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The feasibility of fundamental movement skill assessments for pre-school aged children

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ABSTRACT

Fundamental movement skill (FMS) assessment in preschools allows for early intervention; however it is unclear what assessments are feasible. The purpose of this review is to systematically review the feasibility of FMS assessments for pre-school aged children. The search was conducted across four databases, MEDLINE, Scopus, ERIC and SportsDiscus. Search terms included synonyms of "fundamental movement skills" and "pre-school children". Inclusion criteria were: (i) FMS assessment; (ii) feasibility data; (iii) assessment of children aged three to six years; (iv) assessment of typically developing children; and (v) peer reviewed full text publications in English. Feasibility concepts (administration time, equipment, space, assessment type, item, training, qualification) were each coded as 'poor = 1', 'average = 2' and 'good = 3'; potential total of 21. A total of 330 full text articles were considered but a quarter (n = 86) were excluded due to no feasibility data. Sixty-five studies using 13 different FMS assessments were included. The Athletic Skills Track and DEMOST-PRE assessments were most feasible (18/21) and the Test of Gross Motor Development and Movement Assessment Battery for Children were common but among the least feasible (12–14/21). This review allows pre-school staff to choose a FMS assessment based on feasibility. Future studies need to present feasibility of assessments.

ARTICLE HISTORY
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KEYWORDS
Fundamental movement skills; feasibility; assessment; motor skills; child; preschool

Introduction

Fundamental movement skills (FMS) are gross motor skills that young children acquire and develop as they age, forming the foundation for more advanced movements and specific motor patterns (Gabbard, 2012). Being competent at FMS involves mastering locomotor skills (e.g., running, hopping, skipping and jumping), object-control skills (e.g., throwing, dribbling, catching and kicking) and stability skills (e.g., balancing), providing more opportunity for participation in sport and physical activity (Lloyd, Saunders, Bremer, & Tremblay, 2014; Lubans, Morgan, Cliff, Barnett, & Okely, 2010). Competence in FMS is also associated with fitness (cardiorespiratory/musculoskeletal) and body mass index (BMI), (Cattuzzo et al., 2016; Okely, Booth, & Chey, 2004), and consequently better health outcomes.

Early childhood (the pre-school years) is a critical time for the development of FMS (Clark, 1994; Hardy, King, Farrell, Macniven, & Howlett, 2010; Seefeldt, 1980). Developing FMS at pre-school provides a child with the necessary tools to be physically active, especially as they begin school; with a recent systematic review illustrating a positive association between FMS and physical activity in this age group (Figueroa & An, 2017).

Despite this, recent data shows Australian school children have poor competency in FMS (Active Healthy Kids Australia, 2016), with children's skill levels declining over the past 20 years (Tester, Ackland, & Houghton, 2014). Failing to master FMS at an age-appropriate level can result in a child falling behind in skill acquisition, potentially negatively affecting their physical and mental health (Biddle & Asare, 2011; Ortega, Ruiz, Castillo, & Sjöström, 2008; Piek, Hands, & Licari, 2012). Fortunately, interventions can be an effective way to improve FMS for pre-school aged children (Logan, Robinson, Wilson, & Lucas, 2012). Therefore, being able to assess FMS during the formative years to identify children at risk of poor mastery is crucial (Kambas & Venetsanou, 2014; Lam, Ip, Lui, & Koong, 2003).

There are numerous FMS assessments available with two main approaches used to assess FMS, process and product-oriented (Gabbard, 2012). Process-oriented assessments consider how a movement is performed giving a *qualitative description* e.g., observing arm and leg patterns to qualify how a child ran 10m, whereas product-oriented assessments consider *quantifiable outcomes* e.g., time for the child to run 10m (Logan, Barnett, Goodway, & Stodden, 2017). Thus, it can be noted that due to the requirements of qualitative assessments, process-oriented assessments often require more knowledge and training to administer.

Certain factors can affect the feasibility of using these assessments, especially in field-based environments such as preschools. Different settings, time, staffing expertise, training, space and equipment requirements have all been reported as limitations (Cools, De Martelaer, Samaey, & Andries, 2009). Feasibility can be defined according to eight areas of focus: acceptability, demand, implementation, practicality,

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Supplementary data can be accessed here.

adaptation, integration, expansion, and limited-efficacy testing (Bowen et al., 2009). Similar feasibility models have been used in other studies looking at FMS (Lander, Morgan, Salmon, & Barnett, 2016) and child development (Roux et al., 2012; Vivanti et al., 2014). Areas specific to the use of FMS assessments in a preschool setting include: acceptability (examining how staff/children react to the assessment); demand (considering the actual/predicted use of the assessment); implementation (how well the assessment can be implemented); practicality (consideration of resources needed for the assessment); and integration (how can the assessment fit in within already existing pre-school structures). Overall, this review aims to provide pre-school educators and others who work with children in this age group with a resource to make an informed decision when choosing an FMS assessment on the basis of feasibility.

Methods

This systematic review is in line with preferred reporting guidelines for systematic reviews (Moher, Liberati, Tetzlaff, Altman, & Group, 2009) and was registered with PROSPERO (accepted on the 20th of June 2016, ID: CRD42017058991).

Eligibility criteria

The inclusion criteria were as follows (i) study includes administration/development of an FMS assessment, defined as: including more than one FMS or classified in commonly described groups such as object control and locomotor skills, with or without fine motor subsets; (ii) feasibility was explicitly documented and/or there was sufficient detail to extract data on feasibility, concerning acceptability, demand, implementation, practicality or integration (Bowen et al., 2009; Lander et al., 2016); (iii) the assessment was administered on, or developed for, children aged three to six years; (iv) the assessment was administered on, or developed for, typically developing children or if administered on atypical children there was a control or reference group of typically developing children; and (v) the study was a full text peer reviewed English language study. The feasibility concepts were based upon the focus areas as reported by Bowen et al. (2009), see Table 1 for details.

Information sources and search

The databases MEDLINE, Scopus, ERIC and SportDiscus were searched from inception to 10 March 2017. The search terms were grouped in reference to "pre-school children" including, "child", "pre-school", "preschool", "kindergarten", "kindy", "primary school", and "elementary school"; and "fundamental movement skills" including, variations of "fundamental motor skills", "gross motor skills", "basic motor skills", and "motor competence". The search term "feasibility" was not included in the search due to it generating excessive unrelated results. The only limit applied was English language. The full search strategy can be requested from the corresponding author.

Table 1. Description of feasibility focus areas and concepts.

