Moving better to move more: a systematic review of school-based pedagogies for fundamental movement skills in primary children

Moverse mejor para moverse más: una revisión sistemática de las pedagogías escolares para las habilidades de movimiento fundamentales en niños de primaria

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Abstract

Background. Fundamental movement skills (FMS) are an important foundation for physical activity, physical literacy, sports participation, fitness, and healthy development of children. However, FMS pedagogy in elementary schools is so diverse that a synthesis is needed to identify the most consistent approaches to support children's motor development.
Purpose. This systematic review aims to synthesize the latest evidence on school-based and school-related pedagogy targeting FMS, gross motor skills, motor competence, coordination, physical activity, fitness, and implementation outcomes in primary school children.
Data sources. Records from Scopus and the Web of Science are used as primary sources with a Boolean search strategy that combines the terms FMS or gross motor skills, primary or elementary education, school-based intervention, pedagogy, instruction, and physical education.
Eligibility criteria. Studies published in 2021–2025 were included when they involved elementary school children, teachers, families, or school contexts and reported on motor, physical activity, fitness, psychosocial, or implementation outcomes.
Assessment and synthesis methods. The selection process follows the PRISMA flow; 214 records were identified and 26 reports were included. Data are extracted based on design, sample, intervention, output size, key findings, and evidence domains. Due to the heterogeneity of the study, narrative synthesis is used.
Results. Rhythmic activities, interdisciplinary physical education, BRAINballs, traditional games, Physical Activity Cards, swimming, augmented reality, and exergaming generally show a positive impact on FMS or fitness. Implementation is influenced by teacher competence, feedback, resources, leadership, and school support.
Conclusion. FMS develops most strongly when schools provide specific skills practice, engaging pedagogy, valid assessments, and ongoing implementation support.

Keywords

Fundamental movement skills; primary education, instructional design; movement integration.

Resumen

Introducción. Las habilidades de movimiento fundamentales (FMS) son una base importante para la actividad física, la alfabetización física, la participación deportiva, el estado físico y el desarrollo saludable de los niños. Sin embargo, la pedagogía FMS en las escuelas primarias es tan diversa que se necesita una síntesis para identificar los enfoques más consistentes para apoyar el desarrollo motor de los niños.
Objetivo. Esta revisión sistemática tiene como objetivo sintetizar la evidencia más reciente sobre la pedagogía escolar y relacionada con la escuela dirigida a FMS, habilidades motoras gruesas, competencia motora, coordinación, actividad física, aptitud física y resultados de implementación en niños de escuela primaria.
Fuentes de datos. Los registros de Scopus y Web of Science se utilizan como fuentes primarias con una estrategia de búsqueda booleana que combina los términos FMS o habilidades motoras gruesas, educación primaria o elemental, intervención escolar, pedagogía, instrucción y educación física.
Criterios de elegibilidad. Se incluyeron estudios publicados entre 2021 y 2025 cuando involucraban a niños de escuela primaria, maestros, familias o contextos escolares e informaban sobre resultados motores, de actividad física, de aptitud física, psicosociales o de implementación.
Métodos de evaluación y síntesis. El proceso de selección sigue el flujo PRISMA; Se identificaron 214 registros y se incluyeron 26 informes. Los datos se extraen según el diseño, la muestra, la intervención, el tamaño del resultado, los hallazgos clave y los dominios de evidencia. Debido a la heterogeneidad del estudio, se utiliza la síntesis narrativa.
Resultados. Las actividades rítmicas, la educación física interdisciplinaria, los BRAINballs, los juegos tradicionales, las Tarjetas de Actividad Física, la natación, la realidad aumentada y los exergaming generalmente muestran un impacto positivo en la FMS o el fitness. La implementación está influenciada por la competencia de los docentes, la retroalimentación, los recursos, el liderazgo y el apoyo escolar.
Conclusión. FMS se desarrolla con mayor fuerza cuando las escuelas brindan práctica de habilidades específicas, pedagogía atractiva, evaluaciones válidas y apoyo continuo a la implementación.

Palabras clave

Habilidades de movimiento fundamentales; educación primaria, diseño instruccional; integración del movimiento.

Introduction

Elementary school is a strategic context to develop children's ability to move competently, confidently, and sustainably. Basic movement skills (FMS), including locomotor skills, object control, and stability, provide a foundation for participation in physical education, active play, exercise, fitness, and physical literacy. In this perspective, FMS is not just a set of isolated motor tasks, but a core element of motor competence that allows children to use the repertoire of movements across the context of learning and daily life. Motor competence is consistently linked to children's movement participation, fitness, and health (Lopes et al., 2021), while FMS has been positioned as an important component of physical literacy and a bridge to sustainable physical activity (Piotrowski et al., 2025). Physical literacy further expands this view by linking movement competencies to motivation, confidence, knowledge, and understanding for lifelong participation (Jean de Dieu & Zhou, 2021; Mendoza-Muñoz et al., 2022).

Despite this importance, the evidence on the development of FMS in primary schools remains diverse and fragmented. Recent studies have examined physical education interventions, neuromuscular training, teacher capacity building, family engagement, school-based assessments, and the relationship between FMS, fitness, and physical activity. Neuromuscular training and school-based intervention studies show potential benefits for FMS and fitness (Lin et al., 2022; Yin et al., 2025), while evidence of teacher capacity shows that teachers' abilities, knowledge, and attitudes are essential to support physical activity and FMS (Bourke et al., 2024). At the same time, school-based screening and technology-enabled assessments have expanded the ways in which children's movement competencies can be identified and monitored (Eddy et al., 2021, 2024; A. Ha et al., 2021; Makaruk et al., 2025). This development shows that FMS pedagogy cannot be evaluated simply by asking whether a program of activities is working; It must also be understood in relation to the quality of assessment, teacher competence, school implementation, and sustainability.

The relevance of this topic creates an immediate need for a systematic review as the current evidence base is spread across interventions, assessments, implementations, and socio-ecological studies that are rarely synthesized within a single, coherent pedagogical framework. The relationship between FMS, physical activity, fitness, family support, and school context further reinforces this need. For example, the proficiency barrier perspective suggests that limited mastery of basic movement skills can limit children's participation in more complex physical activities (de Oliveira et al., 2022), while empirical studies show that FMS is associated with cardiorespiratory fitness, health-related fitness, body mass index, quality of life, and physical activity opportunities (AL-Nemr & Reffat, 2024; Madu et al., 2025a; Zhang et al., 2024). Social and family factors also shape children's movement competencies (Cheng et al., 2025; Menescardi & Estevan, 2021; Pelyvás & Kovács, 2025). Therefore, a systematic synthesis is needed to clarify not only which pedagogical approaches are effective, but also how school, teacher, assessment, family, and child-level factors interact in supporting FMS development.

