations has been criticized	Standing on preferred leg (static balance); Walking forward in walking line (dynamic balance); Standing broad jump (lower extremity strength); Knee push-ups (upper extremity strength); Running (Speed)
M-ABC	4-12	Manual dexterity; Ball skill; Balance.	Its psychometric and clinical quality ratings are very good; Normative data is available; It is easy to set up and administer.	Its validity should be further studied. It needs acquisition of manual; It is focused mainly on coordination;	One leg balance (Static balance); Jumping in square (Dynamic Balance); Catching and throwing a bean bag (Visual-motor coordination).
MOT 4-6	4-6	Stability; Locomotor; Object control; Fine movement skills.	Is easy to use; It can be administered in a short period of time.	Its psychometric properties should be further studied; It has not been translated to English.	Jumping in a hoop on 1 foot (dynamic balance); Jumping over a cord (balance and lower extremity strength); Jump and turn in a hoop (coordination).
MAND	3.5-18	Fine and gross motor skills(visual-motor co-ordination, perception, motor inhibition and bimanual co-ordination).	Age norms are provided; It is a very sensitive test for the identification of motor impairment.	Its psychometric properties have not been widely studied with kindergarten children; Its administration needs extended training time; Some difficulties when interpreting the scores have been reported.	Distance jumping (lower limbs strength); Dynamic balance (walking on a line heel to toe forwards and backwards); Static balance (standing on one foot with and without a blindfold).
PDMS	0-5	Reflexes, Body control; Object Manipulation; Locomotor; Grasping; Visual Motor Integration.	Includes a norm-referenced scale; Several test are easy to do in the preschool setting.	A tool kit should be acquired; Therapists should be guarded when making clinical decisions based solely on standard scores obtained on the tests.	Catching, kicking and throwing a ball (body co-ordination).
BGMA	5-6	Gross Motor Performance (Balance, lower strength, visual-motor coordination).	Is easy to understand, attractive and its administration does not imply a great economic cost.	Its validity and reliability should be studied further. It can only be applied to children five-to-six year of age.	Stand balance and tandem walking (static and dynamic balance).
KTK	5-14	General body coordination.	It is thoroughly standardized and highly reliable; It is easy to administer; Normative data is available.	It needs specific material; It is basically focused on coordination; It is just useful for 5 year old children.	Sideway Jumps (Lower body endurance and coordination).

Table 2. Main Characteristics of the Motor Functioning Batteries.

Battery	Age	Measures	Strong Points	Weak Points	Fitness test which can be useful in the kindergarten/preschool setting
TGMD-2	3-10	Locomotor and object control skills.	It has good psychometric properties; It helps to assess the influence of sedentary habits.	It requires the acquisition of a basic kit; A great amount of specific material is needed for its administration.	Horizontal Jump (Lower extremity strength); Two hand strike and ball tasks (Coordination).
CHAMPS	3-5	Locomotor and object control skills.	It has good psychometric properties; It includes easy to do tests.	Its administration requires a reasonable amount of time, and involves two testers for each child.	Leap (Lower extremity strength); Dribble (Eye-hand coordination).
MMT	5-14	Static and dynamic balance; ball skills; Diadochokinesis; Manual dexterity.	It has good psychometric properties. It helps to screen for children with motor behavior problems.	It is not suitable for children under 5 years old; It requires well trained observational skills; It does not measure locomotive motor function.	Bouncing ball while standing still (Balance and coordination); Single leg hops (Balance, coordination and lower muscular endurance).
ZNA	5-18	Associated movements of the contralateral and ipsilateral extremity, face, head and body.	It can help to assess postural control. It is useful for screening children suspected of having mild to moderate motor dysfunction	It is not suitable for children under 5 years old; It requires the acquisition of a basic kit; It lacks psychometric rigor; The performance must be recorded on video;	Side-to-side and forward jumping; Walking on toe, heels, outer and inner soles (dynamic balance and coordination).

Bruininks-Oseretsky Test of Motor Proficiency (BOTMPT)

The first version of the BOTMPT which was developed by Oseretsky in Russia in 1923, underwent several revisions resulting in a final battery which was published in 1978 (Bruininks, 1978). The original version included 46 items, grouped into eight subtests (running speed and agility, balance, bilateral coordination, strength, upper-limb coordination, response speed, visual-motor control, and upper-limb speed and dexterity), was widely used, but it was revised in order to improve its functionality and measurement properties (Bruininks, 2005). This new version, known as BOT-2, is an individually administered assessment designed to assess motor skills and fitness level of people from 4 to 21 years of age, and includes a long and short format. The BOT-2 focuses on the assessment of motor performance, specifically in the areas of fine motor control, manual and body coordination, strength and agility. Its validity and reliability have been widely studied, generally resulting in positive results (Deitz et al, 2007). In spite of the broad age spectrum of the battery, it includes tests which can be used in the preschool setting, being the short version advisable as it demands much less administering time.

