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Fundamental motor skills: A systematic review of terminology

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ABSTRACT

The three aims of this systematic review are to describe: (1) use of the term fundamental motor/movement skills (FMS) in published articles; (2) the quality of definitions; and (3) relative use of process- and product- oriented assessments to measure FMS. The inclusion criteria included: (a) peer-reviewed article, (b) printed in English, (c) published between January 2000 and 31 December 2015, (d) presence of either the term “fundamental motor or movement skill” in the title and/or abstract, and (e) FMS were a measured outcome. There has been an increase in the number of publications on FMS in recent years, with the majority of studies conducted in Australia ($n = 41$, 33%). Approximately 24% of studies ($n = 30$) did not provide any explicit definition of FMS. A majority of studies reported the use of process-oriented measures ($n = 98$, 79%) compared to product-oriented measures ($n = 23$, 19%), and few studies used both ($n = 6$, 5%). We recommend that researchers provide: (1) an operational definition of FMS that states FMS are the “building blocks” (or similar terminology) of more advanced, complex movements; (2) specific categories of skills that compose FMS; and (3) at least one specific example of a FMS.

ARTICLE HISTORY

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KEYWORDS

Systematic review; motor competence; motor development

Introduction

Throughout history, terms used within motor development have evolved with emphasis shifting from the biological maturational processes of motor development to different aspects of motor behavior over time. Today, research has specifically focused on the importance and predictive utility of motor competence on positive health outcomes. A recent review paper published in *Sports Medicine* emphasized the importance of motor competence in relation to positive developmental trajectories of health including physical activity, health-related fitness, perceived competence, and weight status (Robinson et al., 2015). Contemporary use of the term motor competence “...reflect[s] various terminologies that have been used in previous literature (i.e., motor proficiency, motor performance, fundamental movement/motor skill, motor ability, and motor coordination)” (Robinson et al., 2015, p. 1274). The evolution of terms within motor development has created ambiguity in terminology within the literature and across the various disciplines and sub disciplines of human movement and there remain a variety of terms that are used to describe levels of movement skill. This can be problematic, as the definitions of specific terms may inaccurately differentiate the terms and/or terms may be used interchangeably to describe the same phenomenon. It is further challenging to build a comprehensive model of motor development when terms are inconsistently used in the literature. Public health intervention strategies are difficult to develop without a cohesive understanding of the predictive validity of motor competence on health outcomes. There is a need to provide

clarification regarding the different terms that are used to describe motor competence.

The goal of this review is to closely examine how researchers conceptualize, operationalize, and measure *fundamental motor skills*, which has been a popular term used in contemporary literature in reference to motor competence. The term *fundamental skill* in relation to the motor domain was defined by Wickstrom (1977, p. 3) as “...a common motor activity with a general goal [that serves as] ...the basis for more advanced and highly specific motor activities,” including skills such as running, jumping, and throwing, among others. For the purpose of the current review, fundamental motor skills are operationally defined as the “building blocks” of more advanced, complex movements required to participate in sports, games, or other context specific physical activity, and includes object control/ball/manipulative skills (throwing, catching, dribbling, kicking, strike, underhand roll), locomotor skills (walking, running, jumping, hopping, leaping, galloping, sliding, skipping), and balance/stability skills (non locomotor skills such as body rolling, bending, dodging, stick balancing, one-foot balance, stretching, swinging, turning, and twisting) (Gallahue, Ozmun, & Goodway, 2012). We chose to use the Gallahue et al. (2012) definition of fundamental motor skills because it is broader, often used, and reflects a recent trend of researchers highlighting the inclusion of balance/stability skills in the measure of motor competence (Rudd et al., 2015). However, it should be noted that balance/stability skills have traditionally been categorized as underlying abilities for locomotor skills as opposed to stand-alone FMS (Burton & Rodgers, 2001; Fleishman, 1962; Fleishman, Quaintance, & Broedling, 1984).

Several terms have been used to describe fundamental motor skills such as *gross motor skills* (e.g., Mostafavi, Ziaee, Akbari, & Haji-Hosseini, 2013; Pang & Fong, 2009), fundamental motor *patterns* (e.g., Barnett, Hinkley, Okely, Hesketh, & Salmon, 2012), and fundamental *movement skills* (e.g., Barnett, Zask, Rose, Hughes, & Adams, 2015; Staples & Reid, 2010). It is important to understand how researchers conceptualize, operationalize, and measure *fundamental motor skills* to allow comparison of results across studies. This will contribute to a better understanding of the relationship between fundamental motor skills and positive health outcomes. For example, Ziviani, Poulsen, and Hansen (2009) found a weak to non-significant relationship between performances on subscales of the Movement Assessment Battery for Children (MABC) and physical activity participation. Researchers questioned "...the magnitude of the relationship between fundamental movement skills and physical activity" and emphasized "...the need to move away from skills based programs to community, occupationally based and cross-disciplinary approaches to enhancing children's engagement in physical activities" (Ziviani et al., 2009, p. 264). This conclusion is vastly different from other researchers who have called for greater emphasis on teaching fundamental motor skills during early childhood (Robinson, Palmer, & Meehan, 2017; Robinson, Webster, Logan, Lucas, & Barber, 2012). Thus, it is an opportune time to describe the current state of the literature with regard to how fundamental motor skills are conceptualized, operationalized, and measured.