Feasibility focus area	Description (sourced from (Bowen et al., 2009))	Resultant feasibility concepts relating to fundamental movement skill assessments
Acceptability	How the intended recipients react to the intervention/ assessment.	Satisfaction Appropriateness
Demand	Estimated use or actually use of selected intervention/ assessment.	Actual use Interest/need
Implementation	The extent, likelihood, and manner in which an intervention can be fully implemented as planned.	Qualifications Training Execution Scoring
Practicality	How an intervention/ assessment can be delivered when resources, time and/or commitment are restrained in some way.	Cost Equipment Space Number of items Type of assessment Time
Integration	The level of system change needed or not needed to integrate a new program or process.	Sustainability Engagement Burden

Study selection

The electronic database searching was conducted by one author (BK). Two independent researchers each screened for title and abstracts and then full text eligibility. Discrepancies were resolved via consensus agreement. Following the inclusion of full-text studies, reference lists of the included studies and excluded systematic reviews were pearled to ensure all relevant studies were included. Seven experts in this field of research (representing Australia, Belgium, Netherlands, Norway and United States of America) were contacted to determine if any other studies meet the inclusion criteria. All of the experts replied resulting in the addition of one study (Hoeboer, Krijger, Savelsbergh, & de Vries, 2017).

Data extraction

Data were extracted independently by one author (BK) and reviewed by another author (VB), and discrepancies were resolved by a third author. From each study, descriptive data for the FMS assessments were extracted; including the assessment name, location/setting and description. Any reported feasibility data were also extracted based upon the feasibility areas of focus, as explained above.

Data analysis and synthesis

Due to the heterogeneity of the studies and the FMS assessments, descriptive narrative analysis was used. The feasibility data were coded to allow comparison of overall feasibility between different assessments. The coding of the feasibility concepts were numerical scores, with one, two and three representing ratings of "poor", "average" and "good" respectively. Table 2 presents the scoring for each aspect of feasibility with the associated rationale for this rating structure. A degree of interpretation was required due to inconsistent reporting across studies; as such the coding is based on the average of all reported feasibility for each concept. Some feasibility concepts for specific FMS

Table 2. Detailed description of rating of feasibility concepts.

Feasibility concept	Poor (1)	Average (2)	Good (3)	Rationale for rating structure
Administration time	More than 20 minutes	10–20 minutes	Less than 10 minutes	Based upon data within the included assessments
Equipment	Equipment that Australian pre-schools were unlikely to already possess or a test kit incurring purchase costs.	Equipment that could be exchanged for more easily accessible equipment	Equipment likely to be present in most Australian pre-schools and homes	Based on the most specialised item of equipment within the assessment with reference to the standard equipment available in Australian pre-schools (Unpublished data).
Space	More than 10 meters, requiring an outdoor space, gym or large open classroom	6–10 meters, a standard room	Less than 6 meters, a corner of a room	Based upon known commonly available pre-school spaces (Unpublished data).
Assessment type	Process only	Process and product	Product only	Based on i) the challenge of process-oriented assessments being reliable in terms of interrater reliability and therefore requiring more training (Barnett, Minto, Lander, & Hardy, 2014) and ii) assessments combining both types tending to focus more on product-oriented assessment (Folio & Fewell, 1983; Mardell-Czudnowski & Goldenberg, 2000)
Items	More than 12 items	6–12 items	Less than 6 items	Based on noticeable trends in the number of individual skills within included assessments in the review
Training	More than one and a half days	Half a day to one and a half days	Less than half a day	Based on the assumption that a day of training is eight hours long (i.e., a standard work day)
Qualifications required	Requires higher than pre-school staff qualifications	Requiring pre-school teacher level qualifications	Able to be delivered by any qualified pre-school staff or not specified	Based on assumption that early childhood worker is the lowest pre-school qualification.

assessments were not reported in any of the included studies and as such these missing data were sourced via other channels (contact with the author or assessment developer or assessment manuals/development papers) to allow completeness of results.

Results

Study selection

The search yielded 4463 studies with 3682 remaining after removal of duplicates, and one additional study sourced from contact with experts. A total of 330 full text articles were considered but a quarter (n = 86, 26.1%) were excluded as they presented no feasibility data. Sixty five studies met the inclusion criteria and hence were included in this review (Figure 1). The research team acknowledge that some of the excluded studies contained FMS assessments that may also be appropriate for this age range but didn't meet our specific inclusion criteria for the review. As such a table of assessments that were excluded from this review but are appropriate for this age range has been constructed, see supplementary table for details.

Study characteristics

Of the 65 studies included, the majority were from Europe (25 studies) followed by United States of America (16 studies), Australia (8 studies) and Asia (7 studies) with the rest coming from United Kingdom (5 studies), Canada (2 studies), South America (1 study) and Africa (1 study). Six studies were randomised control trials, 12 were non-randomised studies (non-randomised control trials, cohort studies, case-control studies and cross-sectional studies), 22 were quantitative descriptive studies (including case series/report and incidence/prevalence studies) and 25 were mixed method studies (including sequential exploratory/explanatory design and embedded design).

Thirteen uniquely recognised FMS assessments were identified across the 65 studies. The most frequently used were the Test of Gross Motor Development 2nd edition (TGMD-2) (Ulrich, 2000), in 18 studies, and the Movement Assessment Battery for Children (MABC) (Henderson, Sugden, & Barnett, 2007), in 14 studies. The FMS assessments were most commonly conducted at a pre-school site (49 studies), not specifying indoor or outdoor requirements. Assessments in six studies specifically stated in their instructions that an indoor facility was required (Atkinson et al., 2005; Bardid et al., 2016; Kambas & Venetsanou, 2014, 2016; Tortella, Haga, Loras, Sigmundsson, & Fumagalli, 2016; Zachopoulou, Tsapakidou, & Derri, 2004), often a separate room, and assessments in five studies specifically required a gymnasium (Hoeboer et al., 2017; Iivonen et al., 2013, 2016; Logan, Scrabis-Fletcher, Modlesky, & Getchell, 2011; Rokicka-Hebel, 2013). Full descriptive details of included studies can be provided upon request.

Feasibility outcomes

Twelve studies did not use a recognised test battery, choosing to use their own mix of skills to assess FMS (Benefice, Fouere, & Malina, 1999; de Barros, Fragoso, de Oliveira, Cabral Filho, & de Castro, 2003; Fisher et al., 2005; Goshi, Demura, Kasuga, Sato, & Minami, 1999, 2000; Kelly, Dagger, & Walkley, 1989; Kirby & Holborn, 1986; Krombholz, 2006; Lam et al., 2003; Morris, Williams, Atwater, & Wilmore, 1982; Rokicka-Hebel, 2013; Tortella et al., 2016). As it was unclear what these groups of skills included or if they were reproducible, they were not included in further analysis regarding feasibility. The following descriptions highlight the key feasibility concepts of each identified FMS assessment.