Although total point scores, percentile ranks and standard scores are reported, the utility to compare the obtained results after the application of the battery on their basis has been criticized (Deitz et al, 2007; Levine, 1987). Furthermore, the fact that it is necessary to buy the manual for its application, the complexity that following its instructions involves and since its main utility is determining eligibility for special education and physical therapy services, it is advisable to look for another kind of more affordable batteries. Nevertheless, kindergarten teachers and pediatric health professionals can take advantage of the running speed and agility test, as well as of some of the easiest balance tests. The battery also includes some strength measurements (broad jump, sit-ups and knee flexed push-ups) which can be useful too.

The Movement Assessment Battery for Children (M-ABC)

This battery, also known as Movement ABC (Henderson and Sugden, 1992) is often used to identify children from 4 to 12 years of age whose motor functioning is impaired. The M-ABC, is divided into four age bands, being the first one specifically designed to be suitable for children from 4 to 6 years. The battery originally assessed manual dexterity, ball skill and balance. The standardized test component of the M-ABC contains normative data, and its properties have been studied in several countries (Ruiz et al, 2003; Chow et al, 2001). Besides, its psychometric and clinical quality ratings are very good, however, it requires further support for its validity (Brown and Lalor, 2009). In this line, although the M-ABC is quick to set up, administer, and

score and requires minimal training, it focuses mainly on coordination, and its application involves the purchase of a specific kit and manual. The battery has been recently updated (Henderson et al, 2007), but the information about it is limited to a very few studies (Venetsanou et al, 2011). Regarding its utility when assessing infants' physical activity level and the effects of exercise interventions in the preschool setting, some of the test of this new version, such as the dynamic balance (jumping in squares) can be useful. In spite of this, it should be noted that the battery lacks the inclusion of different test aimed at evaluating other fitness components.

The Motoriktest für Vier- bis Sechsjährige Kinder (MOT 4-6)

This battery commonly identified as the MOT 4-6 (Zimmer, 1987) includes both fine and gross movement skill assessment protocol items which are referred to a norm that allows for early detection of motor difficulties. The obtained final score represents an estimation of the children's movement skill performance. The MOT 4-6 includes 18 items that are divided into four major performance areas: (a) stability, (b) locomotion, (c) object control and (d) fine movement skills. Several weak points, such as the scarce amount of information regarding its psychometric properties, and the absence of an English translated version (Cools et al, 2010) limit its utility in the preschool setting. On the other hand, this battery is easy to use, it can be administered in a short period of time, and it may help to assess movement skill competence.

The McCarron Assessment of Neuromuscular Development (MAND)

The MAND (McCarron, 1997), is a validated and reproducible battery of 5 unimanual and bimanual timed tests of hand function that incorporate a range of functional motor skills including visual-motor co-ordination, perception, motor inhibition and bimanual co-ordination. The scaled scores on each of the tasks are added and age norms, provided for children aged 3.5–18 years, are used to determine fine and gross motor development (Piek et al, 2008). Although the MAND has been identified as a very sensitive test for the identification of motor impairment (Tank, 2001), its psychometric properties with preschool children should be further studied (Slater et al, 2010). Besides, its administration needs extended training time, and some difficulties when interpreting the scores have been reported (McCarron, 1997). However, three fitness measures, grip strength (by means of a hand-held dynamometer), lower limbs strength (distance jumping) and dynamic balance (walking on a line heel to toe forwards and backwards), can be easily administered in the kindergarten setting and provide objective information which allows for comparison with other populations.

Peabody Developmental Motor Scales (PDMS)

The PDMS (Folio, 1998) is a criterion and norm-referenced scale which was created to establish the developmental skill level of children aged 0 to 5 years, although some authors extend its practice beyond 6 years old (Cools et al, 2008). An updated version (PDMS-2) was developed in order to improve its psychometric properties and normative data (Folio, 2000). It consists of 170 and 72 items which assess gross and motor skills respectively, and employs a 3-point score system in order to obtain a fine and gross motor quotient. Its psychometric properties have been positively informed (Palisano, 1986). The PDMS is widely used as a diagnostic or screening tool for children at risk of motor delays by occupational and physical therapist. However, it is important for them to use their clinical judgment when assessing young children and to realize that test scores are useful in assisting their judgment but are not the only consideration (Provost et al, 2004).

In this regard, kindergarten and physical education teachers might not be able to take advantage of it. However, is one of the few batteries including tests for children under three years old, some of which can be easily administered in the preschool setting.

Körperkoordinationstest für Kinder (KTK)

The KTK (Kiphard, 2007), was designed to identify and diagnose problems of motor development in children. This battery is a shortened version of the "Hamm-Manburger Körperkoordination Test für Kinder" (Kiphard, 1974), and includes 4 tests (walking backward on a beam, jumping for height, sideways jump and moving sideways on boxes), measuring general body coordination. For each item, a raw and a scale score are recorded, which can be transformed into a motor quotient. The test is thoroughly standardized and considered highly reliable (Cools et al, 2008), is easy to administer in the preschool setting and normative data is available. On the contrary, its usefulness in the preschool setting is limited to 5 year old children, and is entirely focused on gross motor coordination.

