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Review Article

Movement-Based Interventions and Motor Competence in Physical Education and Paediatric Exercise Contexts: A Narrative Synthesis of Experimental Evidence

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Abstract

Objectives. Movement competence is fundamental to physical education, physical literacy, and sustained participation in physical activity. This critical narrative synthesis examined contemporary experimental and intervention-based evidence on movement-based interventions in children and adolescents, focusing on the direction, consistency, specificity, transferability, and methodological limitations of reported effects.

Materials and Methods. A structured narrative review was used to identify and critically integrate literature published from 2018 onward. Study selection considered population, design, intervention or experimental focus, comparator, outcome domain, context, language, and relevance to the review question. Eighteen studies formed the core evidence base: 16 intervention or comparative studies and two structured experimental assessment studies addressing strength-effort regulation as a component of motor control. Evidence was synthesized thematically, with attention to methodological strengths, limitations, inconsistencies, and transfer effects.

Results. Structured physical education and motor-competence programmes generally improved directly targeted gross motor and fundamental movement skills. Structured play, balance-bike training, physical activity programmes, and sport-based activities improved selected motor and fitness outcomes, but these gains did not consistently transfer to broader motor competence. Coordinative interventions improved several balance, jumping, and coordination outcomes, whereas effects on inhibitory control and other cognitive outcomes were inconsistent. Resistance training improved selected muscular fitness and performance outcomes, therapeutic exercise improved specific fundamental movement skills in a paediatric clinical population, and the FIFA 11+ Kids programme reduced overall injury incidence by 57% (IRR = 0.43, 95% CI: 0.29–0.61). Strength-effort studies also suggested that force-regulation accuracy may vary with the relative effort reproduced.

Conclusions. Contemporary evidence supports structured and developmentally appropriate movement experiences for improving motor competence and selected related outcomes in children and adolescents. However, benefits are often domain-specific, and improvements in directly practised abilities should not automatically be interpreted as transfer to generalised motor competence, physical activity, or cognitive functioning. Intervention structure, task specificity, progression, participant characteristics, and assessment methods appear to influence observed effects. Future studies should distinguish direct training effects from broader developmental transfer.

Keywords: motor competence, physical education, movement-based intervention, paediatric exercise, fundamental movement skills, physical literacy, narrative review, motor development.

Introduction

Movement competence is increasingly recognized as a central foundation of physical education, paediatric exercise, and lifelong physical activity participation. It includes fundamental movement and motor skills such as locomotor skills, object-control skills, balance, coordination, body management, effort regulation, and the capacity to adapt movement to changing task and environmental demands. Developmental models of motor competence suggest that children progress through increasingly complex movement stages, shaped by growth, maturation, instruction, practice opportunities, and environmental exposure (Goodway et al., 2019; Malina et al., 2004). From this perspective, motor competence is not merely a physical outcome but an essential developmental capacity linked with physical literacy, self-confidence, participation, and long-term engagement in health-enhancing physical activity (Lubans et al., 2010; Piotrowski et al., 2025; Stodden et al., 2008).

The preschool and school years represent sensitive periods for developing movement competence because neuromuscular, perceptual, cognitive, and psychosocial systems undergo rapid development during this phase. Earlier evidence has shown that fundamental movement skills are associated with habitual physical activity in young children and may influence later activity behaviour and weight-related outcomes (Fisher et al., 2005; Williams et al., 2008). Motor-skill intervention evidence further suggests that children's movement competence can improve when programmes are structured, developmentally appropriate, and task-focused (Logan et al., 2012). Recent experimental studies support this position, showing that brief physical education interventions, specialist-led motor competence programmes, and structured early-childhood activities can improve gross motor skills, balance, manual dexterity, aiming and catching, object movement, and broader fundamental movement skills (Mulvey et al., 2018; Navarro-Patón et al., 2024; Palmer et al., 2019; Strotmeyer et al., 2021).

Movement-based interventions have also expanded beyond traditional physical education lessons into structured play, playground design, family-based activity, technology-supported activity, balance-bike training, and comparative physical activity curricula. Evidence from partly structured playground activity, painted playgrounds, mHealth-supported motor skill programmes, family-based physical activity, and balance-bike or structured physical activity courses suggests that children may benefit most when movement experiences combine enjoyment, repetition, progression, feedback, and varied motor challenges (Kojić et al., 2024; Navarro-Patón et al., 2024; Ren et al., 2025; Staiano et al., 2022; Tortella et al., 2022). Such findings indicate that free play alone may not always be sufficient; rather, guided and contextually meaningful activity may be needed to support transferable motor development.

Recent evidence also highlights the cognitive-motor value of coordinative and cognitively enriched physical activity. Programmes involving coordination, balance, decision-making, inhibition, perceptual discrimination, and attention may contribute not only to physical fitness and motor competence but also to selected executive and attentional outcomes (Başarır et al., 2025; Şendil et al., 2024). This is important because movement learning requires the integration of perception, action, attention, and self-regulation. Similarly, strength-effort assessment studies among school-aged children and pre-adolescent girls show that effort reproduction and force regulation are meaningful components of motor control, particularly when children are required to grade muscular effort across different thresholds (Choudhary et al., 2024; Ivashchenko et al., 2019).

Movement competence is also highly relevant for children with developmental coordination disorder, low motor competence, overweight or obesity, and clinical paediatric conditions. Developmental coordination disorder is associated with impaired functional performance, reduced participation, mental health difficulties, physical inactivity, and possible weight-related concerns (Wilson et al., 2013; J. Yu et al., 2016). Accordingly, therapeutic exercise, injury-prevention programmes, resistance training, Zumba, and collaborative or game-based pedagogies provide broader evidence that structured movement can support fitness, rehabilitation, physiological response, injury reduction, and movement learning across paediatric, adolescent, and educational exercise contexts (Al Attar et al., 2023; P. K. Choudhary & Dubey, 2024; S. Choudhary & Choudhary, 2025; Joschtel et al., 2022; Kumar et al., 2025; Saha et al., 2026).

Therefore, the purpose of this critical narrative synthesis was to examine contemporary experimental and intervention-based evidence concerning movement-based approaches and motor competence in physical education and paediatric exercise contexts. Rather than determining a pooled intervention effect, the review sought to critically compare how structured physical education, guided play, coordinative exercise, resistance training, injury-prevention programmes, therapeutic exercise, sport-based activity, and complementary experimental motor-control evidence contribute to understanding motor development in children and adolescents. Particular attention was given to the consistency of findings across studies, the extent to which improvements were specific to directly trained outcomes or transferred to broader domains, the methodological limitations of the available evidence, and the implications of these patterns for physical education and future research.

Materials and Methods

The present study was designed as a structured critical narrative review rather than a systematic review or meta-analysis. The purpose of the review was to identify, organize, compare, and interpret contemporary experimental evidence relevant to movement-based interventions and motor competence across physical education and paediatric exercise contexts. A structured search and explicit selection framework were used to improve transparency; however, these procedures were intended to support the rigor of the narrative synthesis rather than to claim exhaustive identification of all eligible literature. Accordingly, the review was not conducted according to PRISMA reporting requirements, did not seek to generate a pooled treatment estimate, and should not be interpreted as a systematic review.