The TGMD-2 is a process-oriented assessment with 12 items all assessing FMS. Eighteen studies utilised the TGMD-2 with three studies reporting only on the type of assessment

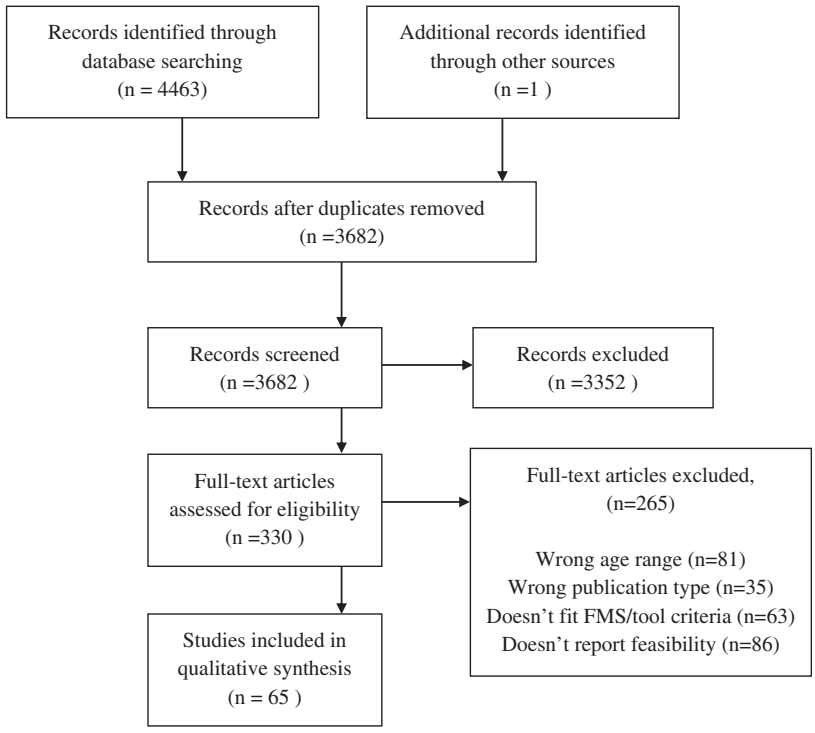

Figure 1. PRISMA flowchart of study selection process.

(Belanger et al., 2016; Hardy, King, Kelly, Farrell, & Howlett, 2010; Logan, Robinson, & Getchell, 2011). No studies reported the equipment requirements. The time to administer was reported in 10 studies (Bardid et al., 2013; Donath, Faude, Hagmann, Roth, & Zahner, 2015; Foulkes et al., 2015; Foweather et al., 2015; Goodway, Crowe, & Ward, 2003; Goodway, Robinson, & Crowe, 2010; Gursel, 2014; Martin, Rudisill, & Hastie, 2009; Morano, Colella, & Caroli, 2011; Woodard & Yun, 2001) and varied widely depending on if the assessment was videotaped, or scored live in the field. Training time, as reported in five studies (Barnett, Hinkley, Okely, Hesketh, & Salmon, 2012; Barnett, Hinkley, Okely, & Salmon, 2013; Chow & Chan, 2011; Chow & Louie, 2013; Zask et al., 2012), varied from 6 to 12 hours of training. Only two studies reported the space required (both 50ft) (Chow & Chan, 2011; Chow & Louie, 2013), and no study reported any qualification requirements for assessors.

The MABC is a product-oriented assessment and was used in 14 studies. It contains eight items, five of which assess FMS. The MABC and the MABC-2 have been grouped together as the assessments contain the same eight items. Four of the studies reported that a specific test kit was required (Atkinson et al., 2002, 2005; Livesey, Coleman, & Piek, 2007; Psotta & Brom, 2016). Nine studies reported the time for administration (Asonitou, Koutsouki, Kourtessis, & Charitou, 2012; Coleman, Piek, & Livesey, 2001; Cools, De Martelaer, Vandaele, Samaey, & Andries, 2010; Giagazoglou et al., 2011; JelovČAn & Zurc, 2016; King-Dowling, Rodriguez, Missiuna, & Cairney, 2016; Piek et al., 2013; Van Waelvelde, Peersman, Lenoir, & Engelsman, 2007; Van Waelvelde, Peersman, Lenoir, Smits Engelsman, & Henderson, 2008), all of which fell within 20–40 minutes per child time band. Only two of the fourteen studies reported any training requirements; one reported one hour (Logan, Scrabis-Fletcher, et al., 2011) and one reported eight hours (King-Dowling et al., 2016). No study reported on the space requirements or need for qualifications.

The Motor-Proficiency-Test for children between 4 and 6 years (MOT 4–6) (Zimmer & Volkamer, 1987) is a product-oriented assessment containing one practice item and 17 test items, 14 of which assess FMS. Four studies utilised the MOT 4–6, two of these studies provided a description of the assessment and equipment (rope, balls, hoop, boxes) (Bardid et al., 2016; Zachopoulou et al., 2004). The other two studies provided information regarding the administration time, both reporting 15–20 minutes per child (Cools et al., 2010; Kambas et al., 2012). One study reported training requirements to be half a day (Bardid et al., 2016). No study reported on the space requirements or need for any qualifications to administer.

The Peabody Developmental Motor Scale 2nd edition (PDMS-2) (Folio & Fewell, 1983) is a process and product-oriented assessment consisting of six subsets: four assessing FMS (containing 143 items) and two assessing fine motor skills. Five studies reported on the PDMS-2 with the equipment requirements not listed in any of the studies. One study only reported the type of assessment (Wang, 2004), the four remaining studies reported on administration time which varied from 20 to 25 minutes when only administering the motor subset (Bellows, Davies, Anderson, & Kennedy, 2013) and up to one and a half hours for the entire assessment per child (Kolobe, Bulanda, & Susman, 2004; Saraiva, Rodrigues, Cordovil, & Barreiros, 2013a, 2013b). No study reported on training, space or qualification requirements.

The APM Inventory (APM) (Numminen, 1995) is a product-oriented assessment that includes eight or more items all assessing FMS. An adapted version of the APM was used in three studies, all conducted by the same main author (Iivonen). Only one study reported on the equipment requirements for the assessment (Iivonen, Saakslahti, & Nissinen, 2011). Two studies reported on the administration time being 20 minutes for a group of three children with two researchers administering the assessment (one demonstrating and the other scoring). Space requirements were reported in two studies as 2–3 meters (Iivonen et al., 2013, 2016). No study reported training or qualification requirements.

The Democritos Movement Screening Tool for pre-school children (DEMOST-PRE) (Kambas & Venetsanou, 2014) is a product-oriented assessment consisting of nine items, seven of which assess FMS. Two studies reported on the DEMOST-PRE, with both reporting easy access equipment and administration time of approximately 15 minutes per child (Kambas & Venetsanou, 2014, 2016). No study reported on training or space requirements. Both studies reported the intended administrator to be pre-school staff.

The CHAMPS Motor Skill Protocol (CMSP) (Williams et al., 2009) is a process-oriented assessment containing 12 items – all assessing FMS. Two studies reported on the CMSP (Williams et al., 2008, 2009), both reporting easy access to equipment and administration time to be approximately 40 minutes per child with two administrators. One of these studies reported that around 51 hours of training was required (Williams et al., 2009). Both studies reported that the assessment should be conducted in a gym or long hallway. A background in motor development was reported as preferable but no formal qualification was reported.