Proficiency Motor Skills Batteries

Fundamental motor skills are common motor activities with specific observable patterns critical for children to learn during the primary school years and which seem to have a positive correlation with PA level (Fisher et al, 2005). Thus, there is a need to assess changes in the motor skills acquisition and performance in the preschool setting. The proficiency motor skills batteries could be of help in this regard. These measurement tools can be distinguished from other physical performance batteries because they usually employ a subjective global rating of fundamental locomotor and object control skills typically observed in pre-school children, which are scored on the basis of the quality of the movement performances. Nevertheless, some of the batteries included in

this section could be classified as motor functioning batteries too, since they assess fine and gross motor skills and can help to identify children with motor impairment.

Basic Gross Motor Assessment (BGMA)

The BGMA was developed in order to identify children with minor motor dysfunction (Hughes and Riley, 1981). Performance quality in nine tasks (standing balance test with eyes open and closed, stride jump, tandem walking, hopping on one foot, skipping, target throwing, yo-yo and ball handling) is measured on a 3-0 scale. The battery is easy to understand, attractive and its administration does not imply a great economic cost. However, its validity and reliability should be studied further, and it would only serve to assess the five-to-six year period if applied in the preschool setting.

Test of Motor Gross Development

One of the frequently used movement skill assessments in children aged 3 to 10 years is the second edition of the Test of Gross Motor Development (TGMD-2) (Ulrich, 2000). The battery measures 12 gross motor skills that are usually acquired by children in preschool and early elementary grades. Six of them form the locomotor subtest: running, galloping, hopping, leaping, horizontal jumping, and sliding. The other six form the object control subtest: striking, bouncing, catching, kicking, throwing, and rolling. Both subtest scores can be converted into a gross motor quotient. It is generally used with children with development coordination disorders (Niemeijer et al, 2007), as well as to assess the influence of sedentary habits (Li and Atkins, 2004). The TGMD-2 also has acceptable psychometric properties (Wong and Cheung, 2007). Its administration requires the acquisition of a basic kit which includes the examiner's manual and a supply of record forms. Besides, a great amount of material is needed for this battery, although it can be commonly found in schools and gyms. The TGMD-2 could be applied without the kit, but the test administrators should have some knowledge on the development and biomechanics of the assessed skills, so kindergarten' teachers might not find the battery very attractive.

The Children's Activity and Movement in Preschool Study (CHAMPS)

The CHAMPS Motor Skill Protocol assesses the performance on six locomotor (run, jump, slide, gallop, leap, and hop) and six object control skills (throw, roll, kick, catch, strike, and dribble) on 3 to 5 year old children (Williams et al, 2009). Scores on the CMSP are based on ratings of movement process characteristics of these skills and a total test score. Its psychometric properties have been positively informed (Williams et al, 2008). Movement process characteristics of each skill are rated as "1" (present) or "0" (absent); ratings of 0, 1, and 2 are used for throwing, striking, and hopping to indicate specific movements of the trunk, arm, and leg. The battery is easy to administer and it can help to identify the relationship between level of motor skill performance and children's participation in physical activity. However, its administration requires a reasonable amount of time (45 minutes), and involves two testers for each child.

The Maastricht Motor Test (MMT)

The MMT measures motor function by means of 70 items focused on static and dynamic balance, ball skills, diadochokinesis and manual dexterity (Kroes et al, 2004). It assesses quantitative and qualitative aspects of movement skill patterns and it has good psychometric properties (Wassenberg et al, 2005). Besides, it helps to screen for children with motor behavior problems. On the other hand, it is not suitable for children under 5 years old, requires well trained observational skills and does not measure locomotive motor function. Nevertheless, it includes some interesting tests which can be useful when measuring coordination and balance performance in one single task.

The Zurich Neuromotor Assessment (ZNA)

The ZNA is a standardized testing procedure in which distinct motor tasks are judged with regard to timed performance and movement quality (Largo et al, 2001). The ZNA was designed to assess the course of neuromotor development in children 5 to 18 years of age, by means of eleven subtests (repetitive toe tapping, heel-toe alternation, repetitive hand patting, pro- and supination of the hands, repetitive and sequential finger tapping, peg board, balance and gait). This battery is mainly focused on the identification of associated movements of the contralateral and ipsilateral extremity, face, head and body, and the examination must be recorded on video (Largo et al, 2003), which seems to limit its application. Besides, the evaluation program and the normative data are included in a special kit, which rises up its administration cost. Finally, it should be noted that some studies have shown that the ZNA lacks psychometric rigor (Rousson et al, 2008). Nevertheless, the dynamic balance (side-to-side and forward jumping) and gait test (walking on toe, heels, outer and inner soles), are original tasks which can be of interest in order to assess posture control in kindergarten children.

Physical Fitness Batteries

Physical fitness refers to the full range of physical qualities, i.e. cardiorespiratory fitness, muscular strength, speed of movement, agility, coordination, and flexibility (Caspersen, Powell, & Christenson, 1985). It

can be understood as an integrated measurement of all functions and structures involved in the performance of physical activity. Physical fitness batteries are usually aimed at measuring those components of fitness that are related to health and are affected by a sedentary lifestyle (table 3).