Search Strategy

Relevant literature published from 2018 onward was identified through a structured and iterative search of

Table 1. Selection framework for studies included in the core narrative synthesis

Criterion	Included in the core synthesis	Excluded from the core synthesis
Publication period	Studies published from 2018 onward, thereby emphasizing contemporary experimental and intervention-related evidence.	Studies published before 2018 were not included in the core evidence table, although selected foundational literature could be used for theoretical or contextual discussion.
Study type	Randomized controlled trials, cluster-randomized trials, pilot randomized trials, quasi-experimental studies, controlled pre-post studies, pragmatic comparative trials, and structured experimental assessment studies with direct relevance to motor control or movement competence.	Systematic reviews, meta-analyses, scoping reviews, narrative reviews, conceptual papers, editorials, commentaries, protocols, validation studies, and general observational or correlational studies without intervention or relevant structured experimental assessment.
Population	Preschool children, school-aged children, adolescents, child athletes, physically active youth, or paediatric clinical populations when outcomes were directly relevant to movement competence, motor skills, physical fitness, exercise response, or physical education.	Adult or university populations and populations without a clear relationship to paediatric exercise, physical education, motor development, child sport, rehabilitation, or movement competence.
Intervention or experimental focus	Structured physical education, movement-based programmes, motor-competence training, structured physical activity, coordination training, guided play, balance-bike activity, resistance training, therapeutic exercise, injury-prevention programmes, sport-based activity, neuromuscular training, or structured experimental assessment directly examining motor-control processes such as strength-effort regulation.	Studies without a relevant intervention, experimental movement condition, structured assessment protocol, or direct contribution to the movement-competence question.
Comparator or experimental contrast	Control groups, usual physical education, free play, wait-list conditions, standard warm-up, regular school activity, active comparator groups, pre-post comparisons, or structured within-participant/age-group experimental comparisons.	Studies without a meaningful intervention, comparison, pre-post, or experimental contrast relevant to interpretation of the review question.
Outcome domains	Motor competence, fundamental movement skills, gross motor development, locomotor and object-control skills, balance, coordination, agility, force or effort regulation, muscular fitness, aerobic fitness, executive or cognitive-motor outcomes, physical activity, exercise capacity, and movement-related injury outcomes.	Outcomes without a meaningful relationship to motor competence, physical education, paediatric exercise, physical fitness, movement development, cognitive-motor control, or movement-related injury.
Context	Preschool, kindergarten, school physical education, youth sport, playground, after-school exercise, structured training, paediatric rehabilitation, and related child or adolescent exercise settings.	Contexts without a substantive movement, physical education, exercise, sport, rehabilitation, or motor-development component.
Language and accessibility	English-language publications with sufficient bibliographic and methodological information to permit interpretation of the design, participants, procedures, and principal outcomes.	Sources with insufficient methodological information, unclear publication details, non-traceable sources, or insufficient information for meaningful interpretation.
Role in synthesis	Studies meeting the above criteria and directly contributing experimental evidence were retained in the core characteristics table and narrative synthesis.	Conceptually relevant but non-core sources were used only to provide theoretical, historical, diagnostic, or interpretive context in the Introduction or Discussion.

academic databases, scholarly search platforms, publisher databases, and reference lists. Sources used during literature identification included PubMed, Google Scholar, ScienceDirect, Taylor & Francis Online, SpringerLink, MDPI, ResearchGate, and journal-specific sources relevant to physical education, sport pedagogy, motor development, rehabilitation, developmental psychology, and exercise science. Publisher and scholarly-network platforms were used to locate potentially relevant articles and bibliographic information; decisions concerning inclusion in the core synthesis were based on the characteristics and content of the original scholarly publications.

Searches combined terms representing movement competence, motor development, physical education, children and adolescents, intervention or experimental activity, coordination, and related outcomes. Representative combinations included "physical education" AND "motor competence"; "physical education" AND "motor coordination"; "fundamental movement skills" AND "children"; "motor development" AND "children" AND "school"; "developmental coordination disorder" AND "motor competence"; "movement-based intervention" AND "physical education"; "coordination" AND "children" AND "exercise"; "structured physical activity" AND "motor competence"; "strength effort" AND "children"; and "motor control" AND "youth." Conceptually related terms such as "movement competence," "gross motor skills," "coordination," "balance," "motor ability," "physical fitness," "executive function," "physical activity," "paediatric exercise," and "injury prevention" were also used where relevant. Reference lists of relevant articles, reviews, and book chapters were examined to identify additional studies directly aligned with the purpose of the narrative synthesis.

The search strategy was deliberately broader than would be expected for a narrowly defined intervention meta-analysis because the objective of the review was to integrate evidence across physical education, motor development, fitness, cognitive-motor, preventive, and paediatric exercise contexts. Nevertheless, only studies meeting the explicit selection framework presented in Table 1 were retained as core evidence for the narrative synthesis.

Source Selection

Potentially relevant sources identified during the literature search were examined according to title, abstract, keywords, study design, population, intervention or experimental condition, outcome domain, and full-text relevance where available. Sources were then classified according to their role in the manuscript. Studies satisfying the selection framework in Table 1 and contributing directly to the principal review domains were retained as the core evidence base. Publications that were useful primarily for theoretical background, diagnostic context, previous review evidence, or conceptual interpretation were not included in the main characteristics table and were used only in the Introduction or Discussion.

This process resulted in a core evidence set of 18 studies. Sixteen studies evaluated an intervention, programme, or comparative movement condition, including physical education-based motor-competence programmes, structured physical activity, guided play, coordinative exercise, balance-bike training, resistance training, therapeutic exercise, sport-based activity, and injury-prevention programming. Two additional studies (Ivashchenko et al., 2019; Choudhary et al., 2024) did not evaluate training effects but were retained as complementary structured experimental assessment studies because they directly examined the regulation and reproduction of muscular effort, a motor-control process relevant to the broader interpretation of movement competence. These two studies were therefore interpreted separately from intervention-effect evidence and were not used to support claims concerning intervention effectiveness. The number of studies included in the core synthesis should consequently be understood as the set of studies retained through the structured narrative selection framework rather than as an exhaustive estimate of every eligible publication in the international literature. Because the study was conceived as a narrative review, a PRISMA-style numerical screening flow was neither generated nor retrospectively reconstructed.

Critical Appraisal of the Evidence

Because this manuscript was designed as a narrative rather than systematic review, a formal systematic risk-of-bias instrument was not used to generate study-level risk-of-bias judgments or an overall quantitative quality score. Nevertheless, methodological quality was explicitly considered during interpretation of the evidence. Each core study was examined in relation to study design, sample size, presence and nature of a comparator, randomized or non-randomized allocation where reported, duration of intervention or observation, baseline comparability where relevant, outcome measurement, follow-up, and the extent to which the design supported causal interpretation. Randomized and cluster-randomised studies were considered to provide stronger evidence for intervention effects than uncontrolled or non-randomized comparisons, whereas pilot studies, small samples, convenience sampling, intact-group allocation, baseline inequalities, lack of longer-term follow-up, and absence of an appropriate control condition were treated as factors requiring more cautious interpretation. For structured experimental assessment studies without an intervention, conclusions were restricted to the motor-control phenomenon directly assessed and were not interpreted as evidence of training effectiveness. The purpose of this appraisal was not to rank studies numerically but to prevent findings from methodologically different designs from being treated as equivalent. Methodological strengths and limitations were therefore integrated directly into the narrative synthesis and Discussion when evaluating consistency, causal interpretation, generalizability, and transfer of effects.

Narrative Synthesis Procedure

The evidence was synthesized through an iterative thematic and comparative narrative process. First, the 18 core studies were classified according to study design, population, movement or intervention characteristics, comparator, outcome domain, and direction of findings. Second, studies were organized into six evidence domains: (1) physical education-based motor-competence interventions; (2) structured play and gross-motor-development programmes; (3) coordinative exercise and cognitive-motor outcomes; (4) physical fitness and resistance-training interventions; (5) injury-prevention and paediatric rehabilitation contexts; and (6) complementary experimental evidence concerning strength-effort regulation.

Third, findings were compared within and across domains to identify convergence, inconsistency, and outcome specificity. Particular attention was given to whether an intervention improved only the directly practised outcome or whether evidence suggested transfer to broader motor, cognitive, physical-activity, or health-related outcomes. Fourth, differences in study design, intervention duration, frequency, comparator condition, participant characteristics, and assessment method were considered as possible explanations for divergent findings. No pooled effect estimate was calculated because the evidence was heterogeneous in population, study design, intervention content, duration, comparator, and measurement approach. The final synthesis therefore emphasized cross-study patterns, methodological interpretation, evidence of task specificity and transfer, unresolved inconsistencies, and implications for future physical education and paediatric exercise research.