The Developmental Indicators for the Assessment of Learning-3 (DIAL-3) (Mardell-Czudnowski & Goldenberg, 2000) is a process and product oriented assessment with seven items; two of which assess FMS (catching and jump/hop/skip sequence). Two studies used either the DIAL (or the updated version, the DIAL-3) both reporting the need for a specific test kit and administration time to be 20–30 minutes per child (Cook & Broadhead, 1984; Mardell-Czudnowski & Goldenberg, 2000). No official training was required as the test kit supplied instructions for administration. Only one study reported on the required space of 6ft (Mardell-Czudnowski & Goldenberg, 2000). No study reported qualification requirements.

The Body Coordination Test for Children or Körperkoordination-Test für Kinder (KTK) (Schilling & Kiphard, 1974) is a product-oriented assessment containing four items which all assess motor coordination. Two studies administered the KTK, reporting the need for specialised equipment (Bardid et al., 2016) and administration time of approximately 25 minutes per child (Hoeboer et al., 2017). One study reported that a half-day training session was required (Bardid et al., 2016). No information was provided on the space requirements and none reported any qualification requirements.

The Charlop-Atwell scale of motor coordination (Charlop-Atwell) assessment (Charlop & Atwell, 1980) is a process oriented assessment containing six items all assessing FMS, with easily accessible equipment. Only one study reported on this assessment reporting the administration time to be 15 minutes per child (Charlop & Atwell, 1980). This study did not report on the training requirements but did report the need for 12ft of clear space. There were no reported qualification requirements.

The Motor Performance Checklist (MPC) (Gwynne & Blick, 2004) was reported in one study which provided very little detail regarding the description of the assessment. As such, the type of assessment and number of items are unknown (Gwynne & Blick, 2004). A specific MPC kit is required and the administration time is seven minutes per child. The study reported the training required as a 2-hour session completed annually. This study did not report on the space or any qualification requirements for the assessment.

The Pre-schooler Gross Motor Quality scale (PGMQ) (Sun, Zhu, Shih, Lin, & Wu, 2010) is a process-oriented assessment with 17 items all assessing FMS. Only one study used the PGMQ providing details on the equipment, easy access, and the training required −12 hours (Sun, Sun, Zhu, Huang, & Hsieh, 2011). This study did not report on the space or qualification requirements.

The Athletic Skills Track (AST) (Hoeboer et al., 2017) is a product-oriented assessment consisting of an obstacle course containing five FMS. One study reported that the AST requires equipment that is easily accessible or transferable (Hoeboer et al., 2017). Administration takes a couple of minutes per child. This study did not report on training requirements, however reported space requirements to be 16 × 6 meters. This study indicates that the intended administrators are school/pre-school staff.

Summary of feasibility outcome

A summary of the key feasibility concepts are displayed in Table 3, with higher and lower scores indicating assessments are rated as more or less feasible respectively. Feasibility data which was not sourced directly from the articles (as per the methods section) is labelled in Table 3.

Overall, there was a large variance in scores from 9 to 18 out of a possible total 21 points. The widely used TGMD-2 scored the lowest in terms of feasibility and the highest scores went to the DEMOST PRE and the AST. The DEMOST-PRE achieved 18/21, scoring "good" in four of the seven feasibility concepts. The AST also achieved 18/21 with "good" scores in five of the seven concepts; however a poor score was also recorded in one concept (space).

Administration time and space requirements were generally scored the poorest. Eight of the 13 assessments had a "poor" score for administration time with only one assessment having a "good" score. The space required was scored as "poor" in six of the assessments with two scoring it as "good". Alternately, the concepts of qualification, training and assessment type were the most common concepts obtaining a "good" score. The qualification concept was scored as "good" on 12 of the 13 assessments with training and assessment type both scored as "good" on six assessments.

Table 3. Summary table of feasibility concepts.

	Administration time	Equipment	Space	Assessment type	Items	Training	Qualification	Total (/21)	Mean
AST	3	2	1	3	3	3[a]	3	18	2.6
DEMOST-PRE	2	3	2[b]	3	2	3[b]	3	18	2.6
Charlop-Atwell	2	3	3	1	3	?	3	15	2.5*
APM	2	2	3	3	1[c]	2[c]	3	16	2.3
MPC	2	1	?	?	?	3	3	9	2.3*
KTK	1	1	1[a]	3	3	3	3	15	2.1
MOT 4–6	1[b]	3	1[b]	3	1	3	3	15	2.1
MABC	1	1	2[d]	3	2	2	3	14	2.0
DIAL-3	1	1	3	2	2	3	1	13	1.9
TGMD-2 (filmed)	2	2[e]	1	1	2	2	3	13	1.9
CMSP	1	3	1	1	2	1	3	12	1.7
PDMS2	1	1[f]	2[f]	2	1	2[f]	3	12	1.7
PGMQ	1[g]	3	2	1	1	1	3	12	1.7
TGMD-2	1	2[e]	1	1	2	2	3	12	1.7

1 = poor, 2 = average, 3 = good, ? = information couldn't be located, *= denominator adjusted according to missing data, [a] = sourced from author Joris Hoeboer, [b] = sourced from author Fotini Venetsanou, [c] = sourced from developer Arto Laukkanen, [d] = sourced from MABC manual (Henderson et al., 2007), [e] = sourced from TGMD-2 manual (Ulrich, 2000), [f] = sourced from PDMS2 manual (Folio & Fewell, 1983), [g] = sourced from author Shih-Heng Sun, APM = APM inventory, AST = Athletic Skills Track, CMSP = CHAMPS Motor Skill Protocol, DEMOST-PRE = Democritos Movement Screening Tool for preschool children, DIAL-3 = Developmental Indicators for the Assessment of Learning-3, KTK = Body Coordination Test for Children, MABC = Movement Assessment Battery for Children, MOT 4–6 = Motor-Proficiency-Test for children between 4–6 years, MPC = Motor Performance Checklist, PDMS2 = Peabody Developmental Motor Scale 2nd edition PGMQ = Pre-schooler Gross Motor Quality scale,TGMD-2 = Test of Gross Motor Development 2nd edition. Sourced information is italicised and underlined.

Discussion

Summary of main results

The aim of this review was to investigate the feasibility of FMS assessments for pre-school aged children. Sixty-five studies were included in this review reporting on 13 unique FMS assessments. The AST and the DEMOST-PRE were considered the most feasible assessments.

The AST and the DEMOST-PRE were amongst the most newly developed assessments (2017 and 2014 respectively). The newness coupled with high feasibility may reflect a preference for "easier" to use tools and a growing demand for use in non-clinical settings. This is reflected in the literature, as effort is being made in schools so that teachers are able to assess children's FMS instead of clinicians and researchers (Hoeboer et al., 2017; Kambas & Venetsanou, 2014; Lam et al., 2003). The assessments scoring the poorest for feasibility factors included the TGMD-2, PDMS2, CMSP and the PGMQ. The TGMD-2 and PDMS2 only scored well in a single concept (qualification requirements) with both scoring poorly in three of the seven concepts. The TGMD-2 and the PDMS2 are both relatively old assessments (albeit the TGMD has an updated version (Ulrich, 2013)) which require comprehensive training before administration; factors which may explain their low feasibility score in this review.