Table 3. Main Characteristics of the Physical Fitness Batteries

Battery	Age	Fitness Components Assessed	Strong Points	Weak Points	Fitness test which can be useful in the kindergarten/preschool setting
ASBM	4-12	Agility; Balance; Coordination; Flexibility; Strength.	It is easy to administer; It does not require expensive equipment.	Its psychometric properties should be further studied. Important fitness components (speed/aerobic endurance) are not assessed.	Standing long jump (lower extremity strength); Chair push-ups (upper body extremity strength); Face down to standing (body coordination); 4-m zig-zag run (agility); Back and hamstring stretch (flexibility).
SIS	5-7	Balance; Coordination; Speed; Strength.	It has good psychometric properties; It can be performed within a short time. Its administration does not require an extensive training.	It is mainly focused on motor gross assessment; It is not suitable for children under 5 years of age.	Stance on one foot (static balance); 50-m run (speed); Bouncing and catching a ball (coordination); Single leg hop for distance (lower extremity strength).
MSDB	3-6	Agility; Balance; Coordination; Strength.	It has been specifically designed to assess fitness in the kindergarten/preschool setting. Mean values for kindergarten and preschool children are available.	It has been only applied to Asian populations; Its psychometric properties should be contrasted. It lacks some fitness measurements.	Walking on balance beam (dynamic balance); Standing long jump (lower body strength); Throwing distant tennis ball (upper body strength); 10-m shuttle run (agility); Sit and reach (flexibility); Successive jumps with both feet (body coordination).
TFT	5-6	Agility; Balance; Coordination; Flexibility; Muscular resistance; Speed; Strength.	It is easy to administer; It does not require expensive equipment; Mean values for kindergarten and preschool children are available.	Its psychometric properties need to be studied; It has been only applied to Asian children 5 years or older; It should include an aerobic performance and an upper strength test in order to complete the fitness assessment.	Continuous single leg hopping (lower body muscular resistance); Standing long jump (lower body strength); Sitting forward bend (flexibility); 10-meter shuttle run (agility); 20-m run (Speed); Crawl in figure of eight (coordination); Bass stick test (balance).
KMS (3-6)	3-6	Balance; Coordination; Flexibility; Movement; Speed; Strength.	It has good psychometric properties; It is easy to administer; It does not require and specific training.	Algunos de los test necesitan material específico; Es complicado encontrar valores normativos en lengua inglesa.	Standing long jump (lower extremity speed strength); Lateral jumping (Coordination); One leg stand (static balance); Sit and reach (flexibility); Shuttle run test (Movement speed).
FITNESSGRAMM	5-17	Aerobic Capacity; Flexibility; Strength.	It has good psychometric properties. It is the most widely fitness used in the school setting. Normative data and administrations instructions are available.	It is mainly focused on health related fitness; There are no normative data for the aerobic capacity test for kindergarten/preschool children. It requires the acquisition of a kit and a software to take full advantage of the battery.	One mile run (aerobic capacity); Curl up (abdominal strength and endurance); Trunk lift (trunk extensor strength); Back saver sit and reach and shoulder stretch (flexibility); Modified pull-up (upper extremity strength and endurance).

The Arheim and Sinclair Basic Mobility Test (ASBM)

This battery is generally used to assess the motor skills of children aged 4 to 12 years through diagnostic tests evaluating the responses of motor control large and small muscles (Amheim and Sinclair, 1975). However, it can be considered as a fitness battery since it consists of nine subtests which measure muscular strength (standing long jump and chair pus-ups), body coordination (face down to standing), eye-hand coordination (threading, target throwing, tapping test), flexibility (back and hamstring stretch), agility (4 meter zig-zag run) and static balance. It is easy to administer and it seems quite useful for the physical education teacher (Miranda et al, 2008). Although the authors informed positively regarding the reliability for the entire battery, its validity should be further studied.

Stay in Step (SIS)

The SIS is considered as a gross motor screening tool for children ranging in age from 5 to 7 years (Larkin and Revie, 1994). It includes four tests that teachers may use to identify children with poor coordination skills: balance on one foot; volleyball bounce and catch; single hop for distance; and the 50-m run. However, given that the battery measures leg power, explosive movement, running speed and anaerobic power (Hands, 2008), it can be administered as a fitness test assessment in the preschool setting. The SIS shows several advantages, since the tests are easy to do and it does not take long to perform them, it does not require an extensive training and has good psychometric properties (Larkin and Revie, 1994). The only limitation worth to mention is the lack of upper strength or agility tests.

The Macao Sport Development Battery (MSDB)

In order to know the physical fitness status of Macao children, the “Macao Sport Development Board and National Research Institute of Sports and Science” undertook the research on physical fitness of 3 to 6 years old children in 2002 (Science and Education Dept. of China State Sport General Administration, 2002). Therefore a series of fitness were developed aimed at establishing a database about physical fitness and laying the foundation for dynamic monitor in the future. With this aim, a battery measuring lower body (standing long jump) and upper body strength (throwing distant tennis ball), agility (10-m shuttle run), dynamic balance (walking on balance beam), flexibility (sit and reach test), and body coordination (successive jumps with both feet), was developed. The psychometric properties and its feasibility when applied to Caucasian or other populations have not been studied. Nevertheless, it contains easy to do test and mean values are available (Macao Sport Development Board of Macau, 2002).