Research Gap

This review is based on three main gaps. First, the literature remains conceptually and methodologically fragmented: some studies focus on the effectiveness of interventions, others on physical literacy, validity of assessments, teacher capacity, or family and socio-ecological influences. Second, pedagogical evidence is often separated from evidence of implementation and assessment, although valid measurement and sustained delivery are essential to assess whether FMS programs can work in real-school settings (Eddy et al., 2021a, 2024; Ma et al., 2021). Third, previous reviews have not necessarily linked these dimensions into mechanism-oriented explanations of how children can "move better to move more".

Novelty

The novelty of this review lies in the synthesis of school-based and school-related FMS pedagogy as part of the movement learning ecosystem. Instead of treating interventions, assessments, teacher capacity, and family support as separate topics, this review integrates them to explain how pedagogical design, valid assessment, implementation support, and children's physical activity opportunities shape children's FMS outcomes. This approach is in line with the idea that motor competence and physical literacy do not develop through a single component, but through the interaction between physical ability, motivation, social support, learning environment, and meaningful movement experiences (Jean de Dieu & Zhou, 2021; Lopes et al., 2021; Piotrowski et al., 2025). Therefore, this review aims to synthesize the

latest evidence on school-based and school-related pedagogy targeting FMS, gross motor skills, motor competence, coordination, physical activity, assessment, and implementation in primary school children.

Conceptual and Theoretical Background

Fundamental movement skills (FMS) provide the conceptual foundation for this review. FMS refers to movement skills that enable children to efficiently and adaptively follow physical education learning, games, sports, and daily activities. In the broader construction of motor competence, these skills represent children's readiness to use movement in a variety of participation contexts. This is in line with the view that motor competence is multidimensional and developmentally important (Lopes et al., 2021), and that FMS forms the motor basis of physical literacy and physical activity participation (Piotrowski et al., 2025).

The theoretical relationship between FMS and subsequent participation can be explained through the perspective of proficiency barriers. Children who do not master basic movement skills may have fewer opportunities or less confidence to engage in more complex physical activities. However, FMS should not be treated as the sole determinant of participation. Evidence suggests that FMS-physical activity relationships can be shaped by cardiorespiratory fitness, health-related fitness, perceived competence, and contextual opportunities (AL-Nemr & Reffat, 2024; de Oliveira et al., 2022; Madu et al., 2025b; Zhang et al., 2024). Thus, FMS is best understood as a basic yet interacting component of children's physical development.

Ecological and pedagogical perspectives are also needed. The development of effective FMS depends on how movement tasks are taught, practiced, assessed, and supported in schools and families. Sustainable interventions require stakeholder engagement and implementation support (Ma et al., 2021), while teacher capacity building is important for translating curriculum objectives into meaningful movement learning experiences (Bourke et al., 2024). Family and social support further contributes to the competence and participation of children's movements (Cheng et al., 2025; Flynn et al., 2023; Menescardi & Estevan, 2021; Pelyvás & Kovács, 2025). Therefore, the theoretical framework of this review views FMS as the result of an interaction between children's abilities, pedagogical design, valid assessments, teacher competence, family support, and school environment that allows children to move better and participate more actively.

Method

Review design and reporting framework

This study was designed as a systematic literature review with a narrative synthesis approach. This review follows the structure informed by PRISMA to ensure transparency in the process of identifying, screening, selection, and synthesis studies on school-based and school-related pedagogy for the development of fundamental movement skills (FMS) in elementary school children. The narrative synthesis was chosen because the studies found showed high heterogeneity in the study design, the form of the intervention, the age of the participants, the context of implementation, the measurement instruments, as well as the reported outputs. The evidence base includes randomized controlled trials, quasi-experimental studies, pre-post one-group studies, observational studies, mixed-methods process evaluations, qualitative studies, and co-creation studies.

Review-question framework

Review questions are structured using population–concept–context logic. The population in this review is elementary school children, generally in the age range of 5–13 years. The main concepts studied include FMS, gross motor skills, motor competence, motor coordination, physical activity, movement quality, physical fitness, and implementation outputs related to children's movement learning. The context of the study is school-based or school-related pedagogy, including physical education lessons, physical

activities in the classroom, active learning, family-supported movement programs, aquatic learning, digital learning, and movement integration at the school level.

The framework was chosen because it shows that the FMS literature contains not only direct intervention studies, but also measurement tool validation studies, studies of the relationship of FMS with fitness and physical activity, and pedagogical implementation studies. For example, Eddy et al. (2021b, 2024) focused on the development and validation of school-based FMS screening tools, while Ha et al. (2022a) tested the validity of information technology-based systems to measure the quantity and quality of movement behavior of elementary school children. In terms of intervention and pedagogy, Duncan et al. (2023), Idamokoro et al. (2024), Sortwell et al. (2024), and Dwihandaka et al. (2025) present different approaches to exercise or movement learning. On the mechanism side, Han et al. (2022a), Liu et al. (2024), Zhang et al. (2024), Madu et al. (2025b), and Kokstejn et al. (2025) show a link between FMS, physical activity, fitness, and child health.

The main questions of this review are:

RQ 1. What school-based or school-related pedagogical approach is most consistent in improving fundamental movement skills, gross motor skills, or motor competencies in elementary school children?

RQ 2. What factors of teachers, classes, schools, families, and socio-ecological contexts support or hinder the implementation of FMS pedagogy in elementary schools?

RQ 3. How does FMS relate to physical activity, fitness, self-perception, quality of movement patterns, and movement opportunities during the school day?

RQ 4. What are the most promising intervention features for curriculum development, physical education practice, and future research on elementary school children's FMS?

Information sources and search strategy

Records were retrieved from Scopus and Web of Science, which were selected because they provide broad and multidisciplinary coverage of peer-reviewed research in education, physical education, sport science, child development, and health-related fields. The database searches were conducted between 1 and 3 April 2026. The search was limited to peer-reviewed journal articles published between 2021 and 2025, written in English, and available as Gold Open Access articles. These limits were applied to ensure that the review focused on recent, accessible, and verifiable evidence relevant to school-based and school-related pedagogy for FMS in elementary school contexts.

The Boolean search string combined terms related to movement competence, school context, pedagogical intervention, and physical education. The search syntax used was: TITLE-ABS-KEY (“fundamental movement skills” OR “basic movement skills” OR “basic motor skills” OR “gross motor skills” OR “motor competence” OR “motor coordination”) AND (“elementary school” OR “primary school” OR “elementary education” OR “primary education” OR “basic education”) AND (“school-based intervention” OR “physical education intervention” OR “teaching intervention” OR “instructional program” OR “educational program” OR pedagogy OR teaching OR instruction) AND (“physical education” OR “PE” OR “school physical activity”). Search results were exported and organized for screening, duplicate removal, eligibility assessment, and documentation in the PRISMA flow diagram.