Some assessments appeared in a large proportion of studies (TGMD-2 in 18 studies and MABC in 14 studies) whereas some appear in only one or two papers (AST and DEMOST-PRE). This uneven spread of research is highlighted when the identified assessments in this review are compared with the assessments in a review conducted by Cools et al. (2009), in which seven unique motor assessments were identified for use in this age group. Five of these assessments were identified within this review (MABC, PDMS, KTK, TGMD-2, MOT 4–6), appearing frequently in the included studies. The additional eight FMS assessments found in this review appear to be infrequently used and/or newly developed. This suggests that although there seems to be a large range of assessments to choose from, only a select few are commonly being used and investigated. In addition, studies utilising the most frequently used assessments (the TGMD-2 and MABC) scored poorly. This suggests that the assessments being most frequently used and researched may not be the most feasible choice in the context of pre-school settings and pre-school staff.

There was an unexpected lack of feasibility reporting, particularly concerning the inclusion of any quantifiable information. This is highlighted by a quarter of the studies (n = 86) being excluded due to lack of feasibility data. It was surprising to find this lack of information even in development papers. Studies mentioned the feasibility concepts but rarely quantified them, meaning the quality of reporting on these concepts was overall very low.

Studies which did report on feasibility aspects, varied in how, if at all, they quantified feasibility elements of the assessment such as training, and space requirements. Often the training (when quantified) was not justified. This meant it was unclear if the training was in terms of training requirements for the particular study or requirements for the assessment generally. Space was often reported as "adequate floor space" or "a long hallway" not allowing a numeric comparison. The reporting of administration time was also an issue, multiple studies reported time for a group of children, time with two administrators or time when the assessment was videotaped and scored later. These variations meant a level of interpretation was required to make the results comparable.

Strengths and limitations of this study

This novel review provides useful information to those wanting to administer an FMS assessment in a pre-school setting. The review's strengths include a strong repeatable methodology containing a clear search strategy and sensitive inclusion and exclusion criteria. A limitation was the exclusion of studies not in English. This study used two independent reviewers to perform the inclusion/exclusion of articles at all stages and

critical appraisal and data extraction was also checked by a second reviewer. Extracted data were coded according to a criteria constructed by the research team and as such is an interpretation of rating feasibility. Although four databases were searched there is a possibility that applicable studies could have been overlooked. This potential limitation was minimised by contacting the experts, which resulted in the inclusion of an additional study (Hoeboer et al., 2017).

Although this review presents a numerical summary of feasibility across different assessments, it is not that simple to encompass all aspects of the assessments in this manner. This systematic review lacks the ability to account for other components of the assessments including the language and access. In addition, this review fails to capture the extra elements of some assessments including the administration format (e.g., the DEMOST-PRE is delivered as a fairy-tale) and additional features (e.g., CMSP has an environmental distraction rating). Consideration of the psychometric properties of the FMS assessments (i.e., reliability and validity) is also not covered by this review, which is similarly important (Portney & Watkins, 2009). Finally, as the psychometric properties weren't considered and this study rates assessments with less items as being more feasible it is possible that the assessments rated as being most feasible may not provide the richest detail with regards to FMS.

Implications and recommendations

To the knowledge of the research team, this is the first systematic review to attempt to evaluate the feasibility of pre-school appropriate FMS assessments. Firstly, for pre-school staff intending to administer FMS assessment in the pre-school setting, the results of this review can act as a guide for tool selection. The findings will allow pre-school staff to choose an assessment that fits to their restrictions, e.g., small space, only a few minutes, only pre-school standard equipment available. Secondly, although the TGMD-2 and the MABC were used the most, they scored among the lowest in regards to feasibility in this context. This implies that when choosing an FMS assessment, pre-school staff should be wary of selecting assessments based on frequency of use. Finally, although this review is systematic in its assessment of feasibility, it fails to account for the reliability and validity of the assessments, which should also be considered.

It is recommended that future research be mindful to quantifiably report on the feasibility of FMS assessment within administration or development studies. This will assist researchers, clinicians and field-based staff when deciding which assessment best suits their resources, capacities and restrictions. However, with the aid of this review, comprehensive guidelines could be created to guide health professionals or pre-school/school staff members through choosing the most feasible FMS assessment for their situation.

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References

Active Healthy Kids Australia. (2016). *Do our kids have all the tools? The 2016 active healthy kids australia report card on physical activity for children and young people*. Adelaide: Author.

Asonitou, K., Koutsouki, D., Kourtessis, T., & Charitou, S. (2012). Motor and cognitive performance differences between children with and without Developmental Coordination Disorder (DCD). *Research in Developmental Disabilities: A Multidisciplinary Journal*, *33*(4), 996–1005.

Atkinson, J., Anker, S., Nardini, M., Braddick, O., Hughes, C., Rae, S., … Atkinson, S. (2002). Infant vision screening predicts failures on motor and cognitive tests up to school age. [Article]. *Strabismus*, *10*(3), 187–198.

Atkinson, J., Nardini, M., Anker, S., Braddick, O., Hughes, C., & Rae, S. (2005). Refractive errors in infancy predict reduced performance on the movement assessment battery for children at 3 1/2 and 5 1/2 years. [Comparative Study Research Support, Non-U.S. Gov't]. *Developmental Medicine & Child Neurology*, *47*(4), 243–251.

Bardid, F., Deconinck, F. J. A., Descamps, S., Verhoeven, L., De Pooter, G., Lenoir, M., & D'Hondt, E. (2013). The effectiveness of a fundamental motor skill intervention in pre-schoolers with motor problems depends on gender but not environmental context. [Article]. *Research in Developmental Disabilities*, *34*(12), 4571–4581.

Bardid, F., Huyben, F., Deconinck, F. J., De Martelaer, K., Seghers, J., & Lenoir, M. (2016). Convergent and divergent validity between the KTK and MOT 4-6 motor tests in early childhood. [Research Support, Non-U.S. Gov't Validation Studies]. *Adapted Physical Activity Quarterly*, *33*(1), 33–47.

Barnett, L., Hinkley, T., Okely, A. D., Hesketh, K., & Salmon, J. O. (2012). Use of electronic games by young children and fundamental movement skills? *Perceptual & Motor Skills*, *114*(3), 1023–1034.

Barnett, L., Hinkley, T., Okely, A. D., & Salmon, J. (2013). Child, family and environmental correlates of children's motor skill proficiency. *Journal of Science & Medicine in Sport*, *16*(4), 332–336.

Barnett, L., Minto, C., Lander, N., & Hardy, L. L. (2014). Interrater reliability assessment using the test of gross motor development-2. [Article]. *Journal of Science and Medicine in Sport*, *17*(6), 667–670.

