



Effect of physical activity on kindergarten students' motor skills, emotional and cognitive development: a systematic review

Efecto de la actividad física en las habilidades motoras y en el desarrollo emocional y cognitivo de los estudiantes de educación preescolar: una revisión sistemática

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Abstract

Introduction: This study provides a comprehensive synthesis of the literature that critically explores the effect of physical activity programmes on developing motor skills, emotional well-being, and cognitive abilities in kindergarten.

Methodology: A comprehensive literature search was conducted using reputable, multidisciplinary academic databases, adhering to the PRISMA-P (Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols). Rigorous eligibility criteria were employed to ensure that the selected studies were relevant and of high quality. The review focused on physical activity-related outcomes in motor, emotional, and cognitive domains.

Results: From an initial pool of 978 articles, 14 studies met the inclusion criteria. Five studies explored the effects of physical activity on motor skills, four on emotional development, and two on cognitive development. One study examined motor skills and cognitive outcomes, while 2 addressed emotional and cognitive aspects.

Conclusions: The findings support the positive influence of diverse physical activity programmes on kindergarten children's motor, emotional, and cognitive development. These results reinforce the importance of incorporating physical activity as a core element within holistic early childhood education, rather than treating it as a supplementary component.

Keywords

Physical; kindergarten; motor skills; emotional; cognitive.

Resumen

Introducción: Este estudio ofrece una síntesis exhaustiva de la literatura que explora críticamente el efecto de los programas de actividad física en el desarrollo de las habilidades motoras, el bienestar emocional y las capacidades cognitivas en la educación preescolar.

Metodología: Se realizó una búsqueda exhaustiva de la literatura utilizando bases de datos académicas reconocidas y multidisciplinarias, siguiendo las directrices PRISMA-P (Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols). Se aplicaron rigurosos criterios de elegibilidad para garantizar que los estudios seleccionados fueran pertinentes y de alta calidad. La revisión se centró en los resultados relacionados con la actividad física en los ámbitos motor, emocional y cognitivo.

Resultados: De un total inicial de 978 artículos, 14 estudios cumplieron con los criterios de inclusión. Cinco estudios exploraron los efectos de la actividad física sobre las habilidades motoras, cuatro sobre el desarrollo emocional y dos sobre el desarrollo cognitivo. Un estudio examinó tanto las habilidades motoras como los resultados cognitivos, mientras que dos abordaron los aspectos emocionales y cognitivos.

Conclusiones: Los hallazgos respaldan la influencia positiva de diversos programas de actividad física en el desarrollo motor, emocional y cognitivo de los niños en edad preescolar. Estos resultados refuerzan la importancia de incorporar la actividad física como un elemento central dentro de una educación integral en la primera infancia, en lugar de considerarla un componente complementario.

Palabras clave

Físico; educación preescolar; habilidades motoras; emocional; cognitivo.

Introduction

Early childhood development is crucial in laying the foundation for an individual's future. This period is often called the "golden age", during which growth and development occur rapidly and simultaneously across motor, emotional, and cognitive domains (Havigerová et al., 2021; Solum et al., 2020). Learning processes and stimulation provided during this stage must be holistic, as each aspect of development interacts with and influences the others (Sugiyana et al., 2025; Aslanian et al., 2024; Lersilp et al., 2024). One form of stimulation that has been proven effective in supporting such development is physical activity. Through structured and purposeful bodily movement, children develop motor skills, strengthen emotional regulation, and enhance cognitive capacities, including attention and memory (Gandotra et al., 2023). Educators and parents must integrate physical activity into young children's daily routines as part of a comprehensive effort to support their overall development.

Physical activity is vital to children's growth and development, particularly in gross and fine motor skills. Children's participation in structured physical activities improves muscle coordination, balance, and fundamental movement skills (Kojić et al., 2024). Physical activity also contributes to developing attentional capacity, working memory, and cognitive flexibility, which are crucial for thinking processes and decision-making (Shi et al., 2022; Veraksa et al., 2021; Jalilvand & Samadi, 2020). Emotional dimensions such as self-control, emotional regulation, and social interaction are also gradually developed through children's active physical play with peers (Hamamcı & Balaban Dagal, 2022). Most existing research tends to be sectoral, focusing on a single developmental domain, and does not connect the motor, emotional, and cognitive domains. This results in a fragmented understanding of the impact of physical activity, without illustrating how these three aspects interact to support the child's holistic development.