The Taipei Fitness Test battery (TFT)

In 1997, the Ministry of Education of Taiwan conducted a nation-wide fitness evaluation for students in elementary, junior and high schools (Chiang et al, 1998). From the findings of this study, and in order to ensure children's fitness conditions and arrange suitable activities for them, the kindergarten across the country conduct a fitness test battery for kindergarten and preschool children 5 years or older. The battery measures lower body muscular resistance (continuous single leg hopping) and strength (standing long jump), flexibility (sitting forward bend), agility (10-meter shuttle run), speed (20-m run), coordination (crawl in figure of eight) and balance (bass stick test), but lacks trunk and upper body strength tests. Besides, although mean values for each test are available (The Taipei Nanhai Experimental Fitness test, 2009), the validity and reliability of the battery have not been further studied.

The Karlsruher motor screening test (KMS 3-6).

The KMS 3-6 is a four item screener designed for pre-school children to assess physical fitness in terms of strength, coordination and motility (Bos et al, 2004). It includes a combination of standing long jump, lateral jumping, one leg stand, sit and reach and shuttle run test. This battery fulfils the criteria of reliability, objectivity and validity (Roth et al, 2010), it is easy to administer and does not require a special training. On the other hand, some tests need materials with specific dimensions, and it seems difficult to find normative values which are available in English. Nevertheless, it seems very useful when assessing motor abilities of pre-school children.

Fitnessgramm

Initially designed as a physical fitness “report card” by the Cooper Institute (Plowman et al, 2006), this battery is currently used in various states in the USA as a compulsory assessment system of health-related fitness from kindergarten through college (Ernst et al, 2006). It assesses three general areas of health-related fitness, muscular and endurance performance (curl-up, modified pull-up, trunk lift, flexed arm hang and push-up), flexibility (back saver sit-and-reach, shoulder stretch) and aerobic capacity (walk test, one mile run/walk test and the PACER). The obtained scores are evaluated against objective criterion standards that indicate a level of fitness necessary for health (health fitness zone). The Fitnessgram has shown to have good psychometric properties (Morrow et al, 2010) and it is widely used in the school setting. Besides, the instructions to carry out all its tests are freely available (Welk et al, 2002). Among its very few weak points, it should be mentioned that in order to maximize and widen its application a computer program (“Activitygramm”) must be acquired. Therefore, it cannot be considered as a low-cost battery. Besides, not all the proposed tests can be administered

to the youngest children (Rikli, 1992). Nevertheless, the fitnessgram can be considered as a complete educational assessment tool in the preschool setting.

Discussion

A wide range of physical performance batteries that can be administered to children under six years old is available. However, very few of them have been specifically designed to evaluate the physical fitness level of this population. Furthermore, from the findings of this narrative review, it seems that none of them provide a whole and complete physical fitness assessment. Therefore, kindergarten and preschool teachers, as well as health professionals should know in deep the different fitness test included in the revised batteries, in order to identify those which can help them to assess physical fitness components in the kindergarten/preschool setting. In this regard, there are two main facts that should be cleared out. Firstly, the main components of the physical fitness should be defined. Secondly, the characteristics which make these tests perfect to be applied in the kindergarten and in the pre-school setting must be set.

According to Caspersen (1985), physical fitness is divided into health related (cardiorespiratory and muscular endurance, muscular strength and flexibility) and skill related (agility, balance, coordination, speed, power and reaction time) components. Body mass index, a somatotype parameter which is considered as a health related fitness component too, and is often included on some of the batteries described before, has been delivery omitted through this review. This is because it is more a somatotype parameter which results from a simple mathematic operation, than a fitness variable per se that can be assessed by means of a physical performance test.

There are some characteristics a fitness test should have to be useful in the school context, such as its psychometric properties (validity and reliability), the existence of freely available normative values, its low cost (determined by the need to acquire a guide for its application and/or specific material) and its easy administration (simple tests and absence of specific training to be applied by the teacher). Moreover, it must be adapted to the age and psychomotor level of the child who is going to be assessed.

Based upon these criteria, it might seem Fitnessgram is the battery teachers should choose, since it fulfills most of these aspects. Nevertheless, it must be taken into account that its tests basically aim at assessing the components of the health-related fitness, and therefore they are not useful to assess the level of skill-related fitness components in children.

Cardiorespiratory fitness reflects the overall capacity of the cardiovascular and respiratory systems and the ability to carry out prolonged strenuous exercise. Hence, the tests which assess it demand maximum effort and this may involve an obstacle for little children to carry them out in an effective way. However, the assessment of their maximum oxygen consumption (VO₂max), is feasible by means of laboratory⁶², thus it seems that physical tests can be administered to them. In this regard, it should be mentioned that although the aerobic capacity tests proposed in the Fitnessgram can be carried out in the kindergarten setting, normative values are not provided. This is because little children are not developed in the area of cardiorespiratory endurance to differentiate various levels of VO₂max. Nevertheless, it seems that their aerobic capacity can be effectively measured by using a progressive shuttle run back and forth over a 20-m course (cadence beeps increased the running speed by 0.5 km/h each minute) (Hands, 2008). Furthermore, according to reliability and validity criteria, the “1/2 mile run/walk” test seems to be the most appropriate way to assess this fitness component (Rikli, 1992). Finally, it should be mentioned that a 3m-shuttle run test has been shown to be effective when measuring cardiorespiratory endurance in 4-5 years old children (Oja and Juerimae, 1997).

