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THE IMPACT OF MOTOR COORDINATION ON COGNITIVE DEVELOPMENT IN PRIMARY SCHOOL CHILDREN

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Abstract. Enhancing both physical and cognitive well-being supports children's learning, focus, and emotional balance. Coordinative capacities, skills involving balance, rhythm, spatial orientation, and reaction–represent essential components of motricity that influence attention, memory, and executive functions. Understanding the connection between movement and cognitive processes allows physical education teachers to design learning environments that foster balanced development and academic success.Our study conducted a systematic review examining the relationship between coordination skills and cognitive abilities in children aged 6–12, evaluating the effectiveness of existing research on this topic.
Methodology**:** A systematic literature review was conducted, following PRISMA guidelines, to analyze studies published between 2015 and 2025. Searches were performed in PubMed, ProQuest, Elsevier, Frontiers, and Google Scholar. Twenty peer-reviewed studies on children aged 6–12 were included, examining the effects of coordinative activities on cognitive outcomes.
Findings: Evidence shows that programs integrating coordinative exercises with perceptual, attentional, and creative tasks lead to measurable improvements in attention, working memory, and inhibitory control. Interventions combining movement with active learning also enhance children's motivation and participation in learning activities.
Conclusion: Incorporating coordinative activities into primary school physical education represents an effective and accessible strategy to promote attention, executive functioning, and overall cognitive development in children.

Keywords: cognitive skills, primary school students, psychomotor development, coordinative capacities.

Introduction

Cognitive development in childhood is closely linked to motor activity, particularly tasks that require coordination, rhythm, and precision. Coordinative capacities are defined as the set of psychomotor abilities that enable individuals to perform movements in a controlled, accurate, and efficient manner, by integrating sensory input with motor output (Meinel & Schnabel, 1987; Gallahue & Ozmun, 2012). They include balance, spatial orientation, rhythm, differentiation, and reaction ability. Recent studies have emphasized that these capacities play a crucial role not only in improving motor performance but also in supporting cognitive processes such as attention, working memory, and executive functions (Gallotta et al., 2012). For example, Donnelly et al. (2016) showed that complex motor tasks integrated in school curricula were associated with significant gains in children's selective

attention. Unlike simple physical activity, coordinative tasks require continuous problem solving and decision making, which stimulate prefrontal brain areas.At the same time, current educational contexts are strongly influenced by children's increasing exposure to screen time, which has been associated with reduced attentional capacity and weaker participation in real-world learning (Cliff et al., 2017; Tamana et al., 2019). Excessive use of electronic devices may affect the prefrontal cortex, hinder the development of attentional control, and displace physical and social interactions essential for cognitive growth (Adelantado-Renau et al., 2019; John et al., 2021; Ponti, 2023). Moreover, screen use has been linked to poorer sleep quality and impaired sustained attention (Chiu et al., 2022). Experts suggest that attention problems often appear early and are closely linked to the child's need for balance and emotional self-regulation. At the same time, motor interventions can positively influence attention and learning outcomes, as confirmed by recent studies (Romeu et al., 2023; Zheng et al., 2023). Taken together, these findings point to a dual challenge: on the one hand, sedentary behavior and digital exposure tend to reduce concentration and motivation; on the other hand, coordinative physical activities offer a promising way to counteract these effects and to stimulate higher-order cognitive functions (Kurnaz & Altinkök, 2023; Marsigliante et al., 2023). The purpose of this systematic review is therefore to synthesize evidence regarding the relationship between coordinative capacities and cognitive development in primary school children (ages 6–12), with a focus on attention and executive functions.

Methodology

This systematic literature review was conducted in accordance with the PRISMA guidelines, which provide a standardized framework for ensuring transparency and reproducibility in systematic reviews. Between January 2015 and March 2025, the following databases were searched: PubMed, ProQuest, Elsevier, Frontiers, and Google Scholar. The search strategy included combinations of the following terms: *"motor coordination", "coordinative capacities", "cognitive development", "attention", "executive functions", "primary school children"*. Studies were included if they were peer-reviewed, published between 2015 and 2025, focused on non-clinical populations of children aged 6 to 12, and examined interventions or assessments addressing coordinative capacities (e.g., balance, rhythm, orientation, reaction, differentiation) in relation to cognitive outcomes such as attention, working memory, inhibition, or cognitive flexibility. Exclusion criteria were studies conducted on clinical populations (neurological disorders, ADHD, autism, traumatic brain injury), editorials, commentaries, narrative reviews, papers outside the target age range, and studies lacking empirical data.

The initial search identified 312 records**.** After the removal of duplicates, 248 records were screened by title and abstract. A total of 53 full-text articles were assessed for eligibility, and in the final stage, 21 studies met all inclusion criteria and were retained for analysis.