There are methodological issues to consider regarding the selection of fundamental motor skill assessments. Typically, assessment occurs through two methods: process or product measures. Process-oriented measures assess the quality of movements performed during skill execution (e.g., demonstration of behavioral components of a skill). Alternatively, product-oriented measures focus on the outcomes of skill execution (e.g., velocity of throw, distance jumped). A recent study noted weak to strong relationships between performances on several process-oriented and product-oriented assessments of fundamental motor skills, depending upon the type of skill (jump, hop, or throw) and age group of participants (4–5, 7–8, 10–11 year olds; Logan, Barnett, Goodway, & Stodden, 2016). This suggests that performance on process-oriented or product-oriented assessments show that *how* a skill is assessed and for *whom*, is important. This may have implications for the predictive validity of motor competence on health outcomes. Researchers have suggested that the use of both process- and product-oriented assessments may provide a more comprehensive view of fundamental motor skill competence (Logan et al., 2016; Robinson et al., 2015; Rudd et al., 2015).

The three aims of this review are to: (1) describe the contemporary use of the terms fundamental **motor** skills and fundamental **movement** skills, including relative frequency and distribution of published articles across time and countries; (2) describe the quality of definitions of both terms found within the research literature; and (3) describe how fundamental motor/movement skills are measured through process- and product-oriented motor assessments. For the remainder of this article, the abbreviation of FMS will be used to simultaneously refer to "fundamental motor skills" and "fundamental movement skills." If we refer to a specific term, then the term will be differentiated.

Methods

This article systematically examined how the term FMS is conceptualized, operationalized, and measured in contemporary literature (i.e., 2000–2015). Standardized guidelines for systematic reviews by *Preferred Reporting Items for Systematic Reviews and Meta-Analysis* (PRISMA; Moher, Liberati, Tetzlaff, & Altman, 2009) were followed. The key words "fundamental motor skills" OR "fundamental movement skills," were used to conduct electronic searches of the following databases in March 2016: PubMed/Medline, Web of Science, and Academic Search Premier. In effort to ensure all eligible articles were identified, the first 15 pages of Google Scholar search results (using the same key search terms listed above) were cross-referenced with the compiled inclusion bibliography, and additional eligible articles collected by the second Author (SR). Inclusion criteria: (a) peer-reviewed article, (b) printed in English, (c) publication date between January 2000 and 31 December 2015, (d) presence of either the term "fundamental motor or movement skill" in the title and/or abstract, and (e) FMS were a measured outcome. To be clear, articles were not included if FMS were measured but did not meet the other inclusion criteria. The rationale for this decision was to allow our searches to be replicated. Exclusion criteria: (a) publications that were not peer reviewed, (b) printed in a language other than English, (c) publication date before January 2000 or after December 2015, (d) did not include either term "fundamental motor/movement skill" in the title and/or abstract, (e) did not measure FMS, (f) review articles, and (g) articles that included "fundamental motor skills" or "fundamental movement skills" as a "key word" but were not found within the title or abstract. The initial search produced 950 articles, which was reduced to 198 articles after abstract screening and removal of duplicates. Figure 1 outlines the search flow process.

A total of 198 full articles were reviewed for data extraction, followed by a secondary audit conducted by lead authors (SL, SR). This secondary eligibility scan resulted in the exclusion of 65 additional articles (e.g., published conference abstracts ($n = 7$), FMS were not directly measured ($n = 31$), see Figure 1 for full list). A total of 124 articles met the inclusion criteria and were retained for data synthesis and analysis (Appendix A).

Data extraction

Data extraction points were developed and agreed upon by the primary researchers (SL, SR). Four trained research assistants extracted the following data from included studies: author, publication year, country of origin, key term used (i.e., fundamental motor skill or fundamental movement skill) and measurement used to assess FMS. Data related to how FMS was defined within each article was also extracted verbatim for further analysis. This included the first sentence in-text that introduced FMS, in addition to any subsequent sentences that explicitly defined FMS. All members of the research team initially examined a random selection of five included articles. Results were discussed to ensure agreement and consistency in data extraction across research assistants. The lead authors (SL, SR) conducted a secondary audit of extracted data. All ambiguous results were discussed until a consensus was reached.

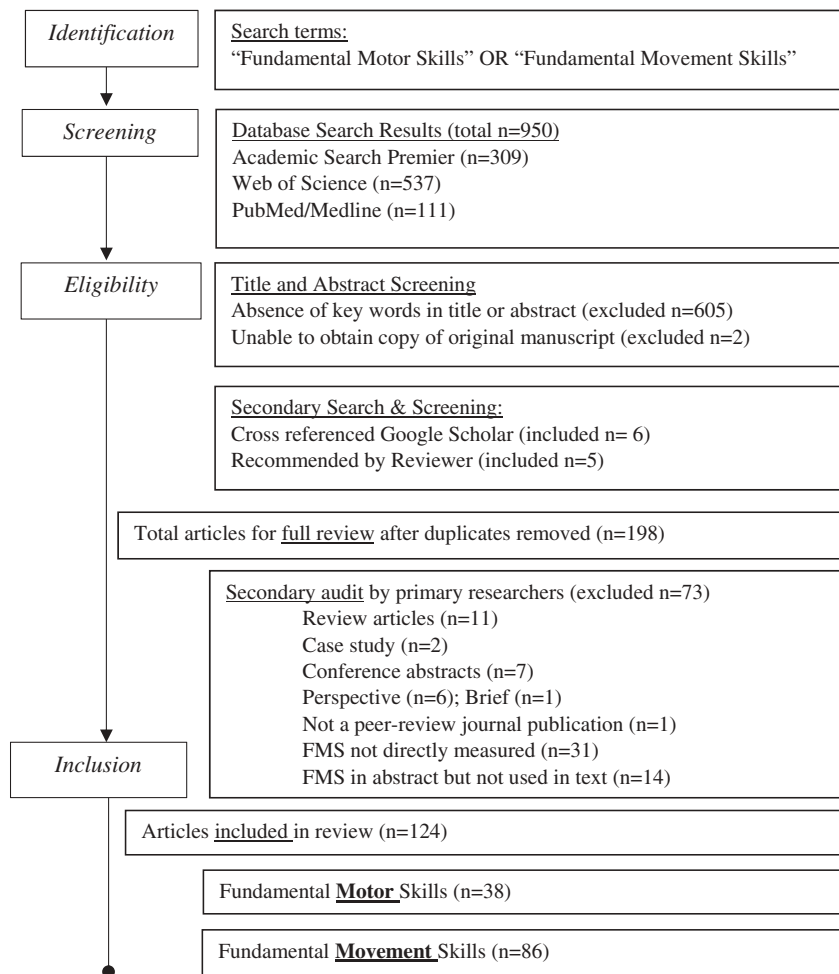


Figure 1. Search flow summary.