Results

The core narrative synthesis comprised 18 studies that satisfied the structured selection framework described in Table 1. Sixteen studies evaluated structured interventions or comparative movement programmes, whereas two studies (Ivashchenko et al., 2019; Choudhary et al., 2024) used structured experimental assessment procedures to examine strength-effort regulation without implementing a training intervention. The latter were retained as complementary motor-control evidence and were interpreted separately from studies evaluating intervention effectiveness.

The intervention studies involved preschool children, school-aged children, adolescents, youth athletes, and a paediatric clinical population and included randomized controlled trials, cluster-randomized trials, pilot randomized trials, quasi-experimental studies, controlled repeated-measures studies, and pragmatic comparative designs. Intervention formats included physical education-based motor-competence programmes, structured movement activity, guided play, motor-skill programmes, balance-bike training, coordinative exercise, resistance training, therapeutic exercise, sport-based activity, and neuromuscular injury-prevention programmes. Table 2 summarizes the study designs, participants, intervention or experimental conditions, comparator conditions, principal quantitative findings, and direction of effects.

Critical Narrative Synthesis of Findings

The evidence was generally favourable toward structured movement-based programming, but the findings were neither uniform nor equally transferable across outcome domains. A central pattern was that the strongest effects tended to occur in abilities that were directly targeted by the intervention. Structured physical education and motor-skill programmes produced comparatively consistent improvements in motor competence and fundamental movement skills, whereas evidence for broader transfer to physical activity or cognitive outcomes was more variable. This distinction is important because improvement in a trained skill cannot automatically be interpreted as generalized improvement in motor development.

Physical education-based interventions provided some of the clearest evidence that intentionally structured instruction can improve motor competence. Mulvey et al. (2018), Palmer et al. (2019), Strotmeyer et al. (2021), and the studies by Navarro-Patón and colleagues generally demonstrated favourable changes following structured or specialist-led movement programmes. Nevertheless, the effects were domain-specific. Strotmeyer et al. (2021), for example, demonstrated an intervention advantage for object movement but not self-movement, whereas Palmer et al. (2019) reported substantial motor-skill gains without evidence that these gains translated into greater physical activity during subsequent outdoor free play. The evidence therefore supports structured instruction more strongly for skill acquisition than for generalized behavioural transfer.

Structured play and gross-motor-development programmes showed a similar pattern. Kojić et al. (2024), Mačak et al. (2022), Navarro-Patón et al. (2024), Ren et al. (2025), and Tortella et al. (2022) demonstrated that structured or targeted movement experiences can improve selected motor and fitness outcomes. However, Tortella et al. (2022) found improvement in playground-specific tasks without significant change in broader standardized motor-competence measures. This finding provides an important counterpoint to the generally favourable evidence and suggests that practising a specific movement environment may improve performance within that environment without necessarily producing generalized motor competence.

Evidence concerning cognitive-motor outcomes was less consistent than evidence concerning physical outcomes. Mulvey et al. (2018) reported improvement in executive-function performance alongside motor improvement, whereas Şendil et al. (2024) and Başarır et al. (2025) reported favourable changes in selected motor or physical outcomes without consistent improvement in inhibitory control. These contrasting findings suggest that motor complexity alone may not guarantee cognitive transfer. The cognitive demands embedded within an intervention, including decision-making, response inhibition, stimulus discrimination, and adaptation to changing information, may be important, although the available studies are insufficient to establish which programme characteristics are necessary to produce such transfer.

Fitness-oriented evidence also demonstrated outcome specificity. Daily physical activity and structured resistance training improved selected fitness measures, but improvements did not occur uniformly across every measured variable. Choudhary and Choudhary (2025), for example, reported favourable changes in several strength, power, speed, and fitness outcomes without significant changes in BMI or flexibility. These findings reinforce the principle that adaptations should be interpreted in relation to the stimulus actually provided rather than assuming that a general exercise programme will influence all dimensions of health or fitness equally.

The injury-prevention and therapeutic-exercise studies extended the relevance of movement-based programming beyond conventional physical education. Al Attar et al. (2023) reported substantially lower injury incidence following the FIFA 11+ Kids programme, whereas Joschtel et al. (2022) demonstrated improvements in locomotor and object-control skills following play-based therapeutic exercise in children with non-cystic fibrosis bronchiectasis. These findings support the potential value of structured movement in preventive and rehabilitative settings but should be interpreted within their population-specific contexts.

The two strength-effort studies made a different contribution. Ivashchenko et al. (2019) and Choudhary et al. (2024) did not test movement interventions and therefore do not provide evidence regarding programme effectiveness. Instead, they suggest that children's ability to reproduce muscular effort varies according to the relative force level being reproduced. Their contribution to the present synthesis is consequently mechanistic and contextual, supporting the broader proposition that motor competence includes

Table 2. Characteristics of the core intervention and experimental-assessment studies included in the critical narrative synthesis (n = 18)

Study	Study design/Sample	Intervention Dose	Comparator / Control	Key Quantitative Findings	Direction of Effect
Mulvey et al. (2018)	Randomized controlled trial (RCT); 107 preschool children (Mean age = 5.14 years); intervention n = 50, control n = 57	6 weeks; 30-min sessions, twice weekly; total dose = 360 min	Business-as-usual recess (30 min/day, 5 days/week)	Significant interaction for gross motor skills (TGMD-2): $F(1,95) = 58.49$, $p < .001$, $\eta p^2 = .38$; SKIP group improved significantly while control did not. Significant interaction for executive function (HTKS): $F(1,100) = 6.143$, $p = .015$, $\eta p^2 = .058$; SKIP group showed higher posttest scores. Significant interaction for motor skills by condition and sex: $F(1,95) = 12.25$, $p < .001$, $\eta p^2 = .11$	Positive effect on gross motor skills and executive function; no improvement observed in control group.
Ivashchenko et al. (2019)	Cross-sectional testing approach; This study analysed 86 boys: 22 aged 11 years, 31 aged 12 years, and 33 aged 13 years. Researchers used t-tests for paired observations to compare different effort levels and t-tests for independent samples to compare age group	Cross-sectional strength-effort assessment protocol. Participants first completed two attempts to determine right-hand maximum strength, with the best value recorded. They then reproduced dosed efforts at 1/3, 1/2, and 2/3 of maximum strength; reproduction error was calculated as a percentage.	Comparisons were made across age groups and within each age group across the three target effort levels.	Boys in all three age groups assessed effort most accurately at 2/3 of maximum strength, $p < .05$. No statistically significant age-group differences were observed for maximum hand strength or effort-assessment ability, $p > .05$. Among 13-year-olds, accuracy at 2/3 effort was 16.97% better than at 1/3 effort, $p = .001$. Correlations between reproduction accuracy at 1/3, 1/2, and 2/3 effort levels were not statistically significant.	Accuracy of strength-effort reproduction improved as the target effort increased from 1/3 to 2/3 of maximum strength. However, no clear age-related improvement was observed between 11 and 13 years.
Palmer et al. (2019)	Cluster randomized controlled trial; 102 preschoolers (mean age 4.4 years; 80% African American) from a single Head Start centre. Participants were assigned to an intervention group (n = 64) or a control group (n = 38).	5-week intervention (CHAMP) totalling 600 minutes. Sessions were held 3 days per week for 40 minutes each, including 32-35 minutes of autonomy-based motor skill engagement.	Outdoor free play (standard recess). Control children participated in their regular daily routine of 40-45 minutes of unstructured outdoor play.	Motor Skills: The CHAMP group significantly outperformed the control group at the late assessment in total motor skills ($p < 0.001$, $d = 2.7$). CHAMP children improved by 45 raw points compared to 9 points for the control group. Physical Activity (PA): There were no significant group differences in PA during outdoor free play. However, children in the CHAMP group significantly increased their MVPA during the intervention sessions over the 5-week period ($p = 0.003$).	Positive for fundamental motor skills (locomotor and ball skills) and Internal Positive for PA (improved PA behaviors occurred during the intervention but did not translate to outdoor recess settings).
Mačak et al. (2022)	Randomized controlled trial (RCT)	6-month intervention consisting of 45-minute organized physical activity sessions, 5 days per week. Activities focused on motor competence, muscle strengthening, and basic sport elements (gymnastics, athletics, soccer, etc.).	The control group (CG) followed their usual routine, which included 30-minute structured physical activity sessions 2 times per week.	The experimental group (EG) showed significantly greater improvements in grip strength (mean diff +1.70 kg vs. +1.08 kg in CG, $p < 0.01$) and sit-ups in 30s (mean diff +3.91 vs. +0.99 in CG, $p < 0.01$). Boys in the EG also saw significantly better results in the 4x10m shuttle run ($p < 0.01$) and standing long jump ($p = 0.04$) compared to the CG.	Positive (favourable) effect specifically on muscular strength and endurance. No significant differences between groups were found for cardiorespiratory fitness, speed-agility (in girls), or flexibility.

