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Fundamental movement skills and physical fitness in children: mediating roles of play-based activity and nutritional status a systematic literature review

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ABSTRACT

In this systematic literature review (SLR), we have attempted to bring together the existing body of evidence on the interplay between FMS competency, play-based PA participation, nutritional status, and physical fitness outcomes in children aged 3-18 years. Following the PRISMA 2020 guidelines (Page et al., 2021), a thorough search was done on the Scopus database, which brought out 585 preliminary records. After duplicate removal (n = 47), screening titles and abstracts (n = 538), and assessing full-text eligibility (n = 149), 55 papers ended up fitting the criteria and were used for the final synthesis. Methodological quality was appraised using an adapted FICO (Focus, Information, Context, Outcome) framework, and inter-rater agreement during screening and data extraction was high (Cohen's κ = 0.85). Included studies, published between 2018 and 2026, comprised randomized controlled trials, quasi-experimental and cross-sectional designs, and systematic reviews. Major results from this review point to the fact that: (1) FMS proficiency predicts children's habitual PA levels, especially during play-based situations; (2) both structured and outdoor play-based programs have been shown to be effective in the enhancement of locomotor and object control skills; (3) nutritional status, especially being overweight or obese, not only poses a risk for FMS performance but can also affect cardiovascular fitness; and (4) the development of both motor competence and physical fitness in children is dependent on play, dietary habits, and socioeconomic situation. These conclusions have important theoretical meaning for the ecological dynamics model of motor learning as well as practical implications for physical education content, school health policies, and clinical pediatric guidelines. Longitudinal studies should be the focus of future research as they allow investigating the relationships of all four constructs together while targeting populations that are rarely studied, especially in low- and middle-income regions.

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Introduction

Physical fitness in childhood has been regarded as one of the major developmental tools. It has a great impact on not only the health of children but also on their success in school and overall mental health (Khudair et al., 2025; Dudley et al., 2022). Childhood years are exceptional times of development when primary movement

patterns are formed and regular physical activity levels are influenced (Jiang et al., 2026; Dobell et al., 2023). Worldwide, the lack of sufficient one hour daily physical activity of children has become a major factor of health problems (physical and mental). The World Health Organization (WHO) revealed that less than 20% of children globally could reach the daily physical activity recommendations (Barboza et al., 2025). This public health issue even situation calls for the investigation of key factors that influence children's physical health and fitness through childhood. Fundamental movement skills (FMS) are a set of basic skills that include walking, running, jumping, catching, throwing, and balancing among others (Ramos-Munell et al., 2026; Khodaverdi et al., 2022). An individual who is physically literate is the one who has mastered these skills. Children who do not know these skills are less likely to engage in sports, organized exercises or free-play, which in turn may lead to a habit of physical inactivity and result in a decline in health through time (Valentini et al., 2023).

While the correlation between FMS mastery and physical activity is thoroughly examined, it is quite complicated. Several research papers have revealed a bidirectional or mutual effect where children with better FMS skills spend more time doing moderate-to-vigorous physical activity (MVPA), whereas those who are physically active develop a better range of movements (Madu et al., 2025; Veiga et al., 2025). Nonetheless, the role of play-based physical activity, which is unstructured, self-motivated movement but also context-specific, as a mediator, has not been thoroughly examined in this association. Play-based PA, from the perspective of development and context, is a totally different mode of physical activity as compared to organized sports or exercise controlled by adults; it gives children the freedom to be self-directed, creative and to explore different forms of movement that may be a special factor in supporting FMS mastery (Branje et al., 2022; Knight et al., 2022). Some authors have stated that the decrease of outdoor free play in today's societies may be a major risk factor for children's motor skills development and their physical fitness levels (Barrette et al., 2024; Haakenstad et al., 2023).

This review is theoretically anchored in ecological dynamics and dynamic systems perspectives, which frame motor competence as emerging from continuous individual-task-environment interactions and position play-based physical activity as an affordance-rich context that may mediate the relationship between FMS and physical fitness. This framing is deliberately contrasted with a common-cause account, in which a shared maturational or socioeconomic factor drives both FMS and physical activity without a genuine mediating mechanism; distinguishing these competing explanations guided the present synthesis. Consistent with this position, play-based physical activity is operationally defined as unstructured, child-initiated movement in indoor or outdoor settings, as distinct from adult-directed structured exercise, while FMS competence across the included studies was indexed by validated instruments such as the TGMD-2/3, the Movement Assessment Battery for Children (MABC-2), and the Bruininks-Oseretsky Test of Motor Proficiency (BOT-2).