Data analysis

Extracted data were compiled and synthesized for comparison of key variables to address specific aim one, to describe use of the term FMS in contemporary research. Total frequency counts for the use of fundamental **motor** skill and fundamental **movement** skill were calculated by publication date and the country of origin.

The primary authors developed "definition quality criteria" *a priori* to address aim two, to describe the quality of FMS definitions. The presence or absence of criteria determined how FMS were defined and operationalized within the research literature. Three criterion were used to score sentences extracted verbatim from included studies (1 = present, 0 = not present) based on a previous and commonly referenced description of FMS (Clark & Metcalfe, 2002; Gallahue et al., 2012): (1) a statement that suggests FMS are the "building blocks" (or similar terminology) of more advanced/complex movements required to participate in sports, games, or other context-specific physical activities; (2) a statement that provides specific categories of skills that compose FMS such as object control, locomotor, manipulation, balance, and/or stability; (3) a statement that provides at least one specific example of FMS such as running, jumping, throwing, or other skill. Scores were summed for a total quality score of (0) no statement met any criterion, (1) one

criterion was met, (2) two criterion were met, or (3) all three criterion were met. Frequency counts for specific criterion and total quality scores are presented in Table 2 for the whole sample, and stratified by fundamental motor skill and fundamental movement skill subgroups.

Included studies were further categorized to address specific aim three according to: (1) process-oriented measures that assessed the quality of movements performed during skill execution (e.g., demonstration of behavioral components of a skill), (2) product-oriented measures of specific skill or movement (e.g., velocity of throw, distance jumped), or (3) both process- and product-oriented measures. Total frequency counts for each assessment and their process- and product-oriented sub-categories are presented in Table 3 for the entire sample and are stratified by fundamental motor skill and fundamental movement skill subgroups.

Results

Motor vs. movement

Of the 124 articles included in this review (Appendix A), the term fundamental **movement** skills ($n = 86$, 69%) was used more frequently than fundamental **motor** skills ($n = 38$, 31%). Regardless of the term used, there has been a steady increase

in number of publications on FMS in recent years (Figure 2), with the majority of studies conducted in Australia ($n = 41$, 33%), the United States ($n = 12$, 10%), Finland ($n = 11$, 9%), the United Kingdom ($n = 7$, 6%) and Canada ($n = 6$, 5%). The remaining countries each accounted for less than 5% of the studies (see Table 1 for full list).

Quality of FMS definition

Definition Quality Criterion: The quality scores for FMS definitions are presented in Table 2 and illustrated in Figure 3. **Total Quality Score:** The average total quality score across studies was 1.39 out of 3.0. Studies were evenly distributed across total quality scores (24–27% for each of the possible quality scores, 0–3; see Table 2). Approximately 24% of studies ($n = 30$) did not meet any of the criteria due to the absence of any explicit definition of FMS within the article.

Of the studies not meeting any of the quality criterion ($n = 30$), approximately 47% ($n = 14$) used the term fundamental **movement** skills. Studies defined by a total quality score of 3 ($n = 31$) were more likely to have used the term **movement** ($n = 25$) than **motor** ($n = 6$). Notably, studies that used the term **movement** had a higher average total quality score of 1.74 out of 3.0, compared to studies using the term **motor** (1.03; see Table 2).

FMS assessment

A majority of studies reported exclusive use of a process-oriented measure to assess FMS ($n = 98$, 79%), with the majority of those studies administering the Test of Gross Motor Development ($n = 63$, 64%, see Table 3). Fewer studies reported exclusive use of a product-oriented measure to assess FMS ($n = 23$, 19%), with the most common measure administered being the FMS Test Package ($n = 6$; 26%, see Table 3). Even fewer studies reported the use of both a product- and process-oriented FMS measure ($n = 6$, 5%). See Table 4 for a description of skills and tasks within each assessment included in this review.

Table 1. Frequency of studies included by country and key term used (fundamental “motor” or “movement” skill).

Study Characteristics	Movement (n)	Motor (n)	Total (N)
Total Articles included	86	38	124
Country			
Australia	35	6	41
Canada	4	2	6
China	5	0	5
Croatia	2	1	3
Finland	8	3	11
Greece	1	2	3
Iran	2	2	4
Ireland	3	0	3
Philippines	2	0	2
Portugal	0	2	2
United Kingdom	6	1	7
United States	3	9	12
Other	15	10	25

Discussion

The goal of this systematic review was to examine how researchers conceptualize, operationalize, and measure *fundamental motor skills* in contemporary literature. The three aims of this review were to: (1) describe the use of the terms fundamental **motor** skills and fundamental **movement** skills, including relative frequency and distribution of published articles across time and countries; (2) describe the quality of definitions of both terms found within the research literature; and (3) describe how fundamental motor/movement skills are measured through process- and product-oriented motor assessments.