Table 2. Continued

Study	Study design/Sample	Intervention Dose	Comparator / Control	Key Quantitative Findings	Direction of Effect
Strotmeyer et al., (2021)	Longitudinal field study using a cluster-randomized design at the class level. The sample consisted of 200 children (58% girls, 42% boys) from third and fourth-grade classes with a mean age of 8.84 years.	The intervention consisted of 16 standardized units conducted once a week during regular physical education (PE) classes. Each unit lasted 45 minutes, with approximately 35 minutes of active time, and the program ran for roughly six months.	The comparison group (CG) participated in regular PE lessons instead of the structured intervention program.	The analysis of variance showed a significant interaction effect between time and group for object movement ($F(1,166)=7.52$;$p=0.007$; partial $\eta2=0.04$), indicating the intervention group improved more than the control. However, there was no significant interaction effect for self-movement ($F(1,166)=0.25$;$p=0.619$), as both groups improved over time. Additionally, a significant interaction between time and sex was found in self-movement ($p=0.014$), where boys improved more than girls regardless of their group assignment.	The intervention had a positive effect on basic motor competencies in object movement. There was no differential effect (intervention vs. regular PE) for self-movement.
Navarro-Patón, Martín-Ayala et al. (2021)	Quasi-experimental design with pre- and post-test.	6-week program consisting of one 40-minute session per week (totalling 270 minutes of intervention). Sessions were led by a physical education (PE) specialist and included a warm-up, tasks for specific motor skills (dexterity, aiming, balance), and a cool-down.	Followed the traditional PE curriculum for pre-school education in Spain, led by non-specialist teachers. Exact duration and frequency for the control group were not recorded.	Intervention Group (IG) Improvements: Statistically significant increases in manual dexterity ($d = 2.63$), aiming and catching ($d = 1.13$), balance ($d = 1.68$), total test score ($d = 3.30$), and total percentile score ($d = 1.88$). IG vs. Control Group (Post-test): Significant differences found in manual dexterity ($p = 0.015$), aiming and catching ($p = 0.003$), balance ($p = 0.050$), and total percentile score ($p < 0.001$).	Positive: The structured intervention led to significant improvements in all motor competence dimensions, moving participants from a clinical range (percentile <5) to a normal range of motor competence (percentile >16).
Navarro-Patón, Brito-Ballester et al. (2021)	Quasi-experimental pre-post-test design	A six-week program consisting of one 40-minute session per week, totaling 240 minutes. The sessions were taught by a Physical Education (PE) specialist and replaced regular PE classes.	A control group of 76 students who continued with their regular PE programming taught by generalist preschool teachers. Their curriculum focused on general aspects such as body image, play, and personal health rather than specific motor competence (MC) training.	Post-intervention, the experimental group showed significantly higher scores than the control group in aiming and catching ($p < 0.001$), balance ($p < 0.001$), total test score ($p < 0.001$; Cohen's $d = 0.88$), and total percentile score ($p < 0.001$; Cohen's $d = 0.91$). Within the experimental group, significant improvements were seen across all dimensions: manual dexterity ($d = 0.45$), aiming and catching ($d = 0.84$), and balance ($d = 0.51$).	Positive improvement; the brief, specialist-led intervention significantly increased the motor competence levels of preschool children compared to standard PE classes.

Table 2. Continued

Study	Study design/Sample	Intervention Dose	Comparator / Control	Key Quantitative Findings	Direction of Effect
Al Attar et al. (2023)	Clustered Randomized Controlled Trial (CRCT)	The FIFA 11+ Kids program was performed as a warm-up during training and matches at least twice a week for one season (6 months). Each session lasted 15 to 20 minutes and consisted of seven exercises focusing on balance, coordination, and core/extremity strength.	The control group continued their usual or standard warm-up regimen.	Total Injuries: 43 injuries in the experimental group (0.85 per 1000 hours) vs. 86 in the control group (2.01 per 1000 hours). • Injury Risk Ratio (IRR): 0.43 (95% CI, 0.29-0.61), indicating a 57% reduction in overall injuries. • Initial Injuries: Significantly lower in the experimental group (IRR 0.43; 95% CI, 0.30-0.63). • Mechanism: Significant reductions in contact (IRR 0.50), noncontact (IRR 0.39), and overuse (IRR 0.27) injuries. • Recurrent Injuries: No significant difference (P = 0.52; IRR 0.34).	Favours the intervention. The FIFA 11+ Kids program significantly reduced overall, initial, and lower extremity injury rates compared to usual warm-ups.
Joschtel et al. (2022)	Pilot randomized controlled trial involving 21 children with non-cystic fibrosis bronchiectasis . The participants had a median age of 6.8 years (IQR: 5.3-8.8)	A 7-week play-based therapeutic exercise program consisting of 7 weekly 60-minute supervised sessions . This was supplemented by a home-based program to be performed two days per week.	A wait-list control group (n = 10) that received the intervention after the post-program assessments were completed for the exercise group.	Fundamental Movement Skills (FMS): The exercise group showed significant improvements in locomotor skills (pre 29.0 ± 2.0 to post 35.2 ± 2.2, p = 0.01) and object control skills (pre 27.0 ± 2.0 to post 35.5 ± 2.2, p = 0.01) . Cardiovascular Fitness: The exercise group saw a 6 percentage point decline in heart rate change (%ΔHR) during a treadmill test, compared to a marginal 0.9 percentage point decline in the control group (effect size d = 0.5), though this was not statistically significant . Secondary Outcomes: No significant group by time interactions were found for perceived competence, PedsQL (Quality of Life), or PC-QoL-8 (cough-specific QoL).	.Significant positive effect on locomotor and object control skills . There was a moderate positive effect on cardiorespiratory fitness . There was no significant effect on perceived competence or health-related quality of life.
Staiano et al. (2022)	Randomized controlled trial (RCT) with 72 children (aged 3-5 years; mean age 4.0 ± 0.8). Participants were randomized 1:1 to either the Motor Skills app (n=35) or the Free Play app (n=37).	12-week mobile app-based intervention delivering 12 hours of instruction. The goal was 12 minutes per day, 5 days per week of structured motor skills activity.	Free Play app: Parents received lessons/videos promoting unstructured physical activity (not parent-guided) for the same duration (12 min/day, 5 days/week).	Children in the Motor Skills group significantly improved their total TGMD-3 percentile (+13.7 vs. -5.3 for control, P < .01). Significant improvements were also seen in locomotor skills (+15.5 vs. -4.8, P < .01) and ball skills (+8.3 vs. -7.3, P < .01). Improvements were sustained at 24-week follow-up.	Positive: The parent-led mHealth intervention significantly improved motor skill proficiency compared to the control group.