Eligibility criteria

The included studies were peer-reviewed journal articles published between 2021 and 2025; involving elementary or elementary school children, teachers, families, or school settings; discussing FMS, gross motor skills, motor competence, motor coordination, movement quality, physical activity, or implementation outcomes; and school-based or school-related hands-on. The exclusion criteria are: studies outside the basic/basic age range; studies that do not focus on motor skills, movement competence, PE pedagogy, or school-day physical activity; non-school interventions unless directly related to the development of the child's school-age movement; inaccessible reports; and duplicate records.

Table 1. Include and exclude criteria

Criteria	Include	Exclude
Population	• Children or primary/elementary school students, generally aged 5–14 years.	• Preschool children only, secondary school students only, university students, adults, or clinical populations not related to school-age motor development.
Study focus	• Studies examining fundamental movement skills, gross motor skills, motor competence, motor coordination, physical education, physical activity, or movement-based learning.	• Studies not related to motor skills, physical education, physical activity, or children's movement development.
Intervention/ exposure	• Physical education programs, movement skill training, traditional games, swimming, exergaming, augmented reality/mobile learning, family-based physical activity, active learning, classroom movement, or observational exposure related to movement skills.	• Interventions unrelated to physical activity, motor learning, physical education, or movement development.
Outcome/ measure	• Studies reporting outcomes such as TGMD-2, TGMD-3, KTK, motor coordination test, physical activity level, motor fitness, attention related to movement training, or implementation outcomes in physical activity programs.	• Studies without clear motor skill, gross motor, physical activity, coordination, or implementation outcomes.
Study design	• Randomized controlled trial, quasi-experimental study, pre-post study, cross-sectional study, longitudinal study, observational study, mixed-method study, qualitative study, co-creation study, process evaluation, or systematic qualitative synthesis.	• Editorials, opinion papers, commentary articles, book chapters, protocols without results, abstracts only, or non-empirical papers.
Setting	• School, physical education class, classroom, community, or family-based settings involving children's movement development.	• Hospital-only, rehabilitation-only, elite sport-only, or non-educational settings without relevance to children's general motor development.

Study selection and data extraction

The study selection process is carried out in stages, including identification, elimination of duplication, screening of titles and abstracts, search for full text, feasibility assessment, and final inclusion. A total of 214 articles were identified, consisting of 77 articles from Scopus and 137 articles from the Web of Science. Once an article is declared ineligible by the auto-screening feature available on the Scopus and Web of Science database interfaces, other irrelevant articles, and duplicate articles are removed, the remaining studies are screened based on inclusion and exclusion criteria. The full-text article was then assessed for eligibility, resulting in 26 reports that were included in the final synthesis.

Differences in study selection were resolved through peer review and consensus. When uncertainty occurred regarding the relevance of a study, the reviewers re-examined the title, abstract, full text, population characteristics, school-related context, outcome measures, and alignment with the review questions. Studies were included only when consensus was reached that they met the eligibility criteria and contributed directly to the synthesis of FMS pedagogy in elementary school or school-related settings.

Data were extracted using a structured extraction table that included author and year, country, study design, sample characteristics, intervention or exposure, outcome measures, main findings, evidence domain, and DOI. Extraction prioritized information related to pedagogical design, intervention dose, implementation context, assessment instruments, and reported outcomes. Common measurement tools included TGMD-2, TGMD-3, 3JS, KTK, accelerometry-based measures, and implementation-related indicators. This extraction strategy ensured that evidence was organized not only by intervention effectiveness, but also by assessment quality, implementation conditions, and relevance to school-based practice.

Risk-of-bias and certainty assessment

Because the evidence base includes diverse study designs, a single formal bias risk tool is not applied to the entire study. In contrast, the quality of the study was assessed narratively using appropriate indicators for diverse design assessments, namely clarity of purpose, design suitability, sufficiency of samples, quality of comparators, use of validated measuring tools, transparency of analysis, and reporting of implementation conditions. Randomized, controlled studies provide stronger evidence for the effects of short-term interventions, whereas pre-post one-group studies are interpreted more carefully. Observational studies are used to explain mechanisms and associations, not to draw causal inferences. Qualitative studies and process evaluations are used to interpret eligibility, acceptance, teacher behavior, and school-level conditions.

This assessment approach is important because it shows a wide variety of research quality and objectives. Some articles focus on the effectiveness of school-based interventions (Duncan et al., 2023; Lin et al., 2022; Sortwell et al., 2024; Yin et al., 2025), partially assess the validity of the instrument or assessment system (Eddy et al., 2021b, 2024; A. S. Ha et al., 2022b; Makaruk et al., 2025), and some others map the role of family, social support, or ecological context in children's movement development (Cheng et al., 2025; Flynn et al., 2023; Menescardi & Estevan, 2021; Pelyvás & Kovács, 2025). Thus, quality assessments are geared towards keeping the interpretation of the synthesis proportional to the strength of the design and the relevance of the data.

Synthesis methods

A narrative synthesis was selected instead of a meta-analysis because the included studies were highly heterogeneous in design, population, intervention format, duration, implementation context, measurement instrument, and reported outcomes. The evidence base included randomized controlled trials, quasi-experimental studies, one-group pre–post studies, observational studies, validation studies, qualitative studies, mixed-methods process evaluations, and co-creation studies. Because these studies did not provide sufficiently comparable effect estimates, intervention characteristics, or outcome metrics, statistical pooling would have risked producing an imprecise or misleading summary of the evidence.

Narrative synthesis was therefore considered the most appropriate approach because it allowed the review to integrate evidence on intervention effectiveness, pedagogical mechanisms, assessment validity, teacher capacity, family support, and school-level implementation conditions. The synthesis was conducted in three stages. First, studies were mapped descriptively according to design, country, population, intervention or exposure, outcome measures, and key findings. Second, studies were grouped thematically into evidence domains aligned with the review questions. Third, a mechanism-oriented interpretation was developed to explain how pedagogical design, instructional quality, teacher competence, assessment practice, and school ecology may support the development of FMS and related outcomes such as physical activity, fitness, self-perception, and participation. Through this approach, the review did not only identify which pedagogical strategies appeared promising, but also examined the contextual and instructional conditions under which FMS programs may be feasible, sustainable, and meaningful in elementary school settings.

Results

Overview of key findings

The synthesis of 26 included studies indicates that school-based and school-related pedagogies can improve fundamental movement skills (FMS) when they provide structured, repeated, developmentally appropriate, and engaging movement practice. The most consistent improvements were reported in interventions that combined explicit skill practice with playful, rhythmic, interdisciplinary, or game-based learning formats. Rhythmic physical activity, interdisciplinary physical education, BRAINballs, traditional games, Physical Activity Cards, swimming, augmented reality, and exergaming generally showed positive effects on FMS, gross motor skills, motor competence, coordination, or fitness-related outcomes.