Physical activity influences a child's development through environmental and individual interactions, as outlined in Bronfenbrenner's theory. Bronfenbrenner's ecological systems theory highlights that a child's development takes place within an environment of interacting systems, ranging from family and school to society (Tong & An, 2024). Physical activity in supportive contexts, like peer play, boosts motor skills and promotes social and emotional development through interaction (Merkel, 2013). Taylor & Boyer (2020) Cognitive development occurs through direct experiences, with structured activities enhancing skills via hands-on problem-solving. Shi & Feng (2022) Argued that cognitive development is shaped by social interaction and language, triggered through cooperative physical activities. Physical activities blending social and cognitive elements boost executive function and self-control, which are key to social and emotional development (Song et al., 2025; Pesce et al., 2021). Physical activity not only develops motor skills but also stimulates the social and cognitive dimensions, accelerating the integration of all three aspects.

Many previous studies have significantly contributed to explaining the relationship between physical activity and early childhood development. Gennari & Valentini, (2023); and Wood et al., (2020) demonstrated that physical activity positively enhances children's cognitive abilities, such as working memory and attention. Physical activity incorporating cognitive and social challenges can improve executive functioning and self-regulation (Kolovelonis et al., 2022). Children's engagement in structured physical activities can foster social skills, including cooperation and emotional control (Vazou et al., 2020; P. Wang et al., 2025). This research will contribute to a deeper understanding of the impact of physical activity on the holistic development of young children by integrating motor, emotional, and cognitive domains. It highlights its originality by analyzing studies from various countries, enriching insights into physical activity in diverse early childhood education contexts.

This study is designed to collect, critically evaluate, and synthesise empirical studies from various countries and early childhood education contexts through a systematic review approach. Physical activity shapes a child's motor, emotional, and cognitive development through environmental interactions, supporting school readiness and long-term success. According to Purssell & Gould (2021), the value of systematic review research lies in its approach, which combines thematic analysis with methodological quality appraisal of each study. Systematic reviews can identify research gaps and provide evidence-based recommendations for education practitioners in designing effective and impactful interventions (Banha et al., 2022; Cook et al., 2020). Therefore, the outcomes of this study will serve as a key reference for curriculum development, teacher training, and educational policies.

The findings of this study are expected to have significant implications for the advancement of early childhood education, particularly in promoting movement-based active learning strategies. Physical activity not only helps children release energy but also strengthens the integration of motor, emotional, and cognitive aspects, which are essential for school readiness and long-term success (Solanki & Solanki, 2024; St. Laurent et al., 2021; Vazou & Mavilidi, 2021). These results inform policymakers to develop holistic education programmes by incorporating physical activity into formal and informal curricula. Teacher training that highlights the value of active, movement-based methods is crucial, given teachers' central role in shaping supportive learning environments (Hidayat et al., 2024). This research fosters collaboration among educators, parents, and policymakers to build a more dynamic, healthy, and evidence-based early childhood education system.

Method

This study was developed using a systematic review approach, guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) as the primary methodological framework. PRISMA-P was selected because it provides a systematic, transparent, and replicable reporting standard, thereby enhancing the validity and reliability of scientific evidence synthesis (Kahrass et al., 2023). The PRISMA-P schematic flow in this study adopts the PRISMA 2020 flow diagram templates, which are distributed under the terms of the Creative Commons Attribution (CC BY 4.0) licence (Page et al., 2021). This allows others to distribute, remix, adapt, and build upon this work for commercial purposes, provided that the original work is appropriately cited.

The PRISMA-P ensures transparency and consistency at each stage, from identification to data synthesis. This approach produces findings that provide a solid foundation for evidence-based policymaking in early childhood education. This review presents a narrative synthesis without effect sizes or measures of heterogeneity. This approach is adopted due to significant heterogeneity in the study designs, interventions, and outcomes reported in the reviewed articles. As an alternative, we provide a descriptive quantitative synthesis to systematically outline the key findings, despite the notable variations across the studies.

Operational Definition

Operational definitions specify how the variables under investigation are measured and applied within the research context. The subsequent section presents a detailed explanation of these operational definitions.