Table 2. Continued

Study	Study design/Sample	Intervention Dose	Comparator / Control	Key Quantitative Findings	Direction of Effect
Navarro-Patón et al. (2024)	Quasi-experimental pre-post-test design. Sample: 98 preschool children (3.86 ± 0.91 years)	9-week structured balance bike program. Dose: 3 sessions per week, 50 minutes per session.	Control Group (CG): 39 students who followed the standard physical education curriculum in Spain without balance bike training.	Pre-intervention: CG significantly outperformed the experimental group (EG) in manual dexterity (p<0.001), balance (p=0.003), total test score (p=0.001), and total percentile (p<0.001). Post-intervention: Significant differences between groups disappeared (e.g., balance p=0.219; total test score p=0.306). The EG showed significant internal improvements in balance (p<0.001), total test score (p=0.003), and total percentile (p=0.007).	Positive: The balance bike program significantly improved motor competence levels in preschoolers, regardless of gender, effectively closing the initial gap between the experimental and control groups.
Tortella et al. (2022)	pretest-post-test pragmatic comparison trial. The sample included 141 children aged 4-6 years from five kindergartens in Treviso, Italy. Participants were divided into three groups: a partly structured activity group (n=62), a free-play group (n=43), and a control group (n=36).	The intervention consisted of 10 weekly sessions, each lasting one hour, conducted in a specific outdoor playground. The partly structured group received 30 minutes of planned activity (scaffolded by instructors) and 30 minutes of free play per session. The free-play group engaged in 60 minutes of unstructured play only.	The control group did not attend the playground activities and continued with their normal kindergarten routine. The free-play group also served as a comparator to determine the added value of structured versus unstructured play.	No significant differences were found between the groups in general motor competence as measured by the Test of Motor Competence (TMC) (p ≥ 0.68) or the Movement Assessment Battery for Children (MABC-2) (p > 0.05). However, the partly structured activity group showed significant improvement in playground-specific tests (summarized playground and elastic platform scores) compared to both the free-play and control groups (p < 0.001).	Positive effect on task-specific balance skills (specifically on the equipment practiced) for the partly structured intervention group. The results showed a neutral effect (no significant change) regarding the transfer of these skills to broader, generalized motor competence batteries like the TMC and MABC-2.
Choudhary et al. (2024)	A descriptive design involving 75 sedentary girls. The participants were divided into three age groups: 10 years (n = 20-24*), 11 years (n = 25), and 12 years (n = 30).	No intervention was implemented. The study focused on evaluating baseline handgrip strength and the participants' ability to accurately reproduce efforts at 1/3, 1/2, and 2/3 of their maximum strength.	The study used comparative analysis between age groups (10 vs. 11, 10 vs. 12, and 11 vs. 12) and within-group comparisons between the three different strength effort levels.	No significant age-related differences were found in maximum hand strength (p > 0.70) or in the accuracy of effort assessment between groups (p > 0.05) . • The most accurate assessment for all groups occurred at 2/3 of maximum strength . • Significant differences in assessment accuracy were found between 1/3 and 1/2 effort (p ≤ 0.001) and between 1/3 and 2/3 effort (p = 0.000) for all ages.	Effort assessment precision improves as the percentage of maximum strength increases, with accuracy being highest at the 2/3 threshold . The ability to assess these efforts remains stable and consistent across the age range of 10 to 12 years.
Kojić et al. (2024)	Controlled two-group, repeated-measures experimental study. Sample of 53 preschool children (24 boys, 29 girls), mean age 6.22 ± 0.43 years.	6-month intervention, with sessions conducted 3 times per week for 35 minutes each.	Free play activity (FRP) group.	The SMA group showed significant improvements in obstacle course backwards (OCB; -24.75%, ES=1.29), plate tapping (PTT; +29.42%, ES=1.24), standing long jump (SLJ; +7.21%, ES=0.45), and shuttle run (SRT; -27.15%, ES=0.84). The FRP group improved significantly only in OCB (-2.88%, ES=0.47). ANCOVA showed significant group × time interactions favoring SMA for coordination, agility, and speed.	Positive (favouring SMA). Structured movement activities were significantly more effective than free play for developing motor coordination, agility, and speed of movement.

Table 2. Continued

Study	Study design/Sample	Intervention Dose	Comparator / Control	Key Quantitative Findings	Direction of Effect
Şendil et al., (2024)	A non-randomized study using convenience sampling consisting of 41 kindergarten children (27 boys and 14 girls) aged 5-6 years. Participants were divided into an exercise group (n = 18) and a control group (n = 23).	A structured coordinative exercise program focusing on locomotor and balance skills (e.g., side-stepping, jumping, running) for 30 minutes, 2 days a week, for 8 weeks.	The control group followed their normal kindergarten curriculum and did not receive the specific exercise intervention.	Mixed measures ANOVA revealed a significant group-by-time interaction effect for the exercise group in: • Static balance ($F(1\text{-}39) = 6.993$, $p = 0.012$). • KTK sideways jump ($F(1\text{-}39) = 6.443$, $p = 0.015$). • KTK eye-hand coordination ($F(1\text{-}39) = 8.180$, $p = 0.007$). No significant effect was found for inhibitory control ($p > 0.05$).	Positive effect on specific elements of physical fitness and motor competence; no significant effect on inhibitory control.
Choudhary & Choudhary, (2025)	Controlled quasi-experimental pre-post design using intact class allocation. The sample consisted of 99 healthy adolescents (52 boys and 47 girls) aged 13-16 years.	12-week program consisting of three 60-minute sessions per week on non-consecutive days. Training included bodyweight and circuit-based exercises (squats, lunges, push-ups, planks, and plyometric jumps) with progressive increases in sets, repetitions, and intensity (RPE 5 to 8).	The control group (CG) continued with the standard school physical education curriculum, which included two 40-minute sessions per week of callisthenics, aerobic games, and flexibility exercises, but no structured resistance training.	Significant Group × Time interactions were found for: • Standing Broad Jump: $\eta^2 = 0.26$ (Large effect), $p < 0.001$. • Sit-ups: $\eta^2 = 0.23$ (Large effect), $p < 0.001$. • Push-ups: $\eta^2 = 0.19$ (Large effect), $p < 0.001$. • 20-m Sprint: $\eta^2 = 0.14$ (Large effect), $p < 0.001$. • CMJ Height: $\eta^2 = 0.12$ (Medium effect), $p = 0.001$. • Flexibility and BMI: No significant changes ($p > 0.05$).	Improvement in the intervention group across multiple fitness domains, including muscular endurance, power, speed, coordination, and aerobic capacity, while the control group showed minimal or no changes.
Başarır et al. (2025)	Randomized experimental design involving 51 preschool children (27 boys, 24 girls) aged 5 to 6 years ($M = 6.03$) from a preschool in Turkey . The children were typically developing with no cardiovascular, neurological, or orthopedic illnesses.	An 8-week coordination-based training program consisting of two 25-minute sessions per week . The program used a game-based format focusing on basic movement patterns that progressed from simple to complex.	A control group (CG; n = 25) that continued their routine preschool activities and scheduled lessons without any additional coordination-based training.	The exercise group (EG) showed a significantly higher score increase than the CG in vertical jumping ($F(1{-}49) = 14.569$, $p < 0.001$) and KTK Balancing Backwards ($F(1{-}49) = 14.051$, $p < 0.001$) . Conversely, the CG showed a significantly higher score increase than the EG in KTK Moving Sideways ($F(1{-}49) = 9.984$, $p < 0.01$) . No statistically significant differences were found between groups for static balance, agility, jumping sideways, hand-eye coordination, or inhibition control (accuracy and response time).	The intervention had a positive effect on lower extremity strength and dynamic balance (as measured by KTK BB) in preschool children . However, it had a neutral effect on cognitive inhibition control, which authors suggest might be due to the low frequency of the intervention (2 days/week).

Table 2. Continued

Study	Study design/Sample	Intervention Dose	Comparator / Control	Key Quantitative Findings	Direction of Effect
Ren et al. (2025)	Three-group quasi-experimental pretest-posttest design. The sample included 45 children aged 3-6 years (15 per group) recruited from a training institution in Shenzhen, China.	12-week intervention consisting of sessions held twice weekly, each lasting 60 minutes.	This was a comparative study between three active groups: Roller Skating (RS), Basketball (BT), and Physical Training (PT). There was no no-intervention control group.	Total Gross Motor Score: Significant interaction effect ($F_{2,42}$=8.00, p=0.001, ηp^2=0.276). All groups improved (p<0.01), but BT and PT outperformed RS post-intervention (p<0.01). Locomotor Skills: Significant main effect of time ($F_{1,42}$=179.11, p<0.001), with all groups showing improvement. Object Control Skills: Significant interaction effect ($F_{2,42}$=11.89, p<0.001); BT and PT showed significantly greater gains than RS (p<0.01).	Positive effect across all groups for gross motor development. However, Basketball and Physical Training were associated with broader and more pronounced improvements in motor skills compared to Roller Skating.