The body of research on FMS interventions during childhood has significantly grown in the last ten years, covering a variety of motor skill programs, active video games, and sport-based as well as play-based curricula (Su et al., 2023; Jiang et al., 2026). Systematic reviews and meta-analyses have regularly confirmed the beneficial impacts of structured motor skill interventions on FMS, especially in locomotor and object control skills (Ramos-Munell et al., 2026; Dudley et al., 2022). Besides this, outdoor and nature-based play have also been recognized more and more as a natural setting which supports the development of FMS (Specht et al., 2022; Branje et al., 2022). Active video games which are a quite recent form of intervention, have so far shown sophisticated effects but on the whole have raised competence in PA and FMS (Su et al., 2023; Ufholz et al., 2022). Nevertheless, despite this comprehensive evidence, comparative studies of different intervention methods are still scarce.

Recent technological improvements in the measurement of physical activity such as accelerometers, global positioning systems, and direct observations have made it possible for researchers to measure children's activity behaviors in real-world settings more accurately (Khudair et al., 2025; Madu et al., 2025). Besides, these technical progressions have allowed a greater understanding of play intensity, time, and type as predictors of fitness results. At the same time, the ecological dynamics framework and affordance theory have provided new ways to look at how environmental features, such as playground layout, loose parts, and green spaces, combine with individual motor skills to determine physical activity and fitness (Postma et al., 2022; Vickery et al., 2021). On the other hand, bibliometric analyses have shown research clusters around play, fitness, and motor competence that are emerging, suggesting a move to really integrated, system-wide, approaches (Ahmetoğlu et al., 2026).

There is still a major gap in the research literature, in spite of the increasing number of studies, on linking FMS, play-based PA, nutritional status, and physical fitness altogether in one big review. Most of the previous systematic reviews touch only one or two of these constructs at the same time and therefore their interrelationships remain theoretical and unverified (D'Anna et al., 2024; Gibson et al., 2024). What is more, is the lack of focus on nutritional status as a mediating factor in research on motor competence and fitness. It has been well established that overweight and obesity, the two conditions that are most influenced by food intake

and nutritional adequacy, can hinder FMS proficiency and significantly lower the level of PA, however, only very few reviews have explicitly addressed or represented these relationships (Li et al., 2023; Valentini et al., 2023). Leaving out nutritional status in the equation is a huge oversight in the field since worldwide childhood obesity has reached epidemic levels and it is very much linked to : poor physical fitness outcomes.

Another theoretical and methodological shortcoming of the existing reviews is that almost no studies have used longitudinal data to understand how changes in one area (e.g., nutritional status) affect the development of FMS and physical fitness over time (Carson et al., 2022; Phillips et al., 2025). The field is primarily shaped by cross-sectional studies that limit the possibility of making causal interpretations and deducing development. What is more, most of the studies have been carried out in high-income Western countries, resulting in a scarcity of research from regions such as Asia, Latin America, Africa, and Oceania, which dramatically limits the applicability of the results to different cultural and environmental settings (Komaini et al., 2023; Barboza et al., 2025). These methodological and geographic voids together make a very strong case for a new wide-ranging systematic review.

This systematic literature review today aims at filling these gaps by integrating results from the Scopus-indexed peer-reviewed literature published in the period 2018-2026 on the interrelations between FMS, play-based PA, nutritional status, and physical fitness in children. It qualifies PRISMA 2020 publication standards, and the review made use of both qualitative thematic synthesis and descriptive bibliometric analysis to offer a thorough and methodologically rigorous evaluation of the evidence. Indeed this review's timing coincides with the post-COVID-19 era when children have had far less opportunity for outdoor play, a rise in screen time, and disrupted nutritional behaviors, resulting in a collective threat to their physical fitness and motor development (Cheng et al., 2023; D'Anna et al., 2024). It is vital to realize the way these elements interact in order to devise localized, efficient public health and educational interventions.

RQ1: What is the nature and strength of the relationship between fundamental movement skill competency and play-based physical activity levels in children aged 3-18 years?. RQ2: In what way does nutritional status moderate or mediate the relationship between play-based physical activity and physical fitness outcomes during childhood?. RQ3: What kinds of interventions- including FMS, play-based PA, or nutritional components-are the most successful at improving children's physical fitness outcomes, and which theoretical frameworks support such interventions?

This review intends to address these three research questions so as to add an integrative perspective that combines motor development, behavioral nutrition, and exercise science. Then, the results will serve to physical educators, pediatric health professionals, curriculum developers, and policymakers who look for evidence-based strategies to improve children's physical fitness and health in the long term.