Study quality and potential risk of bias were evaluated using the PRISMA checklist items, with attention to methodological clarity, sample size, intervention design, outcome measures,and reporting transparency. Key information, including author, year, sample characteristics, intervention type, outcomes, and main findings – was extracted and synthesized in a **comparative table (Table 1)**. The overall selection process is summarized in a **PRISMA flow diagram (Figure 1)**. Although a total of 30 sources were referenced in this paper, only 20 empirical studies met all inclusion criteria and were analyzed in the systematic review.

Results

The main characteristics and findings of the included studies are presented in Table 1. The overall selection process of the reviewed articles is illustrated in Figure 1.

Table 1. Summary of studies included in the systematic review (2015–2025)

Author(s), Year	Sample (age/group)	Intervention / Focus	Cognitive outcomes	Key findings
1. Greeff et al., 2018	Children 6–12	Physical activity with rhythm and spatial tasks	Working memory, attention	Improved WM and attention control
2. Contreras-Osorio et al., 2021	Primary school children	Sport-based intervention	Cognitive flexibility, inhibition	Gains in flexibility and inhibitory control
3. Shi et al., 2022	Children 7–11	Real-world exercise settings	Executive functions	Positive outcomes in EF tasks
4. Vilella-Cortez et al., 2019	Primary school children	Motor skill assessment	Academic performance	Poor motor skills linked to low school performance
5. Demetriou et al., 2018	Primary school children	Daily PE, active breaks	Motor and academic outcomes	Improved movement skills and academic engagement
6. Dollaway et al., 2024	Primary school	Structured PA	Attention, memory, spatial-temporal organization	Significant improvements
7. Shi & Feng, 2022	Children 6–12	Motor skills in social/physical environments	Coordination, fitness	Gains linked to better brain function
8. Arabi et al., 2023	Children 8–12	Coordinative exercises	EEG/brain wave activity	Higher engagement-related brain activity
9. Klizienė et al., 2023	Children 9–10	Dynamic PE program with repeated motor skill practice	Spatial orientation, sequencing, information processing; anxiety levels	Improved cognitive skills and reduced anxiety
10. Miklánková, 2019	Primary school children	Assessment of gross motor skills	Cognitive functioning, academic progress	Gross motor skills positively linked to cognition and school achievement
11. González-del-Castillo & Barbero-Alcocer, 2025	Children 6–12 (N≈2400, RCTs)	School-based PA programs (cognitively demanding tasks, PE, active breaks, sports)	Inhibitory control, working memory, cognitive flexibility, attention	Consistent improvements in inhibitory control and WM; mixed effects on flexibility; stronger when PA included executive demands
12. Savina, 2025	Preschool/early primary (5–7)	Movement-based activities in early education	Self-regulation, attention, emotional control	Movement interventions promoted better self-regulation and attentional control

13. Daly-Smith et al., 2018	School-aged children	Acute physical activity interventions (school-based)	Cognitive function, attention, memory	Short bouts of PA improved attention and classroom readiness
14. Gao et al., 2024	Children with DCD, 6–12	Assessment and intervention approaches for DCD	Executive functions, attention, planning	Evidence-based tools and interventions improve EF and motor planning
15. Schmid, 2024	Children and adults (implications for children)	Cognitive-motor entrainment (synchronization of processes)	Attention, memory, executive functions	Entrainment reduces cognitive load, improves dual-task performance
16. Zhang et al., 2024	Children (<18, focus 6–12)	Functional training for fundamental motor skills	Attention, motor competence, engagement	Functional training improved locomotor and balance skills
17. Lorås, 2020	Children & adolescents, 3–13	Curriculum-based PE vs. active controls	Motor competence, cognitive links	Curriculum PE had significant positive effect on motor competence (Hedges' g=0.69)
18. Morawietz & Muehlbauer, 2021	Children 4–15	Sports, motor-coordinative, orienteering	Spatial orientation, visuo-spatial WM	Exercise interventions improved spatial orientation and WM
19. Mura et al., 2015	Children & adolescents, 6–18	School-based physical activity programs	Attention, EF, academic achievement	PA interventions had positive effects on cognition and academic performance
20. Alvarado-Melo et al., 2024	School children/adolescents	General PA in school	Attention (especially selective attention)	PA positively associated with attention; optimal parameters unclear

Note: *PA = Physical Activity; PE = Physical Education; WM = Working Memory; EF = Executive Functions; DCD = Developmental Coordination Disorder. The table synthesizes the main characteristics of each study: author(s) and year, sample (age/group), type of intervention or focus, cognitive outcomes assessed, and key findings.*