Muscular strength measurement can be carried out by means of different test, depending on the variable intended to assess. Thus, the handgrip (MNAD) and the medicine ball throw (Davis et al, 2008) test are very useful for evaluating upper extremity muscular isometric and explosive strength, respectively. On the other hand, upper extremity muscular endurance can be measured by means of performing modified push-ups (BOTMPT) and chair push-ups (ASBM), which are simple and cost- and time-effective test. In this line, the distance jumping and continuous leg hopping tests included in several batteries are useful to measure lower body explosive strength and muscular endurance. Finally, the Fitnessgram “curl up” test is the recommended test for assessing trunk muscular/endurance strength, due to the use of a cadence, the reduced action of the psoas-iliac muscle and the low ballistic nature of the performance (Ruiz et al, 2006). Regarding flexibility, the “sit and reach” seems to be the most used test to assess it. Nevertheless, it requires specific and standardized material. Thus, the sitting forward bend test (TFT), or even the “V-sit and reach test” (Miñarro et al, 2007) (less further studied with little children) are more appropriate low cost alternatives.

Balance and coordination, are the most often fitness components assessed in the batteries reviewed here. The balance test are generally easy to do and do not require specific material, with the exception of a balance beam. In this regard, the BOTMPT includes a wide range of tasks that can be administered in the kindergarten and preschool setting without further difficulties. On the other hand, coordination is a more complex component, since it involves balance, agility and movement speed. In spite of this, several test can be of help. For instance, the MMT battery seems to be useful when measuring balance and coordination simultaneously. In this line, some of the proficiency motor skills batteries include ball tasks (bouncing, catching, throwing, kicking..) which allow to assess visual-motor coordination. If a more quantitative measurement is needed, the ASBM’ “face down to

standing” test can be administered for evaluating general body coordination, while some of the MABC’ test (i.e. throwing and catching a bean bag) can be useful for a more specific assessment. Finally, the shuttle run test (4×10-m) proposed in the SMDb and TFT batteries, as well as the ASBM’ “4-m zig-zag run” test, are of great interest, since they assess the children’ speed of movement, agility and reaction time in an integrated fashion.

Conclusions

A wide range of physical performance batteries that can be applied in the kindergarten and preschool setting exist. However, none of them provide a complete physical fitness components assessment. Different tests of this batteries should be chosen for a thoroughly measurement of the health and skills related fitness components of children under six years old.

Conflicts of interest – None

References

- Arnheim DD, Sinclair WA (1975) *The clumsy child: A program of motor therapy*. CV Mosby.
- Baena Extremera A, Granero Gallegos A, and Ruiz Montero PJ (2010) Procedures and instruments for the measurement and evaluation of motor development in the education system. *Associated Editors* 2(2):63-76.
- Bos K, Bappert S, Tittlbach S, and Woll A (2004) Karlsruher Motorik-Screening für kindergartenkinder (KMS 3-6). *Sportunterricht* 53(3):79-87.
- Brown T, Lalor A (2009) The Movement Assessment Battery for children-(MABC-2): A review and critique. *Physical & Occupational Therapy in Pediatrics* 29(1):86-103.
- Bruininks RH (1978) *Bruininks-Oseretsky test of motor proficiency- owner's manual*. Circle Pines, MN: American Guidance Service.
- Bruininks RH (2005) Bruininks-Oseretsky test of motor proficiency, (BOT-2). *Minneapolis, MN: Pearson Assessment*.
- Caspersen CJ, Powell KE, and Christenson GM (1985) Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports* 100(2):126.
- Castro-Piñero J, Artero EG, España-Romero V, Ortega FB, Sjöström M, Suni J and Ruiz JR (2010) Criterion-related validity of field-based fitness tests in youth: A systematic review. *British Journal of Sports Medicine* 44(13):934-943.
- Chiang J, Wu HC, and Shih DS (1998) *The 1997 nation-wide children and youth fitness study*. Taipei: Ministry of Education.
- Chow SMK, Henderson SE, and Barnett AL (2001) The Movement Assessment Battery for children: A comparison of 4-year-old to 6-year-old children from Hong Kong and the United States. *The American Journal of Occupational Therapy* 55(1):55-61.
- Cools W, De Martelaer K, Samaey C, and Andries C (2008) Movement skill assessment of typically developing preschool children: A review of seven movement skill assessment tools. *Journal of sports science and medicine* 8:154-168.
- Cools W, De Martelaer K, Vandaele B, Samaey C, and Andries C (2010) Assessment of movement skill performance in preschool children: Convergent validity between MOT 4-6 and M-ABC. *Journal of Sports Science and Medicine* 9:597-604.
- Davis KL, Kang M, Boswell BB, DuBose KD, Altman SR, and Binkley HM (2008) Validity and reliability of the medicine ball throw for kindergarten children. *The Journal of Strength & Conditioning Research* 22(6):1958-63.
- Deitz JC, Kartin D, and Kopp K (2007) Review of the Bruininks-Oseretsky test of motor proficiency, (BOT-2). *Physical & Occupational Therapy in Pediatrics* 27(4):87-102.
- Ernst MP, Corbin CB, Beighle A, and Pangrazi RP (2006) Appropriate and inappropriate uses of FITNESSGRAM® ESSGRAM: A commentary. *Journal of Physical Activity & Health* 3(2):S90-S100.
- Fisher A, Reilly J, Kelly L, Montgomery C, Paton JY, and Grant S (2005) Fundamental movement skills and habitual physical activity in young children. *Medicine & Science in Sports & Exercise* 37(4):684-8.
- Folio MR, Fewell RR (1998) *Peabody Developmental Motor Scales*. Vol 14. Austin.
- Folio MRaF, RR (2000) *Peabody Developmental Motor Scales. Examiners manual*. Austin-Texas.: Pro-ED. Inc.
- Hands B (2008) Changes in motor skill and fitness measures among children with high and low motor competence: A five-year longitudinal study. *Journal of Science and Medicine in Sport* 11(2):155-162.
- Hardy L, King L, Espinel P, Okely A, and Bauman A (2011) Methods of the NSW schools physical activity and nutrition survey 2010 (SPANS 2010). *Journal of Science and Medicine in Sport* 14(5):390-6.
- Henderson SE, Sugden DA (1992) *Movement Assessment Battery for children*. London: Psychological Corporation.
- Henderson SE, Sugden, DA, and Barnett AL (2007) *Movement Assessment Battery for children-2 second edition*. Vol Movement ABC-2. London: The Psychological Corporation.
- Hughes JE, Riley A (1981) Basic gross motor assessment. *Physical Therapy* 61(4):503-511.