Movement vs. motor

One interesting finding was that the term *fundamental movement skills* ($n = 86$, 69%) was used more frequently than *fundamental motor skills* ($n = 38$, 31%). This may reflect a purposeful shift by researchers to use the more general term of “movement” instead of “motor”, recognizing that the terms are often used interchangeably to represent several different aspects of motor competence. This is also consistent with the recent shift by researchers in using the global term motor

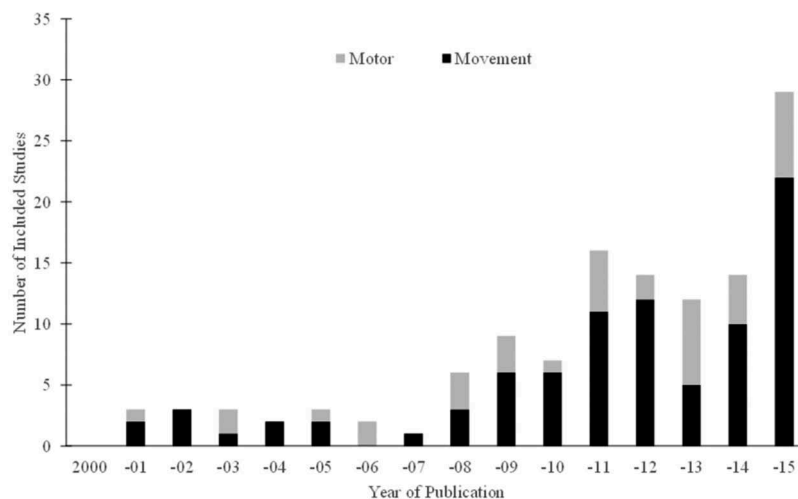


Figure 2. Total number of articles published during years 2000–2015, subdivided by use of the term fundamental “motor” or “movement” skill (FMS).

Table 2. Quality scores for in-text definitions provided for fundamental motor/movement skill (FMS).

Definition Quality Criterion*	FMS Subgroups		Total
	Movement (n)	Motor (n)	n (%total of N = 124)
(0) No explicit definition of FMS provided in text. For example, FMS was used in the context of a health related behavior such as fitness or cardiovascular health	14	16	30 (24.2)
(1) Statement that suggests FMS are the “building blocks” (or similar terminology) of more advanced, complex movements required to participate in sports, games, or other context specific physical activity	53	15	68 (54.8)
(2) Provide specific categories of skills that compose FMS such as object control, locomotor, manipulation, balance, or stability.	46	11	57 (46.0)
(3) Provide at least one specific example of FMS such as running, jumping, throwing, etc.	51	13	64 (51.6)
Total Quality Score**	n (%total of subgroup)	n (%total of subgroup)	n (%total of N = 124)
0	14 (16.3)	16 (43.2)	30 (24.2)
1	19 (22.1)	11 (29.7)	30 (24.2)
2	28 (32.6)	5 (13.5)	33 (26.7)
3	25 (29.1)	6 (16.2)	31 (25.0)
Average	1.74	1.03	1.39

* Mutually exclusive such that an article may be counted more than once within each category independent of scoring on other criterion.

** Included Studies only counted once; Sum of quality criterion scored dichotomously (0 = not present, 1 = present).

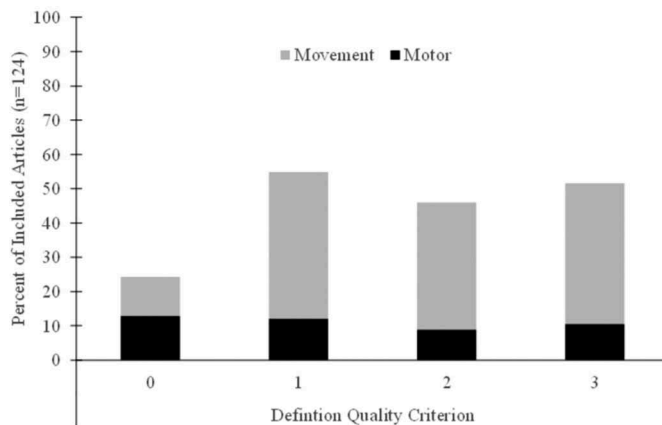


Figure 3. Percent (%) of total included articles ($n = 124$) meeting FMS definition quality criterion (mutually exclusive; subdivided by use of the term fundamental “motor” or “movement” skill.): (0) No explicit definition of FMS provided in text. For example, FMS was used in the context of a health related behavior such as fitness or cardiovascular health, (1) statement that suggests FMS are the “building blocks” (or similar terminology) of more advanced, complex movements required to participate in sports, games, or other context specific physical activity, (2) statement that provides specific categories of skills that compose FMS such as object control, locomotor, manipulation, balance, or stability, and (3) provided at least one specific example of FMS.

competence to encompass multiple terms used to describe the motor domain. One explanation for the increased use of the term fundamental movement skills includes the large number of studies that were conducted within Australia ($n = 41$; 33%). There appears to be a preference of Australian researchers to use the term fundamental movement skills ($n = 35$ out of 41), while the term “fundamental motor skills” continues to be popular for studies conducted within the United States ($n = 9$ out of 12). It remains unclear the specific reason for the differing preference between researchers of various countries. As discussed in the following sections, there does not appear to be major differences in how researchers have used the variations of the terms in regards to the types of motor skills assessed.