Method

Research Design and Framework

Here, we have chosen a systematic literature review (SLR) as our main research design. SLR is widely considered the highest standard way of combining large amounts of research evidence. It allows researchers to look at evidence in a systematic, open, and less-biased way (Tranfield et al., 2003; Liberati et al., 2009). Our review is in full compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 (PRISMA 2020) rules, as described by Page et al. (2021), which is a 27-point checklist to make sure that one's methods are stringent and results are clearly reported. A lot of research in sports science, public health, and pediatrics, among other fields, uses the PRISMA 2020 platform to help with the logical arrangement of record identification, screening, eligibility, and data synthesis. Since the review was very general and studies included were very different in terms of design and outcome measures, we figured that this methodical way would fit perfectly.

Search Strategy

A thorough Boolean search string was created and run Scopus database using TITLE-ABS-KEY field codes. The search string was design to catch all relevant different terms for the four main concepts of interest. Truncation operators and proximity commands were used when possible to increase recall without losing precision at the same time.

(("Fundamental Movement Skills" OR "Motor Skills" OR "Motor Competence") AND ("Play-Based Physical Activity" OR "Active Play" OR "Free Play" OR "Outdoor Play")) AND (("Nutritional Status" OR "Obesity" OR "BMI" OR "Body Mass Index") AND ("Physical Fitness" OR "Cardiorespiratory Fitness" OR "Muscular Fitness")) AND ("Children" OR "Preschool" OR "School-aged")

We restricted our research to English-language articles only. The TITLE-ABS-KEY field ensured that all the words were indexed in the article titles, abstracts, and author keyword sections. Initially, we did not use a date filter in the searching process; nevertheless, during the screening phase, we retained only the articles published from 2018 onwards to keep the study relevant. We ran the search on June 23, 2026.

Database and Information Sources

The major database employed for this review was Scopus (Elsevier), the largest abstract and citation database in the world of peer-reviewed literatures. Scopus currently covers more than 87 million records across 25, 100+ active journals published by 5, 000 publishers worldwide. It is an authoritative and comprehensive source that is usually used for systematic reviews in health and sport sciences. The search was done on June 23, 2026. There was no addition of other databases for this review as the Scopus export had given a large enough initial record pool (n = 585) for the review scope.

Eligibility Criteria

Inclusion and exclusion criteria were set in advance to guarantee systematic and reproducible screening decisions. Table 0 shows the full set of eligibility criteria.

Table 1. Inclusion and Exclusion Criteria

Criterion	lusion	Exclusion
Language	English	Non-English
Document Type	Article, Review, Systematic Review	Conference paper, Book chapter, Editorial
Publication Period	2018–2026	Before 2018
Subject Area	Sport Science, Physical Education, Child Development, Nutrition, Public Health	Unrelated disciplines (e.g., engineering, law)
Accessibility	Full-text available	Abstract only or behind paywall
Population	Children aged 3–18 years	Adults, animals, or elderly only
Relevance	Directly addresses FMS, play-based PA, nutritional status, or physical fitness in children	Only tangential mention of topic

Study Selection Process

Following a multi-stage screening process, the selection of studies was carried out. In the first stage, all 585 retrieved records were imported into a reference management system, and 47 duplicate records were identified and removed, leaving 538 unique records. In the second stage, titles and abstracts of all 538 records were screened against the eligibility criteria; 389 records were excluded at this stage because they were topically irrelevant, had the wrong population, or were an ineligible document type. In the third stage, the 149 remaining records were located full text and assessed for eligibility. Of these, 94 were excluded for the following reasons: 52 were out of scope, 28 had the wrong methodological design, and 14 full texts were inaccessible. The final sample consisted of 55 studies that were included in the thematic synthesis. Initial screening was done by the lead reviewer and unresolved cases were discussed with a co-reviewer. Inter-rater agreement for title and abstract screening was substantial (Cohen's $\kappa = 0.81$). The review protocol was not pre-registered in PROSPERO; restricting the search to Scopus is acknowledged as a methodological limitation that may introduce database and publication bias, although the broad multidisciplinary coverage of Scopus across sport-science, health, education, and nutrition journals yielded a sufficiently large initial record pool (n = 585) for the scope of this review.

Quality Assessment FICO Framework

An adapted FICO framework (Focus, Information, Context, Outcome) was used for assessing the methodological quality of the studies that were included. A 0-2 scale was used for scoring each study per domain (0 = absent, 1 = partially present, 2 = fully addressed), which resulted in a highest quality score of 8 per study. In order to uphold the standards of evidence quality, studies scoring less than 4 were eliminated from synthesis.