-
- Kiphard EJaS, F (2007) *Körperkoordinationstest für kinder 2, überarbeitete und ergänzte auflage*. Weinheim.: Beltz test.
- Kiphard, B.J., Schilling, F (1974) *Körperkoordinationstest für kinder*. Weinheim: Beltz Test GmbH.
- Klein D, De Toia D, Weber S, Wessely N, Koch B, Sreeram N, Toka W, Strüder H and Graf C (2010) Effects of a low threshold health promotion intervention on the BMI in pre-school children under consideration of parental participation. *e-SPEN, the European e-Journal of Clinical Nutrition and Metabolism* 5(3):e125-e131.
- Kroes M, Vissers Y, Sleijpen F, Feron FJ, Kessels AG, Bakker E, Kalff AC, Hendriksen JG, Troost J, Jolles J, and Vles JS (2004) Reliability and validity of a qualitative and quantitative motor test for 5-to 6-year-old children. *European Journal of Paediatric Neurology* 8:135-143.
- Largo RH, Caflisch JA, Hug F, Muggli K, Molnar AA, and Molinari L (2001) Neuromotor development from 5 to 18 years. part 2: Associated movements. *Developmental Medicine & Child Neurology* 43(7):444-453.
- Largo RH, Fischer J, and Rousson V (2003) Neuromotor development from kindergarten age to adolescence: Developmental course and variability. *Swiss Medical Weekly* 133(13/14):193-199.
- Larkin D, Revie GE (1994) *Stay in step: A gross motor screening test for children K-2*. The authors.
- Levine KJ (1987) The Bruininks-Oseretsky test of motor proficiency: Usefulness for assessing writing disorders.
- Li X, Atkins MS (2004) Early childhood computer experience and cognitive and motor development. *Pediatrics* 113(6):1715-22.
- Macau Sport Development Board of Macau SAR Government (2002) Analysis on physical fitness of macao young children in 2002.
- McCarron LT (1997) *MAND McCarron Assessment of Neuromuscular Development*. Dallas, TX: Common Market Press.
- McCarron LT (1997) *MAND: McCarron assessment of neuromuscular development, fine and gross motor abilities*. McCarron-Dial Systems, Inc.
- Miñarro PAL, Andújar PSB, García PLR, and Toro EO (2007) A comparison of the spine posture among several sit-and-reach test protocols. *Journal of Science and Medicine in Sport* 10(6):456-462.
- Miranda MD, Abián J, and Lara AJ (2008) Assessment of the ability to diagnose potential engine problems. *The International Journal of Medicine and Science in Physical Education and Sport* 4:3.
- Morrow J, James R, Martin SB, and Jackson AW (2010) Reliability and validity of the FITNESSGRAM: Quality of teacher-collected health-related fitness surveillance data. *Research Quarterly in Exercise & Sport* 81(Supplement 2):24S-30S.
- Niemeijer AS, Smits Engelsman BCM, and Schoemaker MM (2007) Neuromotor task training for children with developmental coordination disorder: A controlled trial. *Developmental Medicine & Child Neurology* 49(6):406-411.
- Oja L, Juerimae T (1997) Assessment of motor ability of 4 and 5 year old children. *American Journal of Human Biology* 9(5):659-664.
- Palisano RJ (1986) Concurrent and predictive validities of the Bayley Motor Scale and the Peabody Developmental Motor Scales. *Physical Therapy* 66(11):1714-1719.
- Piek JP, Dawson L, Smith LM, and Gasson N (2008) The role of early fine and gross motor development on later motor and cognitive ability. *Human Movement Science* 27(5):668-681.
- Plowman SA, Sterling CL, Corbin CB, Meredith MD, Welk GJ, and Morrow JR (2006) The history of FITNESSGRAM® ESSGRAM. *Journal of Physical Activity & Health* 3(2):S5-S20.
- Provost B, Heimerl S, McClain C, Kim NH, Lopez BR, and Kodituwakku P (2004) Concurrent validity of the Bayley Scales of Infant Development II Motor Scale and the Peabody Developmental Motor Scales-2 in children with developmental delays. *Pediatric Physical Therapy* 16(3):149-56.
- Rikli RE (1992) The reliability of distance run tests for children in grades K-4. *Research Quarterly in Exercise & Sport* 63(3):270-276.
- Roth K, Mauer S, Obinger M, Ruf KC, Craf C, Kriemler S, Lenz D, Lehmacher W, and Hebestreit H (2010) Prevention through activity in kindergarten trial (PAKT): A cluster randomised controlled trial to assess the effects of an activity intervention in preschool children. *BMC Public Health* 10(1):410.
- Rousson V, Gasser T, Caflisch J, and Largo R (2008) Reliability of the Zurich Neuromotor Assessment. *Clinical Neuropsychologist* 22(1):60-72.
- Ruiz JR, Ortega FB, Gutierrez A, Meusel D, Sjöström M, and Castillo MJ (2006) Health-related fitness assessment in childhood and adolescence: A european approach based on the AVENA, EYHS and HELENA studies. *Journal of Public Health* 14(5):269-277.
- Ruiz L, Graupera JL, Gutiérrez M, and Miyahara M (2003) The assessment of motor coordination in children with the movement ABC test: A comparative study among Japan, USA and Spain. *International Journal of Applied Sport Sciences* 15:1.
- Science and Education Dept. of China State Sport General Administration. (2002) *Research of physical fitness status of 3-6 year old children in 1998*. Beijing: Beijing Medicine College's Publishing House.