Quality of FMS definition

The current review offers interesting insight into the quality of FMS definitions provided by researchers. A surprising finding is that several studies did not provide any operational definition of FMS ($n = 30$; 24%). The use of several different terms throughout history to represent the motor domain stresses the importance for researchers to provide a high-quality, operational definition for the construct of motor development that is of interest within a study. This practice will provide a framework of global understanding for motor development constructs, such that readers may easily interpret the context of the research regardless of readers’ knowledge base. This issue is especially important for the construct of FMS due to the interdisciplinary research collaborations that examine FMS. For example, researchers in public health may not have a strong background in motor development but are interested in how FMS contribute to physical activity engagement and related health outcomes. The practice of providing a high-quality, operational definition of FMS will ensure consistency and understanding across fields of study. Another finding indicates that a similar distribution of studies that met each of the three criteria (“building blocks” statement, identification of subgroups of FMS, and identification of specific FMS examples), with no visible differences between the terms of “fundamental motor skills” or “fundamental movement skills”. It appears the terms “fundamental motor skills” and “fundamental movement skills” are defined in similar ways within contemporary research literature. We suggest that these terms can be used interchangeably, unless researchers provide a specific rationale for choosing one over the other.

FMS assessment

One important finding is the general consistency between the operational definition of FMS provided and the types of skills within the assessments that researchers used in included studies of this review. Table 4 provides a description of skills and

Table 3. Product- and process-oriented fundamental motor/movement skill (FMS) assessments used by included studies.

Assessment	Movement	Motor	Total
TOTAL	86	38	124
PRODUCT, only	16	7	23 (18.5%)
APM Inventory	0	² _{60,61}	2
Discrete skill outcomes (e.g., throwing distance)	0	² _{104,113}	2
FMS Test Package	⁶ _{62–64,66–68}	0	6
FMS-Polygon	¹ ₃₄	0	1
KTK	0	¹ ₈₂	1
M-ABC/M-ABC 2	² _{37,123}	0	2
PDMS-2	¹ ₁₁₁	¹ ₁₄	2
Other (e.g., Neuromotor fitness test, BOT, MOT 4–6)	⁶ _{15,32,65,87,97,117}	¹ ₇₄	7
PROCESS, only	⁶⁵ _a	³³ _a	98 (79.0%)
GSGA	¹¹ _*	³ _{8,10,105}	14
Motor Skill or Developmental Sequence Checklist	⁶ _{16,88,89,91,106,115}	⁵ _{21,54,59,86,99}	11
TGMD/TGMD-2	⁴⁴ _{**}	¹⁹ _{***}	63
Other (e.g., FG-COMPASS, OSU-SIGMA)	⁴ _{12,44,98,107}	⁶ _{1,3,83,92,95,114}	10
BOTH	6	0	6 (4.8%)
TGMD			
+ FMS Polygon	² _{42,124}	0	2
+ Modified TGMD-2	¹ ₂₃	0	1
+ Discrete throwing task	¹ ₂₀	0	1
+ MABC	¹ ₅₇	0	1
Video Analysis	¹ ₄₅	0	1

^aSome studies used more than one measure and were counted twice within table.

*13,17,41,50–52,55,58, 85, 90,116; **6,7,9,11,18,19,22,24–31,35,36,39,40,49,53,56,70–79,85,93,94,103,105,108–110,112,120–122; ***2,4,5,33,38,43,46–48,69,80,81,84,96,100–102,118,119.

Assessment of Perceptual and Fundamental Motor Skills (APM) Inventory (Numminen, 1995).

Fundamental Motor Skills (FMS) Test Package (EUROFIT, Adam et al., 1988; Kalaja, Jaakkola, Liukkonen, & Digelidis, 2012).

Fundamental Motor Skill (FMS) Polygon (Žuvela, Božanić, & Miletić, 2011).

Movement Assessment Battery for Children (MAB-C) (Bruininks, 1978; Henderson & Sugden, 1992).

Peabody Developmental Motor Scale (PDMS) (Folio & Fewell, 2000; Henderson, Sugden & Barnett, 2007).

Get Skilled Get Active (GSGA) (NSW Department of Education and Training, 2000).

Koordinations Test fur Kinder (KTK) (Schilling & Kiphard, 2000).

Motor Skill Checklist (State of Victoria, Department of Education, 1996).

Test of Gross Motor Development (TGMD) (Ulrich, 1985, 2000).

Bruninks-Oseretsky Test of Motor Proficiency (BOT) (Bruininks, 1978).

Furtado-Gallagher Computerized Observational Movement Patter Assessment System (FG-COMPASS; Furtado, 2009).

Component Developmental Sequence (DevSeq) (Haubenstricker & Seefeldt, 1986).

Motriktest fur Vier- bis Sechsjährige Kinder (MOT 4–6) (Zimmer & Volkamer, 1987).

Ohio State University, Scale for intra-Gross Motor Assessment (OSU-SIGMA; Vameghi, Shams, & Dehkordi, 2013).

tasks within each assessment included in this review. Each assessment includes at least one of the categories of object control/ball skills, locomotor, or balance/stability skills. Regardless of whether or not researchers provide an operational definition of FMS, there appears to be similarities in the types of skills measured within the variety of assessments that were used to assess FMS.

Another interesting finding was that the majority of studies measured FMS by administration of a process-oriented measure. Today, the field of motor development is still considered to be within the process-oriented period (1970–present; see Clark & Whitall, 1989 for an in-depth historical overview). During this period, there was a shift of emphasis from the product to the process of FMS and this emphasis remains in contemporary literature. In the current review, the most common assessment used was the Test of Gross Motor Development (TGMD; 1st or 2nd edition, Ulrich, 1985, 2000) ($n = 63$; 51%). One reason for the popularity of the TGMD may be because it includes object control/ball and locomotor skills that are considered necessary to apply in context-specific sports, games, and other physical activities.