Note- RCT = randomized controlled trial; CRCT = cluster randomized controlled trial; n = sample size/number of participants; PE = physical education; IG = intervention group; EG = experimental group; CG = control group/comparison group; PA = physical activity; MVPA = moderate-to-vigorous physical activity; FMS = fundamental movement skills; MC = motor competence; TGMD-2 = Test of Gross Motor Development, Second Edition; HTKS = Head-Toes-Knees-Shoulders task; CHAMP = Children's Health Activity Motor Program; FIFA 11+ Kids = Fédération Internationale de Football Association 11+ Kids injury-prevention programme; IRR = injury rate ratio/incidence rate ratio; CI = confidence interval; IQR = interquartile range; HR = heart rate; %ΔHR = percentage change in heart rate; PedsQL = Pediatric Quality of Life Inventory; PC-QoL-8 = Parent Cough-Specific Quality of Life Questionnaire, 8-item version; TMC = Test of Motor Competence; MABC-2 = Movement Assessment Battery for Children, Second Edition; KTK = Körperkoordinationstest für Kinder/Body Coordination Test for Children; KTK BB = KTK Balancing Backwards; OCB = obstacle course backwards; PTT = plate tapping test; SLJ = standing long jump; SRT = shuttle run test; SMA = structured movement activity; FRP = free play activity; RPE = rating of perceived exertion; CMJ = countermovement jump; BMI = body mass index; RS = roller skating; BT = basketball training; PT = physical training; ANOVA = analysis of variance; ANCOVA = analysis of covariance; F = F-statistic; p = probability value/statistical significance level; η^2 = eta squared; ηp^2 = partial eta squared; ES = effect size; d = Cohen's d; M = mean; SD = standard deviation.

regulation and grading of force as well as visible movement execution.

Taken collectively, the evidence suggests that structured movement experiences are generally more reliable for improving directly targeted outcomes than for producing broad developmental transfer. Differences in programme design, dose, progression, comparator condition, age group, measurement approach, and methodological strength appear to contribute to variation between studies. This pattern informed the critical interpretation developed in the Discussion.

Discussion

The principal finding of this critical narrative synthesis is not simply that movement-based interventions produce favourable outcomes, but that their effects appear to be governed by three interrelated characteristics: structure, specificity, and transfer. Across the included literature, intentionally organized and progressively delivered movement experiences generally produced more favourable outcomes than usual practice, free play, or less targeted comparison conditions. At the same time, the strongest effects were usually observed in outcomes closely aligned with the content of the intervention, whereas evidence that these gains generalized to broader motor competence, habitual physical activity, or cognitive functioning was substantially less consistent. This distinction provides a more cautious interpretation of the literature than a general conclusion that all forms of movement intervention are universally beneficial.

Structure: Guided Movement Appears More Reliable Than Exposure Alone

A recurring pattern across the evidence was the advantage of structured, developmentally appropriate movement experiences over less directed exposure. Physical education and motor-skill programmes involving deliberate practice, task progression, feedback, and targeted skill development repeatedly produced improvements in directly assessed motor outcomes (Mulvey et al., 2018; Navarro-Patón, Brito-Ballester, et al., 2021; Navarro-Patón, Martín-Ayala, et al., 2021; Palmer et al., 2019; Strotmeyer et al., 2021). Structured movement activity was also more effective than free play for several measures of coordination, agility, and speed in Kojić et al. (2024).

The implication is not that free play lacks developmental value, but that opportunity to move and systematic development of motor competence are not equivalent. Children may receive considerable physical activity exposure without repeatedly practising the specific movement patterns, control strategies, and progressive challenges needed to develop proficiency. From this perspective, the role of the physical educator is not merely to provide activity time but to organize movement experiences so that learners encounter appropriate challenge, repetition, variation, and feedback.

Specificity: Intervention Effects Closely Follow the Trained Stimulus

The second cross-study pattern was outcome specificity. The interventions were generally most successful for the physical or motor abilities explicitly addressed by programme content. Resistance training predominantly improved strength-, power-, and performance-related outcomes; balance-bike training improved selected dimensions of motor competence and balance; neuromuscular warm-up training reduced injury incidence; and therapeutic exercise improved specific locomotor and object-control abilities. Conversely, outcomes not directly targeted by the intervention were less consistently affected.

This principle is illustrated particularly clearly by findings in which some outcomes improved while others did not. Strotmeyer et al. (2021) observed differential effects for object movement and self-movement. Choudhary and Choudhary (2025) reported substantial improvements across several fitness measures but no significant changes in BMI or flexibility. Başarır et al. (2025) demonstrated improvements in selected jumping and dynamic-balance outcomes while several other coordination and inhibition outcomes remained unchanged. Such findings argue against describing movement interventions as producing a single generalized developmental effect. Instead, programme effectiveness should be interpreted in relation to the match between the intervention stimulus and the outcome being assessed. This has important implications for both research and practice: an intervention should first specify the developmental characteristic it intends to influence and then provide sufficient task exposure, progression, and measurement sensitivity to evaluate that characteristic.

Transfer: Improvement in Practised Skills

The third and perhaps most important finding concerns transfer. Several studies demonstrated substantial improvement in directly practised or closely related outcomes without equivalent improvement in broader or less directly trained domains. Tortella et al. (2022), for example, found improvements in playground-specific performance but not in generalized motor competence measured through broader test batteries. Palmer et al. (2019) demonstrated marked improvements in fundamental motor skills, yet the intervention did not produce corresponding between-group differences in physical activity during outdoor free play.

These results indicate that intervention success should be considered at different levels. The first is direct learning of the practised task. The second is near transfer to related but untrained motor abilities. The third is far transfer to broader outcomes such as habitual physical activity, generalized motor competence, executive function, participation, or long-term physical literacy. The present evidence provides comparatively strong support for direct task improvement and some evidence for near transfer, but substantially less consistent evidence for far transfer.

This distinction is important because movement competence is often discussed as a pathway toward broader physical activity and health outcomes. Although such developmental relationships are theoretically plausible and supported by broader literature, individual intervention studies cannot establish them merely by demonstrating improvement in a specific motor test. Future research should therefore assess transfer directly rather than infer it from improvements in trained skills.

Cognitive-Motor Benefits

The evidence concerning cognitive outcomes was particularly inconsistent. Mulvey et al. (2018) demonstrated an improvement in executive-function performance alongside motor-competence gains. In contrast, coordination-based interventions reported by Şendil et al. (2024) and Başarır et al. (2025) did not produce consistent improvements in inhibitory control despite improvements in selected motor or fitness outcomes.

These findings suggest that improving motor coordination does not automatically result in cognitive improvement. One possible explanation is that cognitive adaptation depends upon the cognitive demands embedded within the movement task. Activities requiring response selection, inhibition, anticipation, memory, perceptual discrimination, or adaptation to unpredictable information may provide a different stimulus from repetitive coordination activities even when both are physically demanding. Intervention frequency, duration, developmental stage, and sensitivity of cognitive assessment may also contribute to the inconsistent findings.

The present evidence is therefore insufficient to support broad claims that movement-based intervention improves executive functioning in general. A more defensible conclusion is that selected cognitively demanding movement programmes may influence specific cognitive outcomes, but the conditions necessary to produce reliable cognitive transfer remain uncertain.

Intervention Dose Cannot Be Interpreted Solely as Programme Duration

Considerable variation was evident in intervention duration and frequency. Some programmes lasted only several weeks, whereas others extended for several months. Importantly, longer programmes were not uniformly superior across all outcomes, and comparatively brief specialist-led interventions sometimes produced substantial improvements.

This suggests that intervention dose should not be conceptualized solely in terms of number of weeks or sessions. Active practice time, task repetitions, movement complexity, progression, instructional quality, feedback, participant engagement, and fidelity may all contribute to the effective dose received by participants. Two interventions of equal duration may therefore provide markedly different developmental stimuli.