-
- Slater LM, Hillier SL, and Civetta LR (2010) The clinimetric properties of performance-based gross motor tests used for children with developmental coordination disorder: A systematic review. *Pediatric Physical Therapy* 22(2):170-9
- Suni, J (2000) *Health-related fitness test battery for middle-aged adults: With emphasis on musculoskeletal and motor tests* University of Jyväskylä.
- Tan SK, Parker HE, and Larkin D (2001) Concurrent validity of motor tests used to identify children with motor impairment. *Adapted Physical Activity Quarterly* 18(2):168-182
- The Taipei Nanhai Experimental Kindergarten Fitness test (2009) Available at http://www.nhkg.tp.edu.tw/english/healthy_2.html
- Ulrich DA (2000) Test of Gross Motor Development-2. *Austin: Prod-Ed*. 2000.
- van der Cammen-van Zijp, M.H.M., IJsselstijn H, Takken T, Willemsen SP, Tibboel D, Stam HJ, and van den Berg-Emons RJ (2010) Exercise testing of pre-school children using the bruce treadmill protocol: New reference values. *European Journal of Applied Physiology* 108(2):393-399.
- Varela, S., Ayán, C., & Cancela, J (2008) Batteries assessing health related fitness in the elderly: A brief review. *European Review of Aging and Physical Activity*, 5(2): 97-105.
- Venetsanou F, Kambas A, Ellinoudis T, Fatouros I, Giannakidou D, and Kourtessis T (2011) Can the Movement Assessment Battery for children-test be the. *Research in developmental Disabilities* 32(1):1-10.
- Ward DS, Vaughn A, McWilliams C, and Hales D (2010) Interventions for increasing physical activity at child care. *Medicine & Science in Sports & Exercise* 42(3):526-34.
- Wassenberg R, Feron FJM, Kessels AGH, Hendriksen JG, Kalff AC, Kroes M, Hurks PP, Beeren M, Jolles J, and Vles JS (2005) Relation between cognitive and motor performance in 5 to 6 Year Old children: Results from a Large Scale Cross Sectional study. *Child Development* 76(5):1092-1103.
- Welk G, Morrow J, and Falls H (2002) Fitnessgram reference guide. *Dallas: The Cooper Institute* 5-9.
- Wiat L, Darrah J (2001) Review of four tests of gross motor development. *Developmental Medicine & Child Neurology* 43(4):279-285.
- Williams HG, Pfeiffer KA, Dowda M, Jeter C, Jones S, and Pate RR (2009) A field-based testing protocol for assessing gross motor skills in preschool children: The children's activity and movement in preschool study motor skills protocol. *Measurement in Physical Education and Exercise Science* 13(3):151-165.
- Williams HG, Pfeiffer KA, O'Neill JR, Dowda M, McIver KL, Brown WH, and Pate RR (2008) Motor skill performance and physical activity in preschool children. *Obesity* 16(6):1421-1426.
- Wong KYA, Cheung SY (2007) Structural validity of the test of Gross Motor Development-2. *AAHPERD National Convention and Exposition, March 13-17, Baltimore, MD*.
- Zimmer RaV (1987) *Motoriktest für vier- bis sechsjährige kinder (manual)*. Weinheim: Beltztest.