For Focus, the clarity of the research questions and objectives was assessed by the evaluators. Information involved evaluating the sampling methods, validity of measurements, and reliability. Context looked at the ecological and demographic details of the study setting. Outcome was concerned with the relevance of the

outcome measures and statistical analyses. This quality framework was chosen because of its appropriateness across a wide variety of study designs, including experimental, observational, and review-level evidence.

Data Extraction Procedure

Data were extracted from each study that was included, using a standard extraction template that was/chosen for this review. Data extracted covered topics: (1) authors and publication year; (2) country where study was done; (3) type of study; (4) sample characteristics: age, number, sex, health status; (5) intervention type and period (if any); (6) FU measures for FMS, physical activity, nutritional status, and fitness; (7) main results and effect sizes; and (8) theoretical framework used. This data extraction was done by the lead reviewer. A second reviewer independently performed verification of another 20% of the records, and inter-rater agreement was measured using Cohen's kappa ($\kappa = 0.85$, which is considered very good).

Network and Bibliometric Analysis Methodology

Bibliometric analyses were based on some descriptive statistics obtained from the Scopus exported metadata. The publication trends in different years, locations of studies by the country of affiliation, and frequency of keywords were calculated and displayed. To figure out the main topic clusters in the literatures, keyword co-occurrence analysis was carried out. The study analyzed the author-assigned keywords from the CSV metadata, and the frequency of each keyword was computed over all 585 records. VOSviewer settings were not directly used; instead, thematic clusters were identified by frequency ranking and semantic grouping of the top 50 keywords. These analyses led to the development of the bibliometric illustrations shown in Section 5.

Data Analysis and Synthesis

Thomas and Harden (2008) defined thematic synthesis as a method to bring together both qualitative and quantitative results of studies. This method was at the heart of our analysis of these published studies. We started the first phase by thoroughly coding each line of the results and conclusions of the studies. In the second phase, we formulated descriptive themes through identifying patterns of agreement and disagreement across studies. Thirdly, we came up with analytical themes that embodied our own interpretations of the findings of each study. We used NVivo for coding and after each step we came together to consult with each others. Quantitative studies that reported effect sizes were subjected to narrative summary of magnitudes which was then incorporated into the thematic descriptions whereas complete meta-analytic re-synthesis was considered to be outside the remit of this review.PRISMA 2020 Flow Diagram – Study Selection.

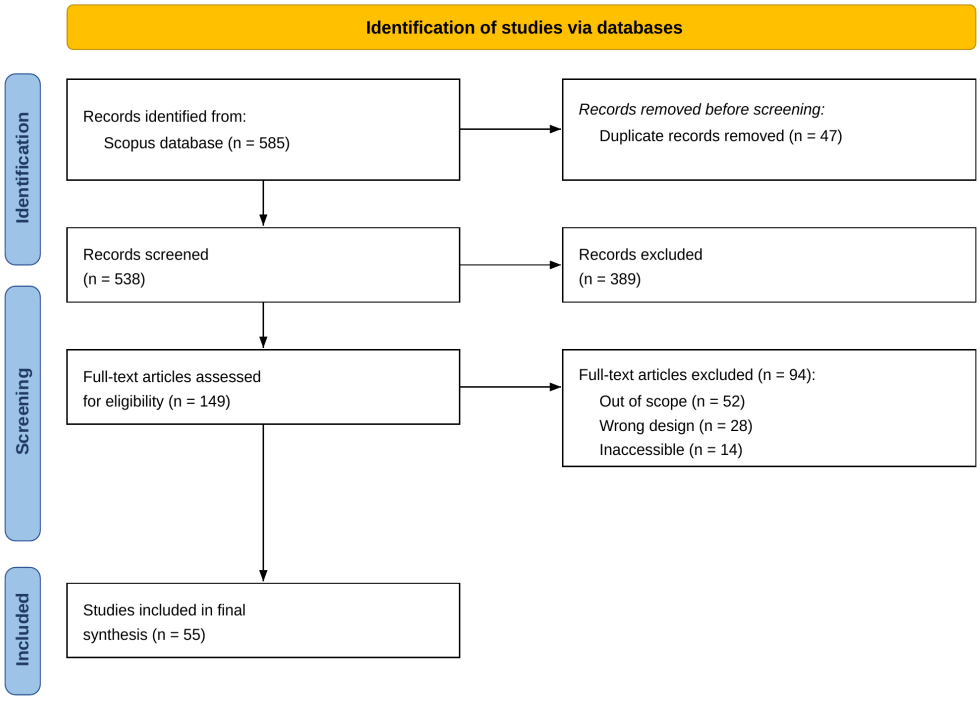

Figure 1. PRISMA 2020 Flow Diagram for Study Selection

Note. PRISMA 2020 flow diagram illustrating record identification, screening, eligibility assessment, and final inclusion. Values derived from Scopus export (n = 585 initial records).