The current evidence base does not permit identification of an optimal dose for motor-competence development. Future research should report the active components of interventions more precisely and directly compare alternative frequencies, durations, and progression strategies.

Methodological Differences Affect the Strength of the Evidence

The generally favourable direction of findings should also be considered in relation to methodological heterogeneity. The evidence base included randomized controlled trials, cluster-randomized designs, pilot trials, quasi-experimental studies, pragmatic comparisons, and structured experimental assessments. These designs do not provide equivalent levels of causal evidence. Randomized and cluster-randomized trials provide comparatively stronger protection against selection-related explanations than non-randomized designs. In contrast, several quasi-experimental studies used intact groups, convenience sampling, or populations with initial between-group differences. Navarro-Patón et al. (2024), for example, reported several significant baseline differences before the balance-bike intervention. The pilot trial by Joschtel et al. (2022) involved only 21 participants, making its findings important for feasibility and preliminary effect estimation but less suitable for broad generalization. Similarly, Ren et al. (2025) included only 15 participants in each of three active intervention groups and did not include a no-intervention control condition.

Outcome measurement was another source of heterogeneity. Some studies used established motor-development assessments, whereas others evaluated fitness tests, task-specific outcomes, cognitive tasks, or injury incidence. Consequently, apparent differences between programmes may reflect not only intervention effectiveness but also differences in what was measured and how closely the assessment corresponded to the intervention.

These methodological differences do not negate the positive findings, but they require caution when making generalized causal statements. The literature is more convincing in demonstrating that structured programmes can improve selected proximal outcomes than in establishing that such improvements persist over time or generalize across developmental domains.

Complementary Evidence on Strength-Effort Regulation

The experimental strength-effort studies should be interpreted separately from the intervention literature. Ivashchenko et al. (2019) and Choudhary et al. (2024) did not evaluate training programmes; accordingly, they cannot establish whether movement intervention improves motor competence. Their relevance lies instead in demonstrating that children must regulate and reproduce graded levels of muscular force and that accuracy appears to differ according to the relative effort required.

This evidence broadens the conceptual interpretation of motor competence by highlighting force regulation as a component of movement control. Effective performance in throwing, jumping, landing, pushing, pulling, balancing, and many sport-specific skills depends not only on producing force but on scaling force appropriately to the task. Strength-effort regulation therefore represents a potentially relevant but comparatively underexplored motor-control dimension. Future intervention research could determine whether this ability is trainable and whether improvements transfer to functional movement performance.

Original Conceptual Contribution: A Structure-Specificity-Transfer Perspective

The principal conceptual contribution emerging from this synthesis is a structure-specificity-transfer perspective for interpreting movement-based interventions. Structure refers to the recurring advantage of intentionally organized, progressive, and guided movement experiences over exposure alone. Specificity refers to the tendency for the strongest improvements to occur in outcomes closely aligned with the training stimulus. Transfer refers to the less consistent evidence that improvements extend beyond directly practised abilities to generalized motor competence, physical activity, cognition, or other distal developmental outcomes.

This perspective should not be interpreted as a formally validated theoretical model. Rather, it represents an evidence-informed interpretation generated through comparison of the included studies. Its value lies in preventing an overly broad conclusion that any structured movement intervention will automatically produce multidimensional developmental benefits.

The current evidence more strongly supports the proposition that appropriately structured programmes can improve specific targeted capabilities. Whether these improvements subsequently generalize depends on task variability, programme content, developmental characteristics, measurement approach, and potentially the duration and quality of exposure. Future research should therefore ask not only whether an intervention works, but what it improves, why it improves that outcome, whether the improvement transfers, and whether the effect persists after the intervention ends.

Practical Implications for Physical Education and Paediatric Exercise

The findings have direct implications for physical education teachers, coaches, paediatric exercise specialists, and rehabilitation professionals. First, motor competence should be treated as a central learning outcome within physical education rather than as an assumed by-product of general participation. Evidence from PE-based interventions indicates that children improve when they receive structured practice in locomotor, object-control, balance, coordination, and body-management tasks (Mulvey et al., 2018; Navarro-Patón, Martín-Ayala, et al., 2021; Palmer et al., 2019; Strotmeyer et al., 2021). These skills should therefore be systematically embedded within preschool and school PE curricula. Second, early screening and monitoring of motor competence should be strengthened. Children with low motor competence, developmental coordination difficulties, overweight, or low physical confidence may require adapted instruction and additional support. Tools such as the Movement Assessment Battery for Children-2 and related checklists have been widely used for identifying motor difficulties and monitoring developmental progress (Serbetar et al., 2019). Screening is especially important because developmental coordination disorder may affect school function, participation, physical activity, and psychosocial well-being (Wang et al., 2009). Third, physical education should combine structured instruction with play-based exploration. The evidence suggests that free play alone may not always produce broad motor development, whereas partly structured activity, balance-bike training, structured movement activities, and guided gross motor programmes can produce meaningful improvements (Kojić et al., 2024; Navarro-Patón et al., 2024; Ren et al., 2025; Tortella et al., 2022). Teachers should therefore design lessons that preserve enjoyment and autonomy while also ensuring progression, repetition, feedback, and skill variety. Fourth, coordination-based and cognitively enriched activities should be used more deliberately in PE lessons. Activities involving decision-making, response inhibition, sustained attention, perceptual discrimination, rhythm, spatial orientation, and rapid adjustment may support both motor and cognitive-motor development (Başarır et al., 2025; Şendil et al., 2024). This is particularly relevant for physical literacy, which includes physical, cognitive, affective, and social dimensions. Fifth, age-appropriate resistance training and neuromuscular exercises should be integrated into adolescent PE and after-school programmes. Choudhary & Choudhary (2025) showed that structured resistance training can improve muscular endurance, power, speed, aerobic capacity, balance, and coordination. Such programmes should emphasize technique, progression, supervision, bodyweight control, and safe exercise habits rather than maximal loading. Sixth, youth sport settings should include structured injury-prevention warm-ups. The FIFA 11+ Kids evidence suggests that neuromuscular warm-up programmes can reduce injury rates among child soccer players when implemented consistently (Al Attar et al., 2023). These programmes are practical because they can be integrated into regular training and match preparation without requiring complex equipment. Finally, paediatric rehabilitation and adapted PE programmes should use task-oriented and goal-directed movement activities. Evidence from DCD intervention research supports the value of motor-based, task-oriented, and participation-focused approaches (Smits-Engelsman et al., 2018; Thornton et al., 2016; J. J. Yu et al., 2018). For children with clinical conditions or motor delays, therapeutic exercise should be playful, functional, progressive, and connected to everyday movement participation.

Limitations

Several limitations should be considered when interpreting this narrative synthesis. First, although a structured search and explicit selection framework were used to increase transparency, the study was conceived as a narrative review and was not designed to provide exhaustive identification of all potentially eligible literature. Consequently, the 18 core studies should be understood as a deliberately selected contemporary evidence base rather than as a complete census of all studies in the field.

Second, the review was restricted to English-language and sufficiently accessible scholarly publications from 2018 onward. Relevant non-English, older, regional, or less accessible evidence may therefore not have been represented. The decision to emphasize contemporary literature improves the relevance of the synthesis to current physical education and paediatric exercise practice but limits historical comprehensiveness.

Third, considerable methodological and clinical heterogeneity existed across the core studies. Populations ranged from preschool children to adolescents, youth athletes, and a paediatric clinical population. Study designs included randomized, cluster-randomized, pilot, quasi-experimental, pragmatic, and structured assessment approaches. Intervention duration, frequency, instructional format, comparator conditions, and outcome measures also varied considerably. These differences limit direct comparison between studies.

Fourth, methodological quality was evaluated narratively rather than by means of a formal systematic risk-of-bias instrument. This approach was consistent with the narrative design of the review but does not provide domain-level risk-of-bias judgments comparable with those expected in a systematic review. The findings should therefore be interpreted as critical narrative integration rather than as evidence graded according to a formal certainty framework.