Belanger, M., Humbert, L., Vatanparast, H., Ward, S., Muhajarine, N., Chow, A. F., … Leis, A. (2016). A multilevel intervention to increase physical activity and improve healthy eating and physical literacy among young children (ages 3-5) attending early childcare centres: The Healthy Start-Depart Sante cluster randomised controlled trial study protocol. [Randomized Controlled Trial Research Support, Non-U.S. Gov't]. *BMC Public Health*, *16*, 313.

Bellows, L. L., Davies, P. L., Anderson, J., & Kennedy, C. (2013). Effectiveness of a physical activity intervention for head start preschoolers: A randomized intervention study. [Multicenter Study Randomized Controlled Trial Research Support, U.S. Gov't, Non-P.H.S.]. *American Journal of Occupational Therapy*, *67*(1), 28–36.

Benefice, E., Fouere, T., & Malina, R. M. (1999). Early nutritional history and motor performance of Senegalese children, 4-6 years of age. *Annals of Human Biology*, *26*(5), 443–455.

Biddle, S. J., & Asare, M. (2011). Physical activity and mental health in children and adolescents: A review of reviews. *British Journal of Sports Medicine*, *45*(11), 886–895.

Bowen, D. J., Kreuter, M., Spring, B., Cofta-Woerpel, L., Linnan, L., Weiner, D., … Fernandez, M. (2009). How we design feasibility studies. [Research Support, N.I.H., Extramural]. *American Journal of Preventive Medicine*, *36*(5), 452–457.

Cattuzzo, M. T., dos Santos Henrique, R., Ré, A. H. N., de Oliveira, I. S., Melo, B. M., de Sousa Moura, M., … Stodden, D. (2016). Motor competence and health related physical fitness in youth: A systematic review. *Journal of Science and Medicine in Sport*, *19*(2), 123–129.

Charlop, M., & Atwell, C. W. (1980). The charlop-atwell scale of motor coordination: A quick and easy assessment of young children. *Perceptual and Motor Skills*, *50*(3), t21291–21308.

Chow, B. C., & Chan, L. (2011). Gross motor skills of hong kong preschool children. *Asian Journal of Physical Education & Recreation*, *17*(1), 71–77.

Chow, B. C., & Louie, L. H. (2013). Difference in children's gross motor skills between two types of preschools. [Comparative Study]. *Perceptual & Motor Skills*, *116*(1), 253–261.

Clark, J. (1994). *Motor development encyclopedia of human behavior* (Vol. 3, 3rd ed.). San Diego: Academic Press.

Coleman, R., Piek, J. P., & Livesey, D. J. (2001). A longitudinal study of motor ability and kinaesthetic acuity in young children at risk of developmental coordination disorder. [Article]. *Human Movement Science*, *20*(1–2), 95–110.

Cook, C. F., & Broadhead, G. D. (1984). Motor performance of pre-school twins and singletons. *Physical Educator*, *41*(1), 16–20.

Cools, W., De Martelaer, K., Samaey, C., & Andries, C. (2009). Movement skill assessment of typically developing preschool children: A review of seven movement skill assessment tools. *Journal of Sports Science & Medicine*, *8*(2), 154–168.

Cools, W., De Martelaer, K., Vandaele, B., Samaey, C., & Andries, C. (2010). Assessment of movement skill performance in preschool children: Convergent validity between MOT 4-6 and M-ABC. *Journal of Sports Science & Medicine*, *9*(4), 597–604.

de Barros, K. M., Fragoso, A. G., de Oliveira, A. L., Cabral Filho, J. E., & de Castro, R. M. (2003). Do environmental influences alter motor abilities acquisition? A comparison among children from day-care centers and private schools. [Comparative Study]. *Arquivos de Neuro-Psiquiatria*, *61* (2A), 170–175.

Donath, L., Faude, O., Hagmann, S., Roth, R., & Zahner, L. (2015). Fundamental movement skills in preschoolers: A randomized controlled trial targeting object control proficiency. [Article]. *Child: Care, Health and Development*, *41*(6), 1179–1187.

Figueroa, R., & An, R. (2017). Motor skill competence and physical activity in preschoolers: A review. *Maternal and Child Health Journal*, *21*(1), 136–146.

Fisher, A., Reilly, J. J., Kelly, L. A., Montgomery, C., Williamson, A., Paton, J. Y., & Grant, S. (2005). Fundamental movement skills and habitual physical activity in young children. *Medicine & Science in Sports & Exercise*, *37*(4), 684–688.

Folio, M. R., & Fewell, R. R. (1983). *Peabody developmental motor scales: Manual*. Austin, TX: George Peabody College for Teachers.

Foulkes, J. D., Knowles, Z., Fairclough, S. J., Stratton, G., O'Dwyer, M., Ridgers, N. D., & Foweather, L. (2015). Fundamental movement skills of preschool children in northwest England. *Perceptual & Motor Skills*, *121*(1), 260–283.

Foweather, L., Knowles, Z., Ridgers, N. D., O'Dwyer, M. V., Foulkes, J. D., & Stratton, G. (2015). Fundamental movement skills in relation to weekday and weekend physical activity in preschool children. [Observational Study Research Support, Non-U.S. Gov't]. *Journal of Science & Medicine in Sport*, *18*(6), 691–696.

Gabbard, C. (2012). *Lifelong motor development* (6th ed.). San Francisco: Pearson Benjamin Cummings.

Giagazoglou, P., Kabitsis, N., Kokaridas, D., Zaragas, C., Katartzi, E., & Kabitsis, C. (2011). The movement assessment battery in Greek preschoolers: The impact of age, gender, birth order, and physical activity on motor outcome. *Research in Developmental Disabilities: A Multidisciplinary Journal*, *32*(6–), 2577–2582.

Goodway, J. D., Crowe, H., & Ward, P. (2003). Effects of motor skill instruction of fundamental motor skill development. *Adapted Physical Activity Quarterly*, *20*(3), 298.

Goodway, J. D., Robinson, L., & Crowe, H. (2010). Gender differences in fundamental motor skill development in disadvantaged preschoolers from two geographical regions. *Research Quarterly for Exercise and Sport*, *81*(1), 17–24.

Goshi, F., Demura, S., Kasuga, K., Sato, S., & Minami, M. (1999). Selection of effective tests of motor ability in preschool children based on pass-or-fail criteria: Examination of reliability, objectivity, and rate of passing. *Perceptual & Motor Skills*, *88*(1), 169–181.

Goshi, F., Demura, S., Kasuga, K., Sato, S., & Minami, M. (2000). Use of subjective estimation in motor skill tests of young children: Judgment based on observation of behavior in daily life. *Perceptual & Motor Skills*, *90*(1), 215–226.

Gursel, F. (2014). Inclusive intervention to enhance the fundamental movement skills of children without hearing: A preliminary study. *Perceptual & Motor Skills*, *118*(1), 304–315.