The use of product-oriented assessments in research was less frequent overall ($n = 23$; 19%) as compared to process-oriented assessments. One explanation is the lack of standardized, product-oriented assessments for all FMS. However, there are some standardized, product-oriented assessments for individual skills

such as running, throwing and kicking speed, standing long jump and hop distance divided by height, and balance time. Another explanation for the less frequent use of product-oriented assessments may be the cost, or the lack of adequate technology such as a radar gun, or video equipment and software for biomechanical analysis (Ex. Dartfish) to assess FMS performance. Finally, there is a lack of understanding of how performances on process- and product-oriented assessment relates to each other. Specifically, Logan et al. (2016) found weak to strong correlations (r range = .26–.88) between process- and product- FMS performances depending upon age (4–5, 7–8, 10–11 year olds) and skill (standing long jump, hop, or throw). In addition, the comparison of performance on three process-oriented assessments led to significant differences of non-mastery and advanced skill level classifications. This suggests differences in predicting developmental delay based upon the selection of a process-oriented assessment, and may lend to differential predictive validity for other health outcomes. Researchers have recently suggested using both process- and product-oriented assessments to provide a more comprehensive measurement of FMS competence (Logan et al., 2016; Robinson et al., 2015; Rudd et al., 2015). Only six studies included in the current review administered at least one process- and one product-oriented assessment. Likely, this is due to challenges related to administering multiple FMS assessments including the time, cost, and availability of trained personnel.

Table 4. Skills and scoring systems for FMS assessments included in the review.

Assessment	Term	FMS Skills	Scoring	Citation
Assessment of Perceptual and Fundamental Motor Skills (APM) Inventory	Motor	Static balance Right and left foot Dynamic balance Locomotor Running Sliding Galloping Standing board jump Manipulative skills Throwing-Catching combo Throwing at target Stationary ball kick Stationary ball kick at running speed	Maximum time 40.00 seconds Total time taken to jump 15 times sideways over platform with feet together Speed over 10 m Performance score (2 = success, 1 = unsuccessful) Length # of successful catches/10 trials Sum score (3 points for center, 2 for middle ring, 1 for outer ring of target; 3 trials) Performance score (2 = successfully hit target, 1 = unsuccessful)	Numminen (1995)
Fundamental Motor Skills (FMS) Test Package* <i>*Adapted EUROFIT Fitness Test Battery</i>	Motor	Static Balance Flamingo Balance test Dynamic Balance Rolling Test Locomotor Leaping Test Shuttle Run Test Rope Jumping Manipulative Skills Throwing Test Figure-8 Dribbling Test (hand- and foot-dribbling)	Number of attempts required to complete 30 seconds on 1 leg Time required to roll a 5-meter distance over end line and back Total length covered by 5 consecutive leaps Total time required to run 10 shuttles (5 meters each) Number of times jump rope on one leg in 30 seconds (change leg at 15 second mark) Total number of accurate throws out of 10 (5 with each hand) Total number of figure-8 completed in one minute (change from foot- to hand dribbling at 30 sec. mark)	Adam et al. (1988); *Kalaja et al. (2012)
Fundamental Movement Skill (FMS) Polygon	Movement	Space Covering Skills Chest Crawling Back Crawling Straight Running Rolling Sideways Changing Course running Beam Walking Surmounting Obstacles Skills Running across obstacles Skipping across obstacles Crawling through obstacles Single leg hops Climb Swedish bars Jumping over & through obstacles Resistance overcoming skills Rolling a tube backward Carrying medicine ball Carrying Pilates ball around cones Rolling ball around cones Pulling the bag Lifting medicine ball onto table Object Control Skills Rolling ball by hand to wall Dribbling the football around cones Rolling the handball around cones Dribbling the handball around cones Tossing & catching tennis ball against a wall Tossing & catching a volleyball against the wall	[Time to complete task] Time to cover 3.3 meters Time to cover 3.3 meters Time to cover 20 meters Time to cover 2.3 meters Time to cover 12 meters with 2 course challenges Time to cover 4 meters long, 15 cm high & 30 cm wide beam Time to surmount 15 meters with 3 obstacles Time to surmount a 20 meters long area across 4 obstacles Time to surmount 12 meters through 2 obstacles Time to surmount 10 meters Time to accomplish single climb up & down bars Time to surmount 3 jumps & 3 crawling through obstacles Time to cover 6 meters Time to cover 3 meters with 3 kg ball 2 times Time to cover 7.5 meters with 3 kg ball Time to cover 6 meters Time to pull 5 kg bag 6 meters Time to lift 3 balls of 3 kg onto table Time to accomplish 6 times consecutively Time to cover 6 meters Time to cover 6 meters Time to cover 6 meters Time to accomplish 5 times consecutively Time to accomplish 5 times consecutively	Žuvela et al. (2011)

(Continued)

Table 4. (Continued).