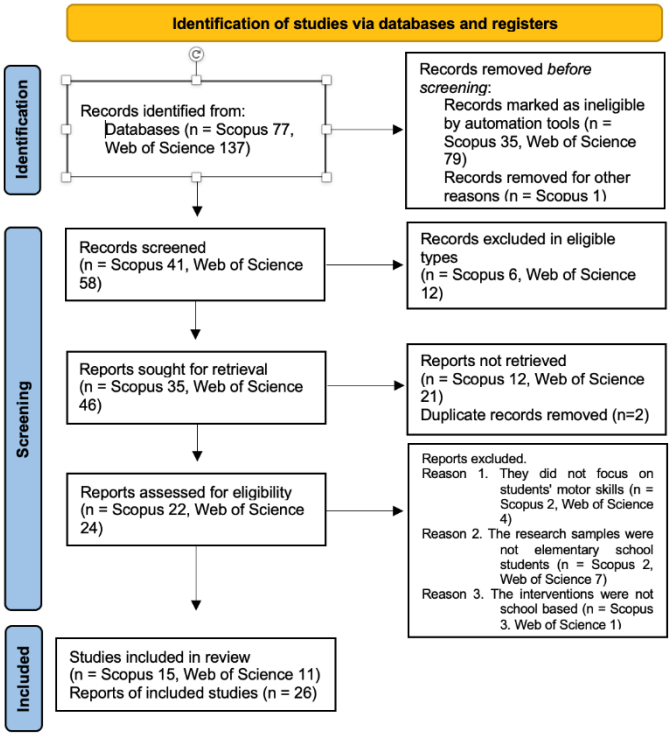
In relation to the research questions, the findings suggest that pedagogies most consistently associated with improved FMS were those that: 1) targeted specific locomotor and object-control skills; 2) provided sufficient opportunities for repetition and feedback; 3) used enjoyable and meaningful learning activities; and 4) were supported by appropriate assessment and feasible implementation conditions. However, the strength of evidence varied across studies because of differences in design, intervention duration, measurement instruments, and implementation context. Therefore, the findings are interpreted narratively rather than as a pooled effect estimate.

Study selection

Figure 1 summarizes the selection process informed by PRISMA. A database search identified 214 records, including 77 from Scopus and 137 from the Web of Science. After the deletion of records marked as ineligible by the automation tool, one additional deletion, and one duplicate, 99 records are filtered. Eighty-one reports were sought for retrieval and 46 reports were assessed as eligible. Nineteen reports

were excluded on eligibility because they did not focus on students' motor skills, did not include an elementary school sample, or were not school-based. The last PRISMA count was 26 reports included.

Figure 1. PRISMA-informed flow diagram for the Scopus and Web of Science database records



The study selection process has been carried out gradually and transparently. The PRISMA flow shows a narrowing of the evidence from 214 initial records to 26 final reports. The number of reports issued at the feasibility stage shows that a focus on the primary school population and relevance to FMS are the main selection criteria. Thus, Figure 1 serves as methodological evidence that the synthesis is not compiled based on arbitrary selection of articles, but through a systematic process of identification, screening, report taking, feasibility assessment, and inclusion.

Characteristics of included studies

The included studies show the diversity of design, geographic context, population, and pedagogical approaches. Geographically, articles come from Indonesia, Brazil, Italy, the United Kingdom, Canada, South Korea, China, Australia, Albania, Turkey, Ukraine, Spain, Vietnam, Germany, Hong Kong, Estonia, as well as international studies. Methodologically, the study included a randomized controlled trial, quasi-experimental study, one-group pre-post study, cross-sectional study, longitudinal study, observational mixed methods, qualitative focus group, process evaluation, co-creation study, and systematic qualitative meta-synthesis. This diversity strengthens the scope of the evidence, but it also demands caution in drawing causal conclusions.

Table 2. Quality Assessment Tool for Studies with Diverse Designs (QATSDD)

Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Final % quality
Dwihandaka et al. (2025)	3	3	3	1	2	3	2	2	2	3	n/a	3	2	n/a	1	3	79%
Duarte et al. (2025)	2	3	3	3	2	3	3	2	3	3	n/a	3	3	n/a	0	2	83%
Nicolosi et al. (2024)	2	3	2	1	2	3	2	2	2	3	n/a	3	2	n/a	1	2	71%
Cline et al. (2021)	3	3	3	1	2	3	3	2	1	3	3	3	2	2	2	2	79%
Salters & Scharoun Benson (2022)	3	3	2	1	2	3	3	3	3	3	3	3	2	3	0	3	83%
Park et al. (2024)	2	3	2	1	3	3	2	1	1	3	n/a	3	2	n/a	0	2	67%
Eyre et al. (2022)	3	3	3	1	2	3	3	3	n/a	n/a	3	3	3	3	1	3	88%
Han et al. (2022)	2	3	2	1	2	3	3	2	3	3	n/a	3	3	n/a	0	2	76%
Sortwell et al. (2024)	2	3	2	2	2	3	3	2	3	3	n/a	3	2	n/a	0	3	79%
Clifford et al. (2023)	3	3	3	1	2	3	3	3	n/a	n/a	3	3	3	2	3	2	88%
Faruk et al. (2025)	2	3	2	1	2	3	2	1	2	3	n/a	2	1	n/a	2	1	64%
Ushtelenca et al. (2024)	2	3	2	1	2	2	2	1	2	3	n/a	2	1	n/a	0	1	57%
Fauzi et al. (2023)	2	3	2	1	2	2	2	1	1	3	n/a	2	1	n/a	0	1	55%
Kırlangıç & Bozkurt (2025a)	3	3	2	1	1	3	3	2	2	3	n/a	2	2	n/a	0	3	71%
Yunak et al. (2022)	2	3	1	1	2	3	2	2	1	3	n/a	3	3	n/a	0	1	64%
Romeu et al. (2023)	3	3	3	1	1	3	3	2	3	3	3	3	3	3	1	1	81%
Kırlangıç & Bozkurt (2025b)	3	3	2	1	1	3	3	2	2	3	n/a	3	2	n/a	0	3	74%
Pratt et al. (2024)	2	3	3	1	2	3	3	3	3	3	n/a	3	2	n/a	0	3	81%
Pham et al. (2021)	2	3	2	1	2	3	3	2	2	3	n/a	3	2	n/a	0	1	69%
Ketelhut et al. (2022)	2	3	3	3	2	3	3	3	3	3	n/a	3	3	n/a	1	3	90%
Wu et al. (2021)	3	3	2	1	2	3	3	2	3	3	n/a	3	3	n/a	0	3	81%
Crotti et al. (2022)	3	3	3	3	2	3	3	3	3	3	n/a	3	3	n/a	0	3	90%
Liu et al. (2024)	2	3	3	2	3	3	3	3	3	3	n/a	3	3	n/a	0	3	88%
Ha et al. (2021)	3	3	3	3	2	3	3	3	3	3	n/a	3	3	n/a	0	2	88%
Bikalawan et al. (2024)	1	3	3	0	1	2	2	1	1	2	n/a	2	2	n/a	0	2	52%
Kalma et al. (2022)	3	3	3	1	2	3	3	3	2	3	3	3	2	2	3	3	88%

Legend: 1) explicit theoretical framework; 2) a statement of the aims or objectives in the main body of the report; 3) clear description of the research setting; 4) evidence that the sample size was considered in relation to the analysis; 5) representative sample of the target group of an appropriate size; 6) rationale for the choice of data collection tool(s); 7) rationale for the choice of data collection procedure or method; 8) detailed recruitment data; 9) statistical assessment of the reliability and validity of measurement tool(s) (quantitative studies); 10) fit between the stated research question and the method of data collection (quantitative); 11) fit between the research question and the format and content of the data collection tool, such as an interview schedule (qualitative); 12) fit between the research question and the method of analysis; 13) good justification for the selected analytical method; 14) assessment of the reliability of the analytical process in (qualitative); 15) evidence of user involvement in the study design; and 15) a critical discussion of the strengths and limitations of the study. Each criterion is scored on a scale ranging from 0 to 3.