Fifth, several studies had methodological characteristics requiring cautious interpretation, including small samples, non-randomized allocation, convenience sampling, baseline between-group differences, limited information concerning long-term follow-up, and heterogeneous assessment procedures. Such limitations reduce the strength with which causal and generalized conclusions can be drawn.

Sixth, not all reported improvements represented broader transfer. Some interventions produced substantial changes in directly practised or task-specific outcomes without corresponding improvements in generalized motor competence, physical activity, or cognitive measures. Future studies should therefore distinguish direct training effects from near and far transfer.

Finally, two of the 18 core studies were structured experimental assessment studies rather than intervention trials. These studies were deliberately retained because they provided complementary information concerning strength-effort regulation as a motor-control process, but they were interpreted separately and should not be considered evidence of intervention effectiveness.

Future Research Directions

Future research should move beyond establishing whether movement-based programmes produce statistically significant pre-post improvements and focus more explicitly on intervention mechanisms, specificity, transfer, and sustainability. Larger and methodologically rigorous randomized and cluster-randomized trials are required, particularly in school-based settings. Studies should clearly report allocation procedures, participant flow, adherence, intervention fidelity, assessor procedures, and prespecified primary outcomes.

A major priority should be to distinguish directly trained improvement from broader transfer. Future studies should include outcomes representing the practised task, related but untrained motor abilities, and more distal outcomes such as habitual physical activity, participation, cognitive functioning, psychosocial well-being, or physical literacy. This would make it possible to determine whether interventions improve only what children practise or whether their effects generalize meaningfully beyond the intervention context.

Intervention dose also requires more precise investigation. Researchers should report not only programme duration and weekly frequency but also active practice time, movement repetitions, task complexity, progression, feedback, participant engagement, and instructor characteristics. Comparative studies examining different doses and instructional structures would help determine which programme components are responsible for observed improvements.

Greater consistency in assessment would also strengthen the field. Use of common, validated motor-competence outcome measures alongside intervention-specific assessments would make it easier to distinguish task learning from generalized developmental improvement and would facilitate future quantitative synthesis.

The inconsistent cognitive findings require particular attention. Future studies should describe the perceptual and cognitive demands embedded within movement programmes and determine whether activities involving decision-making, inhibition, anticipation, working memory, or stimulus-response adaptation produce different outcomes from predominantly repetitive coordination training.

Long-term follow-up should be incorporated wherever feasible to determine whether improvements persist after structured intervention ends. Future research should also include more diverse populations, particularly children with low motor competence, developmental coordination difficulties, disabilities, overweight or obesity, and clinical conditions.

Finally, the complementary findings concerning strength-effort regulation suggest a further research direction. Experimental intervention studies should determine whether force-regulation accuracy can be systematically trained and whether improvement in effort grading contributes to broader movement competence, sport skill, or functional motor performance.

Conclusions

This critical narrative synthesis indicates that structured movement-based interventions can improve motor competence and selected related outcomes in children and adolescents, but the available evidence does not support the assumption of a uniform effect across all developmental domains. The most consistent benefits were observed when activities were intentionally structured, progressively delivered, and closely aligned with the outcomes being assessed.

Cross-study comparison suggests three important principles. First, structured and guided movement experiences generally appear more reliable for targeted motor development than exposure or unstructured activity alone. Second, intervention effects are frequently specific to the abilities directly addressed by programme content. Third, transfer from practised skills to broader motor competence, habitual physical activity, or cognitive functioning is less consistent and should be demonstrated rather than assumed. These patterns support a structure-specificity-transfer perspective for interpreting movement-based programming. Although this perspective requires further empirical testing, it offers a more cautious explanation of why some programmes produce substantial improvements in selected outcomes while showing limited effects elsewhere. Methodological heterogeneity, variation in participant characteristics, mixed study designs, differences in assessment, and limited long-term follow-up restrict the strength of broad causal conclusions. The two experimental strength-effort studies additionally provide complementary rather than intervention-effect evidence and highlight force regulation as an underexplored aspect of motor control. For physical education teachers, coaches, and paediatric exercise professionals, the practical implication is that movement programmes should be designed around clearly defined developmental objectives and should incorporate appropriate structure, progression, variation, and feedback. Future research should determine not only whether movement programmes produce improvement, but whether those gains persist, generalize beyond the trained task, and ultimately contribute to broader physical literacy and sustained participation in physical activity.

Ethics Approval

Not applicable.

Informed Consent

Not applicable.

Data Availability Statement

Data are available from the corresponding author upon reasonable request.

AI Transparency Statement

The authors used Paperpal solely to improve the language, grammar, spelling, and readability of the manuscript. The scientific content, literature selection, data synthesis, interpretation of findings, and conclusions were developed and verified by the authors. The authors reviewed and approved the final manuscript and take full responsibility for its content.

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Conflicts of Interest

The authors declare no conflict of interest.

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Рухово-орієнтовані втручання та рухова компетентність у контексті фізичного виховання та рухової активності дітей і підлітків: наративний синтез експериментальних доказів

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 18 с., 2 табл., 36 джерел.

Мета. Рухова компетентність є фундаментальною складовою фізичного виховання, фізичної грамотності та тривалої участі у фізичній активності. У цьому критичному наративному синтезі проаналізовано сучасні експериментальні та інтервенційні дані щодо рухово-орієнтованих втручань у дітей і підлітків з акцентом на спрямованість, узгодженість, специфічність, переносимість ефектів та методологічні обмеження отриманих результатів.

Матеріали та методи. Для виявлення та критичного узагальнення літератури, опублікованої з 2018 року, застосовано структурований наративний огляд. Під час відбору досліджень враховували популяцію, дизайн, спрямованість втручання або експерименту, наявність групи порівняння, сферу оцінюваних результатів, контекст, мову та відповідність дослідницькому питанню. Основну доказову базу становили 18 досліджень: 16 інтервенційних або порівняльних досліджень і два структуровані експериментальні дослідження, присвячені регуляції м'язових зусиль як компоненту рухового контролю. Дані синтезували тематично з урахуванням методологічних переваг, обмежень, суперечностей і ефектів переносу.

Результати. Структуровані програми фізичного виховання та розвитку рухової компетентності загалом сприяли поліпшенню безпосередньо тренованих грубих рухових і фундаментальних рухових навичок. Структурована гра, тренування на баланс-велосипеді, програми фізичної активності та спортивно-орієнтовані заняття покращували окремі показники рухової підготовленості та фізичної працездатності, однак ці зміни не завжди переносилися на ширшу рухову компетентність. Координаційні втручання позитивно впливали на низку показників рівноваги, стрибкових здібностей і координації, тоді як результати щодо гальмівного контролю та інших когнітивних показників були неоднозначними. Силові тренування покращували окремі показники м'язової підготовленості та фізичної працездатності, терапевтичні вправи — окремі фундаментальні рухові навички у педіатричній клінічній популяції, а програма FIFA 11+ Kids знижувала загальну частоту травм на 57% (IRR = 0,43; 95% ДІ: 0,29–0,61). Дослідження регуляції м'язових зусиль також засвідчили, що точність відтворення зусилля може залежати від відносної величини відтворюваного зусилля.

Висновки. Сучасні дані підтверджують ефективність структурованого та відповідного віковому розвитку рухового досвіду для покращення рухової компетентності й окремих пов'язаних із нею показників у дітей і підлітків. Водночас ефекти часто мають специфічний характер, тому поліпшення безпосередньо тренованих здібностей не слід автоматично трактувати як перенесення на загальну рухову компетентність, фізичну активність або когнітивне функціонування. На величину спостережуваних ефектів, імовірно, впливають структура втручання, специфічність завдань, прогресування навантаження, характеристики учасників і методи оцінювання. У майбутніх дослідженнях необхідно чітко розмежовувати безпосередні тренувальні ефекти та ширший розвитковий перенос.

Ключові слова: рухова компетентність, фізичне виховання, рухово-орієнтоване втручання, фізичні вправи у педіатрії, фундаментальні рухові навички, фізична грамотність, наративний огляд, руховий розвиток.

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