Assessment	Term	FMS Skills	Scoring	Citation
Movement Assessment Battery for Children (MAB-C)	Movement	Manual Dexterity Aiming & Catching Balance Static Balance Dynamic <i>*Subtest items vary by age band (3–6 years) (7–10 years) (11–16 years)</i>	Test scoring Item performance may be a number of points, a number of performances correct or number of errors performed, and number of seconds to complete task Checklist Items scored based on raw performance scores (1) Very Well (2) Just Ok (3) Almost (4) Not Close	Henderson and Sugden (1992); Henderson et al. (2007)
Peabody Developmental Motor Scale (PDMS)	Motor	Reflexes (8 items) Stationary (30 items) Locomotion (89 items) Object Manipulation (24 items) Grasping (26 items) Visual-Motor Integration (72 items)	3-point scoring system for item performance: (1) Child cannot or will not attempt item or attempt does not show that the skill is emerging (2) Performance resembles item but does not fully meet the specified criteria (3) Performance aligns with item criteria described in test manual	Folio and Fewell (1983)
Get Skilled Get Active (GSGA)	Movement	FMS Skills Static balance Vertical Jump Sprint Run Catch Hop Leap Side Gallop Kick Skip Two-Hand Strike Overarm Throw Dodge	Checklist, Yes/No Skill Components (n = 5) Skill Components (n = 6) Skill Components (n = 6) Skill Components (n = 6) Skill Components (n = 5) Skill Components (n = 5) Skill Components (n = 5) Skill Components (n = 6) Skill Components (n = 6) Skill Components (n = 6) Skill Components (n = 7) Skill Components (n = 6) Skill Components (n = 5)	NSW Department of Education and Training (2000)
Koordinations Test fur Kinder (KTK)	Motor	Body Control Walking Backwards Hopping for height Jumping Sideways Moving Sideways	Task difficulty gradually increased until child reaches performance limits Walk backward on 3 cm., 4.5 cm, 6 cm balance beams One leg hop over 1+ foam panels (5 cm high each) Number of back/forth jumps over bar with both feet in 15 seconds. Manually move two small boards (25 cm × 25 cm) side by side as often as possible in 15 seconds	Kiphard and Shilling (1974) Schilling and Kiphard (2000) Kiphard and Shilling (2007)
Motor Skill Checklist	Motor	Catch Kick Run Vertical Jump Overhand Throw Ball Bounce Leap Dodge Punt Forehand Strike Two-hand side-arm Strike	Checklist, Yes/No Performance criteria (n = 6) Performance criteria (n = 7) Performance criteria (n = 5) Performance criteria (n = 5) Performance criteria (n = 6) Performance criteria (n = 5) Performance criteria (n = 5) Performance criteria (n = 5) Performance criteria (n = 5) Performance criteria (n = 7) Performance criteria (n = 7) Performance criteria (n = 8)	State of Victoria, Department of Education (1996)
Test of Gross Motor Development (TGMD- I & II)	Motor	Locomotor Skills Run Gallop Hop Leap Horizontal Jump Slide Object control Skills Two-hand strike Stationary dribble Catch Kick Overhand throw Underhand roll	Performance Criteria, 2-trials summed per skill Performance Criteria (n = 4) Performance Criteria (n = 4) Performance Criteria (n = 5) Performance Criteria (n = 3) Performance Criteria (n = 4) Performance Criteria (n = 4) Performance Criteria (n = 5) Performance Criteria (n = 4) Performance Criteria (n = 3) Performance Criteria (n = 4) Performance Criteria (n = 4) Performance Criteria (n = 4)	Ulrich (1985) Ulrich (2000)

(Continued)

Table 4. (Continued).

Assessment	Term	FMS Skills	Scoring	Citation
Bruninks-Oseretsky Test of Motor Proficiency (BOT)	Motor	Gross Motor Composite Fine Motor Control Fine Motor Precision Drawing items (n = 5) Fill in shape, draw lines, connect dots Paper folding Cutting Fine Motor Integration Reproduce drawing, close shapes, precise finger-hand control Manual Coordination Manual Dexterity Transfer pennies Sorting cards Making dots in circles Place pegs into pegboard String blocks Upper-Limb Coordination Dribble ball Drop & Catch ball Dribble -alternate hands Drop & Catch- 2 hands Catch Throw Body Coordination Bilateral Coordination Jumping in place – opposite Tapping feet and fingers -opposite Pivoting thumbs and index fingers Jumping Jacks Jump in place- same side Touch nose with fingers-eyes closed Tap feet & Fingers- same side Balance 9-items Posture, standing, walking, static balance, response to visual cues Strength & Agility Running Speed & Agility One-leg side hop Two-leg side hop One-leg stationary hop Shuttle run Step sideways over beam Strength Push-ups with knees Full push-ups	A raw score for item performance may be a number of points, a number of correct activities performed, number of seconds to complete task, and/or complete/incomplete Raw score converted into point scores using scoring form	Bruininks and Bruininks (2005) Bruininks (1978)
Furtado-Gallagher Computerized Observational Movement Pattern Assessment System (FG-COMPASS)	Movement	Locomotor Hop Horizontal Jump Leap Skip Side Slide Manipulative Batting Catch Kick Side-Arm Strike Stationary Dribble Overhand Throw	Composite Decision Trees* used for each skill resulting in classification of (1) Mature (2) Elementary (3) Initial *See Furtado, 2009 Appendix A, p.72	Furtado (2009) Furtado and Gallagher (2012)

(Continued)

Table 4. (Continued).

Assessment	Term	FMS Skills	Scoring	Citation
Component Developmental Sequences (DevSeq)	Motor	Locomotor Jump Hop Manipulative Throw	Performance Criteria ($n = 8$) Performance Criteria ($n = 9$) Performance Criteria ($n = 9$)	Haubenstricker and Seefeldt (1986) Haubenstricker, Branta, and Seefeldt (1999)
Motoriktest für Vier- bis Sechsjährige Kinder (MOT 4–6)	Motor	Forward jump in a hoop Gross Motor Walking forward Sideward jump Catching a stick Carrying balls from box to box Reverse walking Throwing ball at target Passing through hoop Jumping in a hoop on 1 foot, standing on 2 leg Catching a tennis ring Jumping jack (i.e., star jumps) Jumping over a cord Barreled roll Sit to stand holding ball Jump and turn in hoop Fine Motor Placing dots on a sheet of paper Grasping tissue with toes Collecting and sorting matches	Warm up, not scored Scored based on number of completed repetitions in given time and converted to ranking scale: (1) Not just mastered (2) In progress (3) Skill mastered	Zimmer and Volkamer (1987)
Ohio State University, Scale for intra-Gross Motor Assessment (OSU-SIGMA)	Motor	Gross Motor (11 Items)* More information was not available.		Loovis and Ersing (1979)