Table 2 shows that the methodological quality of the studies varied from 52% to 90%. The highest-quality studies were Ketelhut et al. (2022), Crotti et al. (2022), and Daly-Smith et al. (2021), each reaching 90%. Eyre et al. (2022), Clifford et al. (2023), Liu et al. (2024a), Ha et al. (2021), and Kalma et al. (2022) also showed high quality with a score of 88%. Studies with lower scores, such as Fauzi et al. (2023) and Ushtelenca et al. (2024), remain relevant for demonstrating pedagogical practice in primary school contexts, but their findings need to be interpreted with caution due to design and comparator limitations. Overall, Table 2 shows that this synthesis is supported by a combination of high-quality studies and exploratory studies that enrich contextual understanding.

Table 3. Characteristics and key findings of included studies

Study	Country	Design	Sample	Intervention/ exposure	Measure	Key finding
Dwihandaka et al. (2025)	Indonesia	Randomized controlled intervention	40 children, 8–9 years	Sociocognitive rhythmic physical activity, 4 weeks, 3 sessions/week	TGMD-3 Short Form	Significant gains in seven TGMD-3 items; experimental group improved more than general physical activity control.
Duarte et al. (2025)	Brazil	Exploratory assessment comparison	62 children, mean 8.03 years	App-assisted instruction/assessment vs traditional TGMD-3 instruction	TGMD-3	Similar mean performances; reliability ranged poor to fair, emphasizing supervision and evaluator training.
Nicolosi et al. (2024)	Italy	Quasi-experimental	76 children, 7–9 years	12-week interdisciplinary PE vs drill-oriented approach	Italian TGMD; perceived motor competence	Large positive effects on object-control skills and locomotor gains in girls; perceived competence results inconclusive.
Cline et al. (2021)	United Kingdom	Mixed-method process evaluation	716 children; 35 teachers	Busy Brain Breaks classroom physical activity intervention	Questionnaires, observations, interviews, dose	Teacher autonomy, flexible timing and child enjoyment facilitated implementation; time and behaviour were barriers.

Salters & Scharoun Benson (2022)	Canada	Mixed-methods survey/interviews	102 teachers; 11 interviews	Teaching strategies for FMS in PE	Spectrum of Teaching Styles survey; interviews	Preference for practice style, explicit teaching, constructive feedback and professional development support.
Park et al. (2024)	South Korea	Cross-sectional secondary analysis	291 first/second graders	No intervention; FMS-HRF association	FMS tests; HRF tests	Jumping, hopping and static balance associated with muscular strength, cardiorespiratory endurance and flexibility.
Eyre et al. (2022)	United Kingdom	Qualitative focus groups	14 primary teachers	Barriers/facilitators to PA and FMS	Thematic analysis; socio-ecological model	Barriers were multifactorial across individual, interpersonal, school, community and policy levels.
Han et al. (2022)	China	Cross-lagged longitudinal	183 students, 8.8 ± 1.1 years	School-day PA and FMS tracking over 11 weeks	Steps; TGMD-3	Baseline FMS predicted later school-day steps; baseline steps did not predict later FMS.
Sortwell et al. (2024)	Australia	Observational correlational	104 children, 8–10 years	No intervention; FMS/fitness/self-perception/PA	FMS, jumps, medicine ball throw, self-perception	FMS, muscular fitness and athletic self-perception were positively associated; sex-specific predictors differed.
Clifford et al. (2023)	United Kingdom	Co-creation study	Teachers, leaders, specialists, children 8–9 years	Move Well Feel-Good development	Co-creation workshops	Stakeholders identified school-day opportunities and barriers, including overloaded curriculum and parental support.
Faruk et al. (2025)	Indonesia/Malaysia	Experimental control group	60 elementary students	Augmented-reality mobile learning PE intervention	TGMD-2	AR mobile learning yielded greater gross motor skill improvements than control.
Ushtelenca et al. (2024)	Albania	Pre-post academic-year evaluation	151 children, 9–14 years	Regular PE classes across academic year	KTK tasks; BMI	PE classes supported gross motor skill development and highlight need for tailored programs.
Fauzi et al. (2023)	Indonesia	One-group pre-post	43 elementary students	Traditional games: bebentengan and boy-boyan	TGMD-3; participation scale	Significant positive effects on FMS and sports participation.
Kırlangıç & Bozkurt (2025a)	Türkiye	One-group pre-post	24 students, 8–9 years	13-week FMS training with Differential Learning approach	D2 Test of Attention	Improved psychomotor speed, work quality and speed-attention balance.
Yunak et al. (2022)	Ukraine	Discriminant analysis learning study	123 boys, 7–10 years	Algorithmic instruction for throwing skills	Throwing task performance probabilities	Identified age-specific features and task specificity in throwing skill formation.
Romeu et al. (2023)	Spain	Observational mixed methods	21 students, 12 ± 1 years	41 PE sessions to stimulate coordination	COS, 3JS test, T-pattern analysis	Post-intervention coordinative patterns were richer and more diverse; 3JS scores improved.
Kırlangıç & Bozkurt (2025b)	Türkiye	One-group pre-post	16 third graders, 9 years	26 hours of Physical Activity Cards in PE/play lessons	TGMD-3	Significant gains in running, galloping, hopping, jumping, sliding and selected ball skills.
Pratt et al. (2024)	United Kingdom	Controlled school intervention	107 children, 7.8 ± 0.63 years	6-week swimming intervention vs usual PE	TGMD-3, AMP, sprint, long jump	TGMD-3 and aquatic motor competence improved; swimming opportunities correlated with AMP, fear related negatively.
Pham et al. (2021)	Vietnam	Pedagogical experiment, parallel groups	55 second graders, 7 years	BRAINballs twice weekly across school year	TGMD-2	Experimental group showed significantly better locomotor and object-control outcomes than control.
Ketelhut et al. (2022)	Germany	Randomized controlled trial	58 students; 34 final analysis	12-week ExerCube exergaming, 20 min twice/week plus PE	BMI, WHtR, sprint, CMJ, shuttle run	Improved countermovement jump, sprint and shuttle-run fitness; no BMI/WHtR interaction.
Wu et al. (2021)	China	Cross-sectional correlational	117 children, 7–10 years	No intervention; motor fitness, FMS and movement quality	TGMD-2, Functional Movement Screen, fitness tests	FMS and quality of movement patterns weakly correlated with motor fitness, supporting possible proficiency barrier.
Crotti et al. (2022)	United Kingdom	Cluster RCT process evaluation	162 children, 5–6 y; 44 PE lessons	Linear pedagogy, nonlinear pedagogy, usual PE	Accelerometer MVPA; teaching-practice observation	No MVPA differences; intervention lessons used more MVPA-promoting and fewer management practices than control.
Liu et al. (2024)	China	Cross-sectional school-day accelerometry	322 children, 6–10 years	No intervention; school-day segment analysis	TGMD-2; accelerometer MVPA	Locomotor skills associated with recess MVPA; object-control skills associated with long recess and PE MVPA.
Ha et al. (2022)	Hong Kong	Randomized controlled trial	171 families	Active 1 + FUN family-based SDT intervention	Accelerometry, FMS, BMI, questionnaires	No significant MVPA effect, but significant improvement in