Gwynne, K., & Blick, B. (2004). Motor performance checklist for 5-year-olds: A tool for identifying children at risk of developmental co-ordination disorder. [Evaluation Studies Research Support, Non-U.S. Gov't]. *Journal of Paediatrics & Child Health*, *40*(7), 369–373.

Hardy, L. L., King, L., Farrell, L., Macniven, R., & Howlett, S. (2010). Fundamental movement skills among Australian preschool children. *Journal of Science & Medicine in Sport*, *13*(5), 503–508.

Hardy, L. L., King, L., Kelly, B., Farrell, L., & Howlett, S. (2010). Munch and Move: Evaluation of a preschool healthy eating and movement skill program. *International Journal of Behavioral Nutrition & Physical Activity*, *7*(p), 80.

Henderson, S. E., Sugden, D. A., & Barnett, A. L. (2007). *Movement assessment battery for children-2*. London, UK: Harcourt Assessment.

Hoeboer, J., Krijger, M., Savelsbergh, G., & de Vries, S. (2017). Reliability and concurrent validity of a motor skill competence test among 4- to 12-year old children. *Journal of Sports Sciences*, *36*, 1–7.

Iivonen, S., Saakslahti, A., & Nissinen, K. (2011). The development of fundamental motor skills of four- to five-year-old preschool children and the effects of a preschool physical education curriculum. *Early Child Development and Care*, *181*(3), 335–343.

Iivonen, S., Sääkslahti, A. K., Mehtälä, A., Villberg, J. J., Soini, A., & Poskiparta, M. (2016). Directly observed physical activity and fundamental motor skills in four-year-old children in day care. *European Early Childhood Education Research Journal*, *24*(3), 398–413.

Iivonen, S., Saakslahti, A. K., Mehtala, A., Villberg, J. J., Tammelin, T. H., Kulmala, J. S., & Poskiparta, M. (2013). Relationship between fundamental motor skills and physical activity in 4-year-old preschool children. [Research Support, Non-U.S. Gov't]. *Perceptual & Motor Skills*, *117*(2), 627–646.

JelovČAn, G., & Zurc, J. (2016). Preschool children's results in movement ABC tests: Differences between girls and boys in movement deficit. *Annales Kinesiologiae*, *7*(1), 3–19.

Kambas, A., & Venetsanou, F. (2014). The Democritos Movement Screening Tool for Preschool Children (DEMOST-PRE©): Development and factorial validity. [Validation Studies]. *Research in Developmental Disabilities*, *35* (7), 1528–1533.

Kambas, A., & Venetsanou, F. (2016). Construct and concurrent validity of the democritos movement screening tool for preschoolers. *Pediatric Physical Therapy*, *28*(1), 94–99.

Kambas, A., Venetsanou, F., Giannakidou, D., Fatouros, I. G., Avloniti, A., Chatzinikolaou, A., … Zimmer, R. (2012). The motor-proficiency-test for children between 4 and 6 years of age (MOT 4-6): An investigation of its suitability in Greece. *Research in Developmental Disabilities: A Multidisciplinary Journal*, *33*(5), 1626–1632.

Kelly, L., Dagger, J., & Walkley, J. (1989). The effects of an assessment-based physical education program on motor skill development in preschool children. *Education and Treatment of Children*, *12*(2), 152–164.

King-Dowling, S., Rodriguez, M. C., Missiuna, C., & Cairney, J. (2016). Validity of the ages and stages questionnaire to detect risk of developmental coordination disorder in preschoolers. [Research Support, Non-U.S. Gov't Validation Studies]. *Child: Care, Health & Development*, *42*(2), 188–194.

Kirby, K. C., & Holborn, S. W. (1986). Trained, generalized, and collateral behavior changes of preschool children receiving gross-motor skills training. *Journal of Applied Behavior Analysis*, *19*(3), 283–288.

Kolobe, T. H. A., Bulanda, M., & Susman, L. (2004). Predicting motor outcome at preschool age for infants tested at 7, 30, 60, and 90 days after term age using the test of infant motor performance. *Physical Therapy*, *84*(12), 1144–1156.

Krombholz, H. (2006). Physical performance in relation to age, sex, birth order, social class, and sports activities of preschool children. *Perceptual & Motor Skills*, *102*(2), 477–484.

Lam, M. Y., Ip, M. H., Lui, P. K., & Koong, M. K. (2003). How teachers can assess kindergarten children's motor performance in Hong Kong. *Early Child Development and Care*, *173*(1), 109–118.

Lander, N., Morgan, P. J., Salmon, J., & Barnett, L. M. (2016). Teachers' perceptions of a fundamental movement skill (FMS) assessment battery in a school setting. *Measurement in Physical Education and Exercise Science*, *20*(1), 50–62.

Livesey, D., Coleman, R., & Piek, J. (2007). Performance on the movement assessment battery for children by Australian 3- to 5-year-old children. [Article]. *Child: Care, Health and Development*, *33*(6), 713–719.

Lloyd, M., Saunders, T. J., Bremer, E., & Tremblay, M. S. (2014). Long-term importance of fundamental motor skills: A 20-year follow-up study. *Adapted Physical Activity Quarterly*, *31*(1), 67–78.

Logan, S., Barnett, L., Goodway, J., & Stodden, D. (2017). Comparison of performance on process-and product-oriented assessments of fundamental motor skills across childhood. *Journal of Sports Sciences*, *35*(7), 634–641.

Logan, S., Robinson, L., & Getchell, N. (2011). The comparison of performances of preschool children on two motor assessments. *Perceptual & Motor Skills*, *113*(3), 715–723.

Logan, S., Robinson, L., Wilson, A. E., & Lucas, W. A. (2012). Getting the fundamentals of movement: A meta-analysis of the effectiveness of motor skill interventions in children. [Review]. *Child: Care, Health and Development*, *38*(3), 305–315.

Logan, S., Scrabis-Fletcher, K., Modlesky, C., & Getchell, N. (2011). The relationship between motor skill proficiency and body mass index in preschool children. *Research Quarterly for Exercise and Sport*, *82*(3), 442–448.

Lubans, D. R., Morgan, P. J., Cliff, D. P., Barnett, L., & Okely, A. D. (2010). Fundamental movement skills in children and adolescents: Review of associated health benefits. [Review]. *Sports Medicine*, *40*(12), 1019–1035.

Mardell-Czudnowski, C., & Goldenberg, D. S. (2000). A new test for assessing preschool motor development: DIAL-3. *Adapted Physical Activity Quarterly*, *17*(1), 78–94.

Martin, E. H., Rudisill, M. E., & Hastie, P. A. (2009). Motivational climate and fundamental motor skill performance in a naturalistic physical education setting. *Physical Education and Sport Pedagogy*, *14*(3), 227–240.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Group, P. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, *6*(7), e1000097.

Morano, M., Colella, D., & Caroli, M. (2011). Gross motor skill performance in a sample of overweight and non-overweight preschool children. [Comparative Study Research Support, Non-U.S. Gov't]. *International Journal of Pediatric Obesity*, *6*(Suppl 2), 42–46.