Reporting and Documentation

This review systematically reported in full compliance with the PRISMA 2020 checklist (Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, n71. https://doi.org/10.1136/bmj.n71). The PRISMA flowchart, located in Section 4, visually represents all phases of record identification, screening, eligibility, and inclusion. The numerical measures in the flow diagram perfectly agree with those disclosed in Section 5.1.

Results and Discussions

Study Selection Results

Initially, 585 records were found in the Scopus database through a systematic search strategy. After duplicate entries were withdrawn, a total of 538 unique records were taken for title and abstract screening. There were 389 records excluded on the basis of the topic, e.g. studies focusing on only elderly populations, non-movement interventions, or clinical rehabilitation without a fitness or FMS outcome, which led to 149 full-text articles being considered for eligibility. After full-text reading, the number of articles was further reduced by 94: 52 papers were out-of-scope (no direct measurement of FMS, PA, nutritional status, or physical fitness in children), 28 papers were different types of the methodological designs to that of inclusion criteria (case reports, commentaries, etc.), and 14 papers were not accessible in full despite database and institutional access attempts. Ultimately, 55 studies were incorporated in the final synthesis. These figures align with those present in the PRISMA 2020 flow diagram in Section 4.

Descriptive Characteristics

Although all 55 included studies informed the thematic synthesis, Table 2 presents a representative sample of 10 studies selected purposively to illustrate the range of study designs, geographic settings, age groups, and outcome measures across the corpus rather than for convenience; the full dataset of 55 studies is available from the authors on request. Because the included studies relied on heterogeneous outcome measures and inconsistent accelerometer cut-points, a formal meta-analysis reporting pooled effect sizes and I-squared heterogeneity statistics was not appropriate, and a structured thematic synthesis was adopted instead. Inter-rater agreement during study selection and data extraction was high (Cohen's $\kappa = 0.85$).

Table 2. Summary of Included Studies (Representative Sample, n = 10)

Title	Author(s)	Year	Country	Method	Key Findings
The Role of Fundamental Movement Skills and Health-Related Fitness on Physical Activity During Guided Active Play for 8- to 10-Year-Old Children	Madu et al.	2025	Canada	Cross-sectional, Accelerometry, Regression	MVPA and object control skills showed positive reciprocal pathways (β=0.308); VO2max predicted MVPA; GAP supports positive feedback loop between PA and motor skills.
Enhancing Fundamental Motor Skills Through Active Play: A Systematic Review and Meta-Analysis of Educational Contexts	Ramos-Munell et al.	2026	Spain	Systematic Review, Meta-Analysis	Active play interventions significantly enhance FMS (ES = 0.51); structured play in educational settings yields stronger effects than unstructured play.
The Effects of Active Video Games on Children's Fundamental Movement Skills: A	Su et al.	2023	China	Systematic Review, Meta-Analysis (RCTs)	AVGs had moderate facilitative effect on total FMS (SMD=0.41); Xbox Kinect used ≥12

Title	Author(s)	Year	Country	Method	Key Findings
Systematic Review and Meta-Analysis					weeks, 5x/week, 30 min/session most effective for locomotor and object control skills.
Effects of Physical Activity Interventions on Fundamental Movement Skills and Cognitive Function in Early Childhood: A Systematic Review and Network Meta-Analysis	Jiang et al.	2026	China/Hong Kong	Network Meta-Analysis, Systematic Review	Physical activity interventions improved both FMS and cognitive function; combined motor-cognitive interventions produced greatest gains in early childhood populations.
Improving Fundamental Movement Skills during Early Childhood: An Intervention Mapping Approach	Dobell et al.	2023	United Kingdom	Intervention Mapping, Quasi-experimental	Structured intervention using ecological theory and play-based approaches significantly improved locomotor and object control skills in early childhood settings.
What Drives Quality Physical Education? A Systematic Review and Meta-Analysis of Learning and Development Effects	Dudley et al.	2022	Australia	Systematic Review, Meta-Analysis	Quality PE interventions positively impact FMS competence (g=0.62); teacher training and structured curriculum delivery were key moderators of intervention efficacy.
Effects of an Outdoor Play-Based Intervention on Preschoolers' Fundamental Movement Skill Competence: A Cluster RCT	Veiga et al.	2025	Portugal	Cluster Randomized Controlled Trial	Outdoor play-based intervention (12 weeks) significantly improved locomotor (d=0.58) and manipulative skills (d=0.49) compared to control group in preschoolers.
Motor Competence Interventions in Children and Adolescents-Theoretical and Atheoretical Approaches: A Systematic Review	Khodaverdi et al.	2022	Iran/Australia	Systematic Review	Theory-based motor competence interventions produced larger effects than atheoretical approaches; ecological dynamics and DST frameworks