						children's FMS in intervention group.
Bikalawan et al. (2024)	Indonesia	Pre-experimental	46 3rd grade students aged 9–10 years	Flash card; The card contains locomotor motion tasks based on animal motion visualization	TGMD-2 locomotor	Flash card learning media significantly improves students' locomotor skills on runs, gallops, hops, and horizontal jumps, but not significantly on leaps and slides.
Kalma et al. (2022)	Estonia	Co-creation/process evaluation	Schools in Motion teacher training module	Active Lessons teacher training for movement integration	Feedback, observation, timetable mapping, follow-up	Practical resources, autonomy, communication and whole-school alignment supported movement integration.

The primary school FMS literature contains not only studies of the effectiveness of interventions, but also assessment, association, implementation, and co-creation studies. Skill-practice-based interventions, such as rhythmic activities, BRAINballs, traditional games, Physical Activity Cards, swimming, and interdisciplinary physical education, generally reported improvements in FMS, coordination, or gross motor skills. The technology study shows the potential of augmented reality and exergaming, but also confirms the need for supervision and reliability of assessments. Associative studies show that FMS is related to physical activity, fitness, and self-perception, while implementation studies place teachers, resources, autonomy, and school support as important factors.

Interventions with the most promising effects

Table 4. Interventions with the most promising effects

Intervention or pedagogical approach	Main pedagogical feature	Main reported effect	Interpretive implication
Sociocognitive rhythmic physical activity	Rhythmic, structured, and engaging motor practice	Improved seven TGMD-3 Short Form items (Dwihandaka et al., 2025)	Rhythmic and socially engaging activities may support both locomotor and object-control development.
Interdisciplinary physical education	Integration of movement learning with broader curricular content	More effective than drill-oriented approaches for object control and some locomotor skills (Nicolosi et al., 2024)	FMS learning may improve when movement tasks are meaningful, contextualized, and not limited to repetitive drills.
BRAINballs	Learning through physical activity using task-based equipment and active engagement	Improved locomotor skills and object control compared with control conditions (Pham et al., 2021)	Active, cognitively engaging movement tasks can support FMS development in school settings.
Traditional games	Culturally familiar, playful, and game-based movement practice	Positive effects on FMS and sport participation (Fauzi et al., 2023)	Game-based pedagogy may increase children's engagement while developing basic movement competence.
Physical Activity Cards	Teacher-friendly structured activity prompts	Improved locomotor skills and object-control skills (Kırlangıç & Bozkurt, 2025)	Simple instructional tools may help teachers deliver consistent FMS practice.
Swimming intervention	Aquatic motor learning with transfer to selected terrestrial motor indicators	Improved aquatic motor competence and several terrestrial motor indicators (Pratt et al., 2024)	Aquatic environments may provide alternative pathways for developing motor competence.
Augmented reality mobile learning	Technology-supported interactive motor learning	Greater improvement in gross motor skills than control conditions (Faruk et al., 2025)	Digital tools may enhance motivation and movement learning when aligned with pedagogical goals.
ExerCube exergaming	Immersive active gaming with repeated physical engagement	Improved fitness indicators such as jump, sprint, and shuttle-run performance (Ketelhut et al., 2022)	Exergaming may complement FMS-related practice, although evidence remains stronger for fitness than direct FMS outcomes.

Intervention effects on motor outcomes

Across intervention studies, the direction of the evidence generally supports structured, engaging, and developmentally appropriate motor practices. Dwihandaka et al. (2025) reported a significant improvement in seven items of TGMD-3 Short Form after sociocognitive rhythmic physical activity. Nicolosi et al. (2024) found that interdisciplinary physical education is more effective than drill-oriented approaches in improving object control skills and some locomotor skills. Pham et al. (2021) showed that BRAINballs improved locomotor skills and object control compared to the control group. Fauzi et al. (2023) showed that traditional games had a positive impact on FMS and sports participation, while Kırlangıç

and Bozkurt (2025) showed an improvement in locomotor skills and object control after the use of Physical Activity Cards. Pratt et al. (2024) added that swimming interventions can improve motor competence in aquatic environments and several terrestrial motor indicators.

Technology-supported approaches

The technology-based approach shows promising results, but is not yet fully methodologically stable. Faruk et al. (2025) report that augmented reality mobile learning results in a better improvement in gross motor skills compared to control conditions. Ketelhut et al. (2022) showed that the integration of ExerCube exergaming for 12 weeks improved fitness indicators such as countermovement jump, sprint, and shuttle-run performance. Duarte et al. (2025), on the other hand, show that app-based instruction or assessment results in average performance similar to traditional instruction, but its reliability still varies from poor to fair.

Physical activity, fitness, and psychosocial mechanisms

Associative studies show that FMS is related to physical activity, fitness, self-perception, and quality of movement patterns, but those relationships are not always strong and are often domain-specific. Han et al. (2022b) showed that the initial FMS predicted the next school day move, whereas the initial move did not predict the next FMS. Liu et al. (2024b) showed that locomotor skills are related to MVPA during recess, whereas object control skills are related to long recess and MVPA PE. Park et al. (2024) associate jumping, hopping, and static balance with health-related components of fitness. Sortwell et al. (2024) found a positive relationship between FMS, muscular fitness, athletic self-perception, and physical activity. Wu et al. (2021) found a weak but meaningful relationship between FMS, motor fitness, and the quality of motion patterns.

Implementation conditions

Evidence of implementation shows that effective motor learning requires more than just the provision of activities. Salters and Scharoun Benson (2022) show that teachers need explicit teaching strategies, practice styles, facilitation, constructive feedback, and professional development support. Cline et al. (2021) found that teacher autonomy, time flexibility, and children's enjoyment facilitated the implementation of classroom-based physical activity, while time pressure and children's behavior became barriers. Eyre et al. (2022) affirm that physical activity barriers and FMS are multilevel. Daly-Smith et al. (2021) show that the adoption of physical active learning requires school-wide training, resources, capability building, leadership, and support. Kalma et al. (2022) show that movement integration is more sustainable when teachers acquire practical resources, autonomy, communication, and school alignment.