Over the last 15 years, there has been a marked increase in studies that used the term “fundamental motor skills” or “fundamental movement skills”. This suggests a growing importance of FMS from a research standpoint across the world. There are several explanations for the increase in studies examining FMS due to the interdisciplinary interest in motor development and health. In the United States, as well as abroad, the obesity epidemic and physical inactivity has received increased attention as a global health crisis (Ogden, Carroll, Fryar, & Flegal, 2015). As a result, the role of FMS to physical activity, weight status, health-related physical fitness and other positive health-related outcomes has received substantial empirical attention in recent years, as noted by several review papers (see Cattuzzo et al., 2016; Holfelder & Schott, 2014; Logan et al., 2016; Robinson et al., 2015 for reviews). In the United States, there also have been calls to action that may have contributed to the increased research interests in FMS. For example, the Centers for Disease Control and Prevention Division of Nutrition and Physical Activity organized a workshop to determine future directions for physical activity research and suggested the potential impact of motor development on physical activity behaviors (Fulton et al., 2001). Furthermore, Stodden et al. (2008) published an article that used a developmental perspective to suggest an emergent relationship between motor competence and physical activity that also accounted for the roles of perceived motor competence, health related fitness, and weight status. Stodden et al. (2008) provided a developmental model that

could be tested by researchers, likely influencing the increased interest in FMS after 2008. Concurrently, Barnett and colleagues published two longitudinal studies that demonstrated that object control skill competence in childhood was associated with a greater likelihood of vigorous physical activity engagement in adolescence (2008) and that perceived sports competence was a mediator (2009). It is expected that the trend of increased empirical attention on FMS will continue and demonstrates the need for transparent definitions of FMS.

Limitations and conclusions

A limitation of the current review is the defined inclusion criteria for FMS. The criterion of the presence of either the term “fundamental motor or movement skill” in the title and/or abstract may have resulted in missing relevant studies. Furthermore, by only including articles that state they are about fundamental movement skills or fundamental motor skills we did not get a glimpse into the articles that use other terms but essentially are assessing and describing the same concept. Therefore, we are not able to provide an understanding of how FMS might be conceptualized in other ways. Also, studies that may have measured FMS, but did not specifically use the FMS terminology, were not included. Our goal was to answer specific aims regarding the FMS terms and resulted in the inclusion of an adequate number of studies ($n = 124$). Another limitation is that we are unable to determine the rationale of researchers to provide an inadequate or

no operational definition at all of FMS. It is possible that researchers assume that readers have an in-depth understanding of FMS and that an operational definition is not necessary. This is an important issue as the study of FMS continues to become more interdisciplinary and discussed in a wider context of health. For example, a common preconceived belief about FMS is that they consist of skills that are only important to participate in sports. However, only some FMS skills are sport-specific, but rather as a whole, researchers suggest that FMS are important for engagement in lifelong physical activity (Robinson et al., 2015; Stodden et al., 2008). The study of FMS has its roots in motor development research. An understanding of the historical perspective of FMS will provide contemporary researchers with a developmental perspective that will inform future research. Future research may expand upon our review by examining the operational definitions and assessments used by researchers for other related terms such as fundamental motor patterns, gross motor skills, motor skills, motor abilities, motor coordination, or motor fitness. There is also a need for further examination of how performances on product-oriented FMS assessments are related to and predictive of health outcomes. This may provide further justification for researchers' suggestion to include both process-oriented and product-oriented motor assessments within studies.

We provide three recommendations for researchers that are interested in measuring FMS as part of a research study. First, we recommend that researchers provide an operational definition of FMS or the specific aspect/s of motor competence that is examined within a research study. We suggest researchers provide a definition of FMS that includes the three criteria outlined in the current review: (1) statement that suggests FMS are the "building blocks" (or similar terminology) of more advanced, complex movements required to participate in games, sports or other context specific physical activity, (2) statement that provides specific categories of skills that compose FMS such as object control/ball skills, locomotor, or balance/stability skills, and (3) provide at least one specific example of FMS. A second recommendation is that researchers use either the term "fundamental motor skills" or "fundamental movement skills" when examining object control/ball skills, locomotor skills, and/or balance/stability skills. The terms "fundamental motor skills" or "fundamental movement skills" also may be used interchangeably. We suggest that researchers do not use other, although related terms, such as fundamental motor patterns, gross motor skills, or motor skills unless there is a compelling reason to do so, as they may represent an alternative dimension of motor development. Third, we recommend that researchers ensure appropriate alignment between the term used to describe motor competence or the specific aspect of motor competence and the assessment used. That is, the assessment should measure performance of skills or tasks that align with the operational definition provided. We acknowledge the ongoing discussion of cultural considerations regarding specific skills that may or may not be considered "fundamental" to different populations (Barnett et al., 2016). As Barnett and colleagues state (2016) "There will always be individual circumstances, that challenge assumptions that are made on a population basis, but this doesn't preclude the attempt to develop skill batteries that may have relevance for many health behaviors and psychosocial

outcomes on a population level" (p. 220). We share the sentiment in regard to researchers providing an operational definition of FMS. Our recommendations are based on the desire to advance the clarity in communication when researchers globally examine motor competence, specifically assess FMS, or address another specific aspect of the motor domain (e.g., fine motor skills). Efforts should be made toward consistency and clarity in defining the construct of FMS, but our recommendations may be best viewed as suggestions and may be adhered to, modified, or disregarded as researchers determine appropriate. In summation, we offer an eloquent statement by Wickstrom (1977, p. 2); "What is needed is language precise enough to differentiate and clarify but not so incisive as to provoke incessant controversy".

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Appendix A

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