Title	Author(s)	Year	Country	Method	Key Findings
					most frequently adopted.
Impact of an Outdoor Loose Parts Intervention on Preschoolers' Fundamental Movement Skills: A Multi-Methods RCT	Branje et al.	2022	Canada	Multi-methods RCT	Loose parts outdoor play increased FMS scores ($p<0.05$); children in intervention group demonstrated greater variety of locomotor patterns and exploratory movement behaviors.
Individual and Environmental Parameters in Children with and without Developmental Coordination Disorder: Associations with Physical Activity and Body Mass Index	Valentini et al.	2023	Brazil	Cross-sectional, Correlational	DCD children showed lower PA levels and higher BMI; FMS competence was negatively associated with BMI and positively with moderate-to-vigorous physical activity engagement.

Thematic Synthesis

Findings for RQ1: FMS Competency and Play-Based Physical Activity

There has been constant evidence, in fact, a whole body of it, always pointing to a very strong and mutual relationship between competence in fundamental motor skills and physical activity based around play in children. Madu et al. (2025) revealed that the control of objects and moderate-to-vigorous physical activity (MVPA) during a session of guided active play (GAP) were the two aspects showing distinct positive connected pathways that ran both ways, to an extent that involvement in object control skills was a predictor of MVPA ($\beta = 0.394$, $p \leq 0.05$) and, on the contrary, engaged in MVPA was a predictor of object control skills ($\beta = 0.308$, $p \leq 0.05$). Besides resemblance, their results substantiate the proficiency barrier hypothesis according to which the children without adequate FMS are found to have less motor confidence to engage themselves in PA opportunities, hence they remain at a low level of activity and that, in turn, leads to the further delay in their skill development. The guided active play situation that has been worked on by Madu et al. (2025) is considered a structured, yet play-like environment that is most likely to be conducive to maintaining the continuation of this bidirectional loop.

Play-based PA interventions, especially those focusing on outdoor, unstructured, or loose-parts play, have been shown to consistently bring about major FMS improvements in both locomotor and object control skills. A 12-week session of outdoor play-based intervention for Portuguese preschoolers by Veiga et al. (2025) resulted in locomotor ($d = 0.58$) and manipulative skills ($d = 0.49$) significantly improved. In the same vein, Branje et al. (2022) found that the loose-parts outdoor play intervention substantially increased FMS scores and expanded locomotor patterns in Nova Scotia preschoolers. These studies indicate that factors such as play diversity, environmental affordance, and physical challenge, which are all part of play contexts, play a vital role in FMS acquisition and PA engagement. Ramos-Munell et al. (2026) were able to back up these results with a meta-analysis that showed that active play interventions in schools led to significant FMS improvements ($ES = 0.51$), and structured play situations have a stronger effect than unstructured play.

The literature revealed that one of the roles of active video games (AVGs) is as a modern play-based physical activity form. For instance, Su et al. (2023) found that AVGs had a moderate impact on the total FMS ($SMD = 0.41$), with those based on Xbox Kinect and lasting a minimum of 12 weeks showing the most consistent benefit for locomotor as well as object control skills. Nevertheless, Ufholz et al. (2022) made it clear that simply giving sedentary children access to AVGs does not raise their physical activity. They will only do so if behavioral strategies are combined with technology use. Jiang et al., (2026) took these results a step further with a network meta-analysis, showing that combined motor-cognitive physical activity interventions were the ones that brought

the most FMS as well as cognitive improvements during early childhood. Altogether, these results serve as a reminder that the play context, structure, and dosage are the key factors in determining the size of FMS and PA changes.