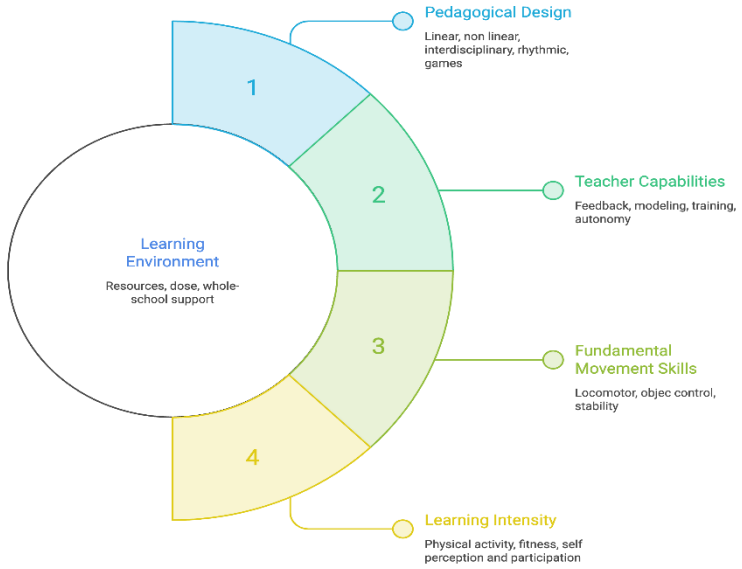
Discussion

The most consistent school-based or school-related pedagogical approach improves FMS, gross motor skills, or motor competence in elementary school children.

Empirically, this review shows that the pedagogy that most consistently improves FMS is one that provides specific, structured, repetitive, fun, and developmentally appropriate movement exercises for the child. The main evidence comes from sociocognitive rhythmic interventions that improve some components of TGMD-3 (Dwihandaka et al., 2025), interdisciplinary physical education that strengthens object control and partial locomotor skills (Nicolosi et al., 2024), BRAINballs that improve locomotor skills and object control (Pham et al., 2021), traditional games that positively impact FMS and sports participation (Fauzi et al., 2023), Physical Activity Cards that improve locomotor skills and object control (Kirlangiç & Bozkurt, 2025a), as well as swimming that supports aquatic motor competence and certain gross motor indicators (Pratt et al., 2024). These findings are reinforced by flash card studies that show significant improvements in run, gallop, hop, and horizontal jump, although not in leaps and slides (Bikalawan et al., 2024), as well as a Teaching Games for Understanding study based on volleyball game modifications that improve motor competence, locomotor skills, and object control of elementary school students (Apriani et al., 2025).

Compared to previous research, the results of this review have similarities in confirming that movement-based learning based on games, tasks, and contextual experiences can strengthen children's motor competence. However, the difference lies in the emphasis that not all physical activity automatically improves FMS. Improvements are more likely to occur when activities are designed as an explicit motor learning experience, rather than simply an increase in the duration of movements. Variation in results in Bikalawan et al. (2024), which showed improvements in some but not all locomotor skills, showed that each component of FMS requires specific teaching strategies and training doses. Theoretically, these findings support the principle that children will be more likely to "move better to move more" if schools provide meaningful, directed, and repetitive movement practices. By practical implication, physical education teachers need to design activities that incorporate explicit instruction, games, feedback, assignment variety, and skill assessments, rather than just general physical activity.

Figure 2. Mechanism-oriented model linking pedagogical design, teacher capability, learning environment, FMS, and downstream outcomes.



Factors of teachers, classes, schools, families, and socio-ecological contexts that support or hinder the implementation of FMS pedagogy

Empirically, the success of FMS pedagogy is strongly influenced by teachers, classrooms, schools, families, and socio-ecological environments. Salters and Scharoun Benson (2022) show that teachers need explicit teaching strategies, exercise variety, facilitation, constructive feedback, and professional development. Cline et al. (2021) added that teacher autonomy, time flexibility, and children's fun are facilitators, while the pressure of time and student behavior is an obstacle. Eyre et al. (2022) affirm that FMS barriers and physical activity are multilevel, while Daly-Smith et al. (2021) and Kalma et al. (2022) point to the importance of school training, resources, leadership, communication, and institutional support. Clifford et al. (2023) show the value of co-creation in identifying school opportunities and barriers, while Ha et al. (2021) show that family support can improve FMS even though the effect on moderate-to-vigorous physical activity is not significant.

These findings are in line with a socio-ecological approach to the promotion of children's physical activity, but this review expands on it by placing implementation as part of the intervention mechanism, rather than just the background of the program. A theoretically strong program can fail if teachers don't have the time, training, resources, or institutional support; On the contrary, a simple approach can be successful when it suits the capacity of teachers and school conditions. Bibliometric evidence also shows that physical education, sports, and physical activity are growing and increasingly international fields (Ramos-Álvarez et al., 2024), so the need to understand the context of implementation is becoming increasingly important. Theoretically, FMS pedagogy needs to be understood as an interaction between

program design, teacher readiness, family support, school organizational capacity, and children's movement culture. Practically, schools need to provide teacher training, adequate learning time, easy-to-use assessment tools, and collaboration mechanisms with families.

FMS relates to physical activity, fitness, self-perception, quality of movement patterns, and movement opportunities during the school day

Empirically, FMS is related to physical activity, fitness, self-perception, quality of movement patterns, and mobility opportunities during the school day, but these relationships are not always strong and often depend on skill domains. Han et al. (2022b) found that the initial FMS predicted a student's move on the next school day, while the initial step did not predict the next FMS. Liu et al. (2024b) showed that locomotor skills are related to MVPA at rest, while object control is related to MVPA at long rest and physical education. Park et al. (2024) linked jumping, hopping, and static balance to health-related fitness, Sortwell et al. (2024) found a positive association between FMS, muscular fitness, athletic self-perception, and physical activity, while Wu et al. (2021) reported a weaker association between FMS, motor fitness, and motion pattern quality.

Similarities with previous research lie in the position of FMS as the foundation of physical participation and movement literacy in children. However, the difference is that this review emphasizes that FMS is not a single predictor of long-term physical activity. The findings of Ha et al. (2021), which showed an increase in FMS without a significant increase in MVPA, show that movement competence must be supported by motivation, access, time, social support, and school culture. Theoretically, FMS opens up opportunities for participation, but these opportunities only become sustained active behavior if the child's environment provides sufficient opportunities for movement. In practical terms, FMS interventions need to be associated with classroom activities, active rest, physical education, home play, and family support so that skill improvement does not stop as a short-term motor output.