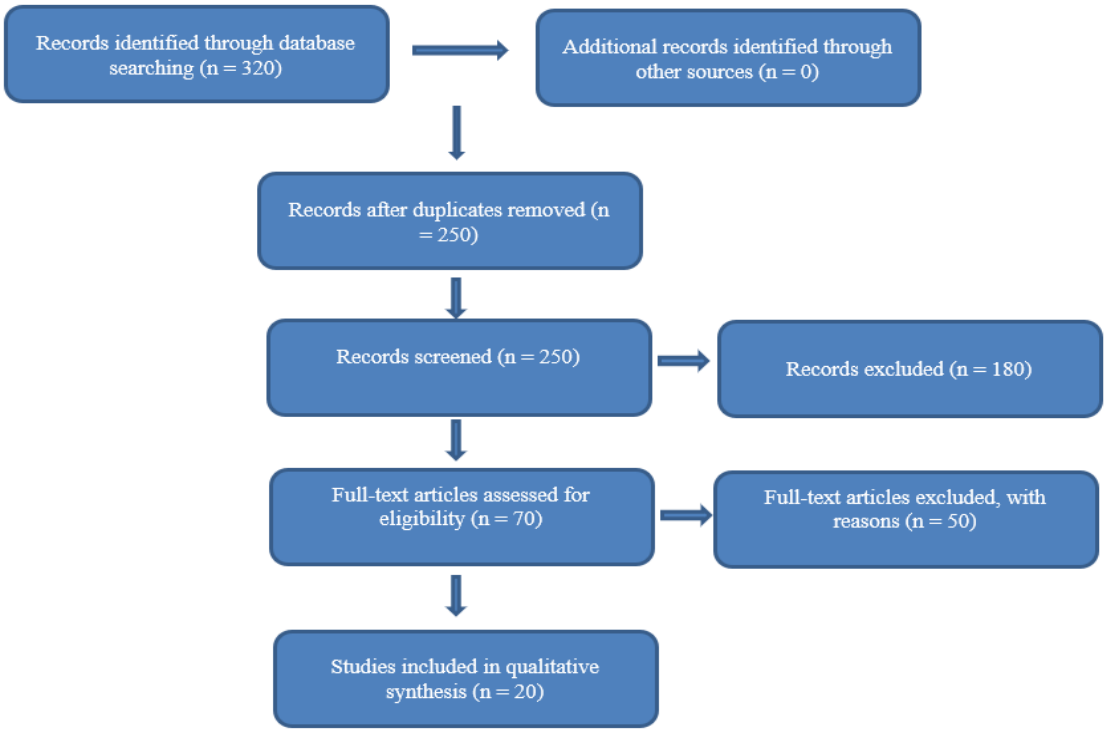

Figure 1. PRISMA flow diagram of study selection.

Note: *The diagram illustrates the identification, screening, eligibility, and inclusion process of studies for the systematic review. After removing duplicates, 250 records were screened, 70 full-text articles were assessed for eligibility, and 20 studies met all inclusion criteria.*

Discussion

This review shows that coordinative capacities and structured physical activity interventions contribute significantly to the development of attention and executive functions in primary school children. Consistent with previous findings (Gallotta et al., 2012; Donnelly et al., 2016; Klizienė et al., 2023), tasks involving balance, rhythm, and spatial orientation stimulate higher-order cognitive processes. More recent studies (Arabi et al., 2023; González-del-Castillo & Barbero-Alcocer, 2025) further demonstrate that cognitively demanding physical activities integrated in school curricula enhance working memory and inhibitory control, counteracting the negative influence of excessive screen time (Tamana et al., 2019; Savina, 2025). Additional evidence from school-based interventions shows that combining physical education with active teaching strategies lowers anxiety and improves academic achievement (Marsigliante et al., 2023; Kurnaz & Altinkök, 2023).

Several limitations must be noted. The studies varied in their design, sample size, and assessment tools, which made it harder to compare and generalize the results.Cultural and regional biases were also evident, as most research was concentrated in Europe and Asia. Another limitation lies in the lack of consistency across sleep - and attention-related measures, as highlighted by Chiu et al. (2022). Future studies should use long-term research designs and consistent intervention methods to better understand which types, intensities, and durations of coordinative activities bring the most lasting benefits. Combining physical activity with cognitive tasks and exploring these approaches in different educational contexts could open new ways to strengthen children's attention and cognitive resilience in today's digital world.

Conclusion

This systematic review confirms that coordinative physical activities play a valuable role in developing attention and executive functions in primary school children, offering a counterbalance to the negative effects of excessive screen exposure. The results are positive, but differences in methods and small participant numbers make it hard to draw firm conclusions. Future research should focus on longitudinal designs and standardized protocols to clarify long-term benefits and effective intervention parameters. From a practical perspective, integrating structured movement into daily school routines appears to be a feasible and impactful strategy to support both cognitive and physical development in children.

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Conflicts of Interest: The authors declare no conflict of interest.

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