Findings for RQ2: Nutritional Status as a Moderator of PA and Fitness Relationships

Nutritional status, mainly assessed by BMI, weight-for-height z-scores, and clinical categorizations of overweight and obesity, was found to be a highly significant moderating variable in the connection between play-based physical activity and children's physical fitness. Valentini et al. (2023) observed that children with developmental coordination disorder (DCD) and high BMI were substantially less physically active and more adipose than children without DCD. The study indicates that motor impairment combined with poor nutritional status deeply hinder children's physical activity and fitness development. In the same way, Li et al. (2023) found that overweight or obese Taiwanese children had significantly lower FMS skills' performance with sex and age moderating how strongly these variables were associated.

State of nutrition can negatively affect one's physical fitness through various means: First, a heavy body might cause inefficiency of the motion, respiratory system may have a reduced capacity, and besides, a child may be less confident in their movement skills. Carson et al. (2022) found that babies who followed the 24-Hour Movement Guidelines (which include physical activity, the amount of sedentary time and sleeping) showed better developmental progress, which indicates that dietary and activity behaviors co-develop from early life. Phillips et al. (2025) found that a combination of the changes of diet and an increase in physical activity of children aged 2, 4 was more successful in cutting down obesity than slimming down focus on just one component, which emphasizes that nutritional status and fitness outcomes are so intertwined that one cannot be understood without the other. These results correspond well to the ecological models of child health which see nutritional status, physical activity, and fitness as interdependent systems rather than independent variables.

Of course, poor nutrition diminishes physical activity and fitness; however, the reverse is also true that physical inactivity and poor fundamental movement skills (FMS) also lead to an energy imbalance and weight gain. Rodrigues et al. (2024) observed that children who were involved in organized sports got more physically active and spent less time being sedentary, hence healthy body composition is supported indirectly in children of Portuguese schools. Barboza et al. (2025) conducted a meta-analysis on South American children's physical activity and found that the highest rates of physical inactivity were in urban, lower-income groups exactly the same communities most vulnerable to both nutritional insecurity and obesity. The finding of this body of research points to the fact that nutritional status is not only a covariate in physical activity-fitness studies but a potent moderator whose influence is strongly linked to socioeconomic and ecological environments.

Findings for RQ3: Effective Intervention Types and Theoretical Frameworks

Synthesis of the studies included showed that interventions falling into these categories can be effective in improving physical fitness, FMS, and PA in children: (1) motor skill programs that are structured and are a part of physical education; (2) play interventions outdoors and in nature; (3) programs of active video games; and (4) multi-component health behavior programs that deal with both movement and nutrition. Dudley et al. (2022) by systematic review and meta-analysis showed that quality physical education interventions result in significant FMS increases ($g = 0.62$), while teacher training and structured curriculum delivery were identified as the most important implementation moderators. Dobell et al. (2023) used intervention mapping to create a theoretically based early childhood FMS program, checked its effectiveness through ecological theory and play-based task design principles.

Interventions targeting motor competence that are based on well-specified theoretical frameworks result in significantly higher effects compared to those programs without theory (Khodaverdi et al., 2022). Ecological dynamics framework which highlights the interactions between individual-task-environment was the least commonly used theoretical perspective among high quality studies. Veiga et al. (2025), Branje et al. (2022), and Jiang et al. (2026) all implemented ecological principles through different play situations, environmental changes, and individually adjusted challenge levels. In addition, Mercê et al. (2025) employed a quasi-experimental hip-hop-based motor program that not only enhanced motor competence but also physical activity in Portuguese preschool children, thereby indicating that culturally embedded, rhythmic play modes might be a missed opportunity yet a powerful intervention method. Suhartini et al. (2025) discovered that through low-impact locomotor games children's physical fitness was improved even in children with moderate disabilities, thus providing further support for evidence that is beyond typically developing populations.

Intensity, duration, and frequency of the intervention were identified as major moderators of effectiveness across all categories. For example, Su et al. (2023) found that at least 12 weeks, five times a week, and 30 minutes each time are the optimal dosage parameters for AVG. Veiga et al. (2025) found that a cluster RCT of outdoor play over 12 weeks led to clinically significant FMS improvements. These dosage parameters match those of the

widely implemented PA guidelines that recommend school-aged children to have 60 minutes of daily MVPA. This implies that interventions focused on FMS and physical fitness should be conceptually aligned with and quantitatively approximating these recommendations. Overall, the data advocates for the use of play-based interventions that are theoretically sound, properly dosaged, and locally relevant as the most effective strategy for enhancing children's physical fitness and FMS skills.