Morris, A. M., Williams, J. M., Atwater, A. E., & Wilmore, J. H. (1982). Age and sex differences in motor performance of 3 through 6 year old children. *Research Quarterly for Exercise & Sport*, *53*(3), 214–221.

Numminen, P. (1995). *Alle kouluikaisten lasten havaintomotorisia ja motorisia perustaitoja mittaavan APM-testiston kasikirja* [Manual and test booklet for assessing pre-school children's perceptual and fundamental motor skills]. Jyvaskyla: Liikunnan ja kansanterveyden edistamissaatio (LIKES): LIKES - Foundation for Sport and Health Sciences.

Okely, A. D., Booth, M. L., & Chey, T. (2004). Relationships between body composition and fundamental movement skills among children and adolescents. *Research Quarterly for Exercise and Sport*, *75*(3), 238–247.

Ortega, F., Ruiz, J., Castillo, M., & Sjöström, M. (2008). Physical fitness in childhood and adolescence: A powerful marker of health. *International Journal of Obesity*, *32*(1), 1–11.

Piek, J. P., Hands, B., & Licari, M. K. (2012). Assessment of motor functioning in the preschool period. *[Review]. Neuropsychology Review*, *22*(4), 402–413.

Piek, J. P., McLaren, S., Kane, R., Jensen, L., Dender, A., Roberts, C., … Straker, L. (2013). Does the Animal Fun program improve motor performance in children aged 4–6years? *Human Movement Science*, *32*(5), 1086–1096.

Portney, L., & Watkins, M. (2009). *Foundations of clinical research: Applications to practice* (3rd ed.). Stamford, CT: Pearson Education.

Psotta, R., & Brom, O. (2016). Factorial structure of the movement assessment battery for children test–second edition in preschool children. *Perceptual & Motor Skills*, *123*(3), 702–716.

Rokicka-Hebel, M. (2013). Preschool attendance as a factor in the motor skill development of children. *Human Movement*, *14*(4), 310–321.

Roux, A. M., Herrera, P., Wold, C. M., Dunkle, M. C., Glascoe, F. P., & Shattuck, P. T. (2012). Developmental and autism screening through 2-1-1: Reaching underserved families. *American Journal of Preventive Medicine*, *43*(6), S457–S463.

Saraiva, L., Rodrigues, L., Cordovil, R., & Barreiros, J. (2013a). Influence of age, sex and somatic variables on the motor performance of pre-school children. *Annals of Human Biology*, *40*(5), 444–450.

Saraiva, L., Rodrigues, L., Cordovil, R., & Barreiros, J. (2013b). Motor profile of portuguese preschool children on the peabody developmental motor scales-2: A cross-cultural study. *Research in Developmental Disabilities: A Multidisciplinary Journal*, *34*(6), 1966–1973.

Schilling, F., & Kiphard, E. J. (1974). *Körperkoordinationstest für Kinder* [Body coordination test for children]. Beltz: KTK.

Seefeldt, V. (1980) *Developmental motor patterns: Implications for elementary school physical education*. Paper presented at the Refereed proceedings of Psychology of motor behavior and sport 1980 (pp. 314-323). Champaign, IL: Human Kinetics.

Sun, S. H., Sun, H. L., Zhu, Y. C., Huang, L. C., & Hsieh, Y. L. (2011). Concurrent validity of preschooler gross motor quality scale with test of gross motor development-2. [Research Support, Non-U.S. Gov't Validation Studies]. *Research in Developmental Disabilities*, *32*(3), 1163–1168.

Sun, S. H., Zhu, Y.-C., Shih, C.-L., Lin, C.-H., & Wu, S. K. (2010). Development and initial validation of the preschooler gross motor quality scale. *Research in Developmental Disabilities: A Multidisciplinary Journal*, *31*(6–), 1187–1196.

Tester, G., Ackland, T. R., & Houghton, L. (2014). A 30-year journey of monitoring fitness and skill outcomes in physical education: Lessons learned and a focus on the future. *Advances in Physical Education*, *4*, 127–137.

Tortella, P., Haga, M., Loras, H., Sigmundsson, H., & Fumagalli, G. (2016). Motor skill development in italian pre-school children induced by structured activities in a specific playground. *PLoS One* [Electronic Resource], *11*(7), e0160244.

Ulrich, D. (2000). TGMD 2–Test of gross motor development examiner's manual. *Austin TX: PRO-ED*, *2*.

Ulrich, D. (2013). The test of gross motor development-3 (TGMD-3): Administration, scoring, and international norms. *Spor Bilimleri Dergisi*, *24*(2), 27–33.

Van Waelvelde, H., Peersman, W., Lenoir, M., & Engelsman, B. C. M. S. (2007). The reliability of the movement assessment battery for children for preschool children with mild to moderate motor impairment. *Clinical Rehabilitation*, *21*(5), 465–470.

Van Waelvelde, H., Peersman, W., Lenoir, M., Smits Engelsman, B. C. M., & Henderson, S. E. (2008). The movement assessment battery for children: Similarities and differences between 4- and 5-year-old children from flanders and the United States. [Article]. *Pediatric Physical Therapy*, *20*(1), 30–38.

Vivanti, G., Paynter, J., Duncan, E., Fothergill, H., Dissanayake, C., Rogers, S. J., & Team, V. A. (2014). Effectiveness and feasibility of the early start denver model implemented in a group-based community childcare setting. *Journal of Autism and Developmental Disorders*, *44*(12), 3140–3153.

Wang, J. H.-T. (2004). A study on gross motor skills of preschool children. *Journal of Research in Childhood Education*, *19*(1), 32.

Williams, H. G., Pfeiffer, K. A., Dowda, M., Jeter, C., Jones, S., & Pate, R. R. (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, H. G., Pfeiffer, K. A., O'Neill, J. R., Dowda, M., McIver, K. L., Brown, W. H., & Pate, R. R. (2008). Motor skill performance and physical activity in preschool children. *Obesity (19307381)*, *16*(6), 1421–1426.

Woodard, R. J., & Yun, J. (2001). The performance of fundamental gross motor skills by children enrolled in head start. *Early Child Development and Care*, *169*, 57–67.

Zachopoulou, E., Tsapakidou, A., & Derri, V. (2004). The effects of a developmentally appropriate music and movement program on motor performance. *Early Childhood Research Quarterly*, *19*(4), 631–642.

Zask, A., Barnett, L., Rose, L., Brooks, L. O., Molyneux, M., Hughes, D., … Salmon, J. (2012). Three year follow-up of an early childhood intervention: Is movement skill sustained? [Research Support, Non-U.S. Gov't]. *International Journal of Behavioral Nutrition & Physical Activity*, *9*(p), 127.

Zimmer, R., & Volkamer, M. (1987). *Motoriktest für vier-bis sechsjährige Kinder: (MOT 4-6)* [Motor test for four to six year old children: (MOT 4-6)]. Beltz.