The most promising features of interventions for curriculum development, physical education practices, and future research

Empirically, the most promising features of interventions include specific skills exercise, activity variation, child active engagement, teacher feedback, valid assessments, and implementation support. Technology can amplify learning, as augmented reality mobile learning improves gross motor skills (Faruk et al., 2025) and ExerCube exergaming improves several fitness indicators (Ketelhut et al., 2022). However, Duarte et al. (2025) show that app-based assessments or instructions still require supervision because their reliability varies. Thus, technology, traditional games, BRAINballs, interdisciplinary physical education, TGfU, and flash card media have similarities as learning experience enhancers, but their effectiveness depends on alignment with skill objectives, task structure, feedback, and assessment.

The evidence was most concentrated in the technology domain, with 10 studies, followed by PE interventions with 6 studies and implementation/teachers with 5 studies. The associative mechanisms domain includes 4 studies, while the family domain includes only 1 study. This distribution suggests that primary school FMS research has evolved towards technology-based interventions and physical education pedagogy, but is still relatively limited in strongly evaluating family models and cross-contextual integration. This table also shows a relative balance between interventional, observational, and qualitative/process studies, which favors the choice of narrative synthesis. Thus, technology should be positioned as a pedagogical amplifier, not a substitute for teachers or mature learning designs.

Figure 3. Mapping evidence domains in school-based FMS pedagogy

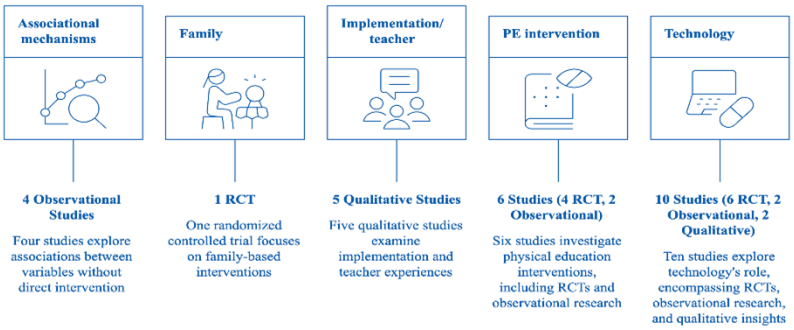
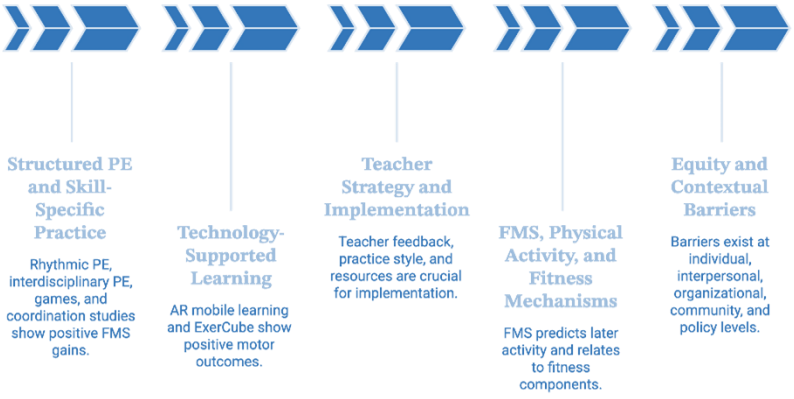


Figure 3 shows that the most consistent evidence supports the practice of specific skills in structured and engaging physical education. Technology has the potential to expand the learning experience, but its effectiveness remains dependent on pedagogy and supervision. Implementation studies show that teachers and schools are the main mechanisms of success, while association studies show that FMS can support physical activity and fitness, but the relationship depends on skill domains and context.

In terms of curriculum, the findings show that FMS development should not be separated from contextual learning experiences. Traditional games can increase engagement through cultural proximity (Fauzi et al., 2023), BRAINballs can connect motion with cognitive learning (Pham et al., 2021), interdisciplinary physical education can expand the meaning of movement learning (Nicolosi et al., 2024), while swimming provides an aquatic context that expands a child's motor experience (Pratt et al., 2024). However, future research needs remain clear. Future studies need to use a more robust design, larger sample sizes, more detailed reporting of intervention fidelity, long-term follow-up, and outcome measures that include FMS, physical activity, fitness, self-perception, and implementation. Research also needs to compare pedagogical models directly so that the contribution of each approach can be differentiated more clearly.

Figure 4. Synthesis of evidence domains



Theoretically, these findings reinforce the framework that children will be more likely to "move better to move more" when schools provide a supportive learning ecosystem. FMS needs to be understood as a result of motor learning as well as a mechanism of physical participation. Practically, teachers and schools need to design learning that is not only active, but also skillfully directed, fun, inclusive, and applicable within the school's real limitations. Methodologically, the available evidence points to the need for a balance between effectiveness studies and implementation studies, since the success of FMS pedagogy is determined not only by the design of the intervention, but also by how the intervention is translated in everyday school practice.

In practical terms, the results of this review show that schools need to develop FMS programs that not only increase the duration of physical activity, but also explicitly teach locomotor skills, object control, and stability through structured, fun, contextual, and repetitive activities. Physical education teachers need to be supported through training, easy-to-use activity guides, valid assessments, and curriculum flexibility to adapt learning to children's abilities and needs. In addition, schools need to strengthen collaboration with families and communities so that movement training opportunities do not only occur during physical education lessons, but also continue at home, while playing, and in community activities. Future research directions need to focus on the design of longitudinal and randomized controlled trials with larger sample sizes, more detailed reporting of intervention fidelity, measurement of skill retention, and evaluation of integrative models that connect schools, families, and communities to ensure that improved FMS can contribute to children's physical activity, fitness, and physical literacy on an ongoing basis.

Conclusions

This systematic literature review shows that school-based and school-linked pedagogies can support the development of fundamental movement skills among primary school children, but their effectiveness depends on more than the presence of physical activity alone. The most consistent evidence comes from approaches that provide structured, repeated, and developmentally appropriate practice of specific movement skills. Rhythmic activity, interdisciplinary physical education, BRAINballs, traditional games, Physical Activity Cards, swimming, augmented reality mobile learning, and exergaming all show promise when they are embedded in meaningful pedagogical design. The review also demonstrates that FMS is connected to broader outcomes, including physical activity, fitness, athletic self-perception, movement quality, and participation opportunities during the school day. However, these relationships are not uniform. FMS appears to function as an enabling foundation rather than a single causal driver of active behaviour. Children with stronger movement competence may be better positioned to participate in varied physical activities, but motivation, access, teacher support, family involvement, and school culture remain essential. A central conclusion is that implementation quality is part of the intervention mechanism. Teacher expertise, explicit instruction, constructive feedback, autonomy, practical resources, leadership, and whole-school alignment strongly shape whether FMS pedagogies can be delivered effectively and sustained over time. Therefore, future curriculum and intervention design should integrate motor learning principles with realistic school implementation strategies.

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