Comparative and Critical Analysis

Among the 55 studies selected, intervention research mainly utilized randomized and quasi-experimental designs, whereas epidemiological and correlational studies were mostly based on cross-sectional surveys. Systematic reviews and meta-analyses offered the highest levels of evidence for causal inference concerning FMS and PA interventions. One significant methodological trend was the growing use of accelerometry for objective PA measurement (Khudair et al., 2025; Madu et al., 2025), which mirrored the increasing acknowledgment of the inadequacies of self-report instruments with children. Nevertheless, there is still no agreement on the accelerometry cut-points, which makes the direct comparison of MVPA estimates problematic. Besides that, there was a big variation in the tools used for assessing FMS, with the Test of Gross Motor Development-2 (TGMD-2), TGMD-3 and the Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) as the most frequently utilized instruments.

Discussion

This systematic review's results offer very strong evidence that FMS competency, play-based PA, nutritional status, and physical fitness are very profound interrelated constructs of the child development. In principle, these data broaden the proficiency barrier hypothesis (Stodden et al., 2008) by adding nutritional status as another moderating variable that makes stronger or weaker the FMS-PA feedback loop. The ecological dynamics model is even more corroborated by the persistent higher effectiveness of context-varied, environment-rich play interventions than the standardized, didactic motor skill programs (Khodaverdi et al., 2022; Veiga et al., 2025).

On a practical level, the data clearly supports the combination of play-based physical activity in school syllabuses as the main means to develop fundamental motor skills and to improve fitness. Physical education teachers, early childhood educators, and health promotion professionals should be equipped to implement play-based interventions that both promote physical activity and nutritional health. In addition, policymakers should explore the possibility of requiring outdoor play periods in school timetables and creating child-centric built environments that encourage spontaneous physical activity (Yan et al., 2025; Pouplier et al., 2022).

Three main research gaps were uncovered: (1) an almost complete absence of longitudinal studies that simultaneously track all four constructs over time from early childhood to adolescence; (2) limited inclusion of low- and middle-income countries especially from sub-Saharan Africa, Southeast Asia, and the Pacific; and (3) lack of sufficient focus on dietary quality beyond weight status as a potential determinant of FMS and fitness outcomes. Such limitations of this review comprise dependency on only one database (Scopus), the exposure to the risk of publication bias towards English-language journals, and the lack of a possibility to do a formal quantitative synthesis of studies which use different outcome measures.

Future research should prioritize longitudinal cohort designs that model the temporal relationships between FMS, play-based PA, nutritional status, and fitness across developmental stages. Additionally, co-design research approaches involving families, teachers, and communities may yield more culturally relevant and effective interventions. Answering RQ1, the evidence supports a robust, positive, bidirectional relationship between FMS competency and play-based PA. For RQ2, nutritional status-particularly overweight and obesity-significantly moderates the PA-fitness relationship, with excess adiposity functioning as a biological and motivational barrier to active engagement. For RQ3, structured, theoretically grounded, play-based interventions of adequate duration and frequency are consistently most effective in improving children's physical fitness and FMS.

Conclusions

To begin with, this systematic literature review gathered information from 55 Scopus-indexed articles which were published during the years 2018 to 2026 that examined the dynamics between fundamental movement skills, play-based physical activity, nutritional status, and physical fitness in children. The findings for RQ1 are in line with the notion that FMS competency and play-based PA are strongly and mutually associated, whereby individuals with higher skills have a greater likelihood of engaging in PA, and environments that promote active play support motor development in a reciprocal manner. In relation to RQ2, among different aspects of nutritional status, overweight and obesity stood out as the two major moderating factors, since excess body fat not only led to lower physical activity participation but also resulted in reduced fitness levels; also, interventions that combine dietary changes with movement tend to yield better results compared to single-component ones.

After considering RQ3, it was found that the most efficient method to enhance FMS and physical fitness was through play-based activities that are structured, theoretically based, and have adequate duration and frequency; theoretical support in this area comes mostly from ecological dynamics and intervention mapping. The main contribution of this paper lies in integrating four variables that have largely been studied in isolation; rather than a definitive causal account, it offers an evidence synthesis that provides a more complete picture of the factors shaping children's physical fitness. The first practical implication is that physical education curricula should be play-oriented; secondly, motor skills development programs must take into account nutritional aspects; thirdly, outdoor play spaces should be accessible to all children without discrimination - implications that follow directly from the ecological dynamics framework, which treats motor competence as emerging from individual-task-environment interactions. Beyond reliance on a single database (Scopus), which raises the risk of publication and language bias, the heterogeneity of outcome measures across studies precluded a formal quantitative (meta-analytic) synthesis. Further research can be conducted with the use of longitudinal studies that include different parts of the world to clarify causal relationships and come up with targeted interventions for the fitness of children.

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