Physical activity: Refers to any bodily movement produced by skeletal muscles that results in an increase in energy expenditure above resting levels. Physical activity can be carried out through running, jumping, dancing, active play, and light sports commonly used by young children in educational and everyday contexts (Maćak et al., 2022). Physical activity is viewed not merely as a form of recreation but also as a developmental stimulus that positively influences various aspects of child growth. Structured and enjoyable physical activities have been shown to enhance physical endurance, improve social skills, and support academic readiness in early childhood (Jones et al., 2021).

Motor skills: Refer to a child's ability to control bodily movements by coordinating the nervous and muscular systems. These skills are generally divided into two main categories: gross and fine motor skills. Gross motor skills involve activities such as running, jumping, kicking, and climbing, which require the coordination of large muscle groups and overall body balance. In contrast, fine motor skills involve small, precise movements, such as threading beads, drawing, and using writing tools, all of which are essential for academic readiness. Motor development is influenced by environmental stimulation and a child's participation in activities that involve object manipulation or physical movement (Karimi et al., 2025). Therefore, understanding and measuring this aspect is crucial for evaluating the effectiveness of movement-based programmes in early childhood education.

Emotional: Refers to a child's capacity to recognise, express, and manage emotions, both individually and within social interactions. Emotions, including empathy, impulse control, and the ability to establish healthy social relationships, all play a vital role in a child's adjustment to the learning environment (Ha-

rrington et al., 2020). Developing emotional skills during early childhood is fundamental for future mental health and social success (Rafiyya et al., 2024). In early childhood education, physical activities are often conducted in groups or social settings, such as team games or interactive role-play. These activities offer children opportunities to learn about turn-taking, sharing, and conflict resolution, thereby enhancing their social-emotional competence.

Cognitive: Refers to a set of mental functions that enable children to acquire, store, process, and utilise information within learning and social interaction contexts. The key cognitive components include attention, working memory, logical reasoning, and executive functions such as planning, decision-making, and impulse control (Fry et al., 2020). Mentally challenging physical activities, such as strategy-based games or sequenced movements, have been scientifically shown to enhance cognitive functions, particularly in concentration and mental flexibility (Mao et al., 2024). Furthermore, the active participation of young children in physical learning activities can promote neuroplasticity and strengthen neural connections that support thinking and learning processes.

Information Sources

The literature search in this study was conducted systematically, utilising a range of reputable and multidisciplinary scholarly electronic databases. The sources consulted include Scopus, the Education Resources Information Center (ERIC), Medline, PsycInfo, PubMed, Google Scholar, SportDiscus, Web of Science, as well as EMBASE and CINAHL. EMBASE provides a comprehensive collection of biomedical and pharmacological literature, covering clinical and health-related research. CINAHL delivers an extensive database for nursing and allied health literature, broadening the scope of studies relevant to health interventions. Each of these databases provides peer-reviewed scholarly articles, thereby ensuring the reliability and relevance of the sources used in this review. The search and documentation process followed the principles of transparency and scientific reproducibility, as outlined by PRISMA-P. This approach ensured validity and accountability in identifying literature for further analysis.

Search terms

The literature search strategy in this study was conducted systematically using the Boolean operators "AND" and "OR". This approach efficiently broadened or narrowed the search results to align with the review's focus. This combination was designed to identify articles relevant to the impact of physical activity on early childhood development, particularly within the motor, emotional, and cognitive domains. The keywords used were grouped into the following categories:

1. Physical activity: health activity, exercise, outdoor free play, physical education, physical games, play activity, and training;
2. Motor skills: fine motor skills, gross motor, motor, motor ability, motor coordination, motor competency, motor performance, motor development, motor fitness, motor skills, motoric, and locomotor skills;
3. Emotional aspects: emotional, emotional adjustment, emotional behaviour, emotional development, emotion, mental development, mental health, self-regulation, social-emotional, and well-being;
4. Cognitive: academic aspects, academic attainment, academic achievement, mental, cognitive functions, cognitive performance, cognitive skills, cognition, intelligence, IQ, learning, memory, thinking skills, and working memory;
5. Population characteristics: children, childhood, preschool, kindergarten, students, and 4–6 years.

All keyword combinations were strategically applied across various electronic databases to ensure comprehensive and relevant coverage of the literature that aligns with the study's objectives. Here is a word cloud highlighting key terms from a bibliometric analysis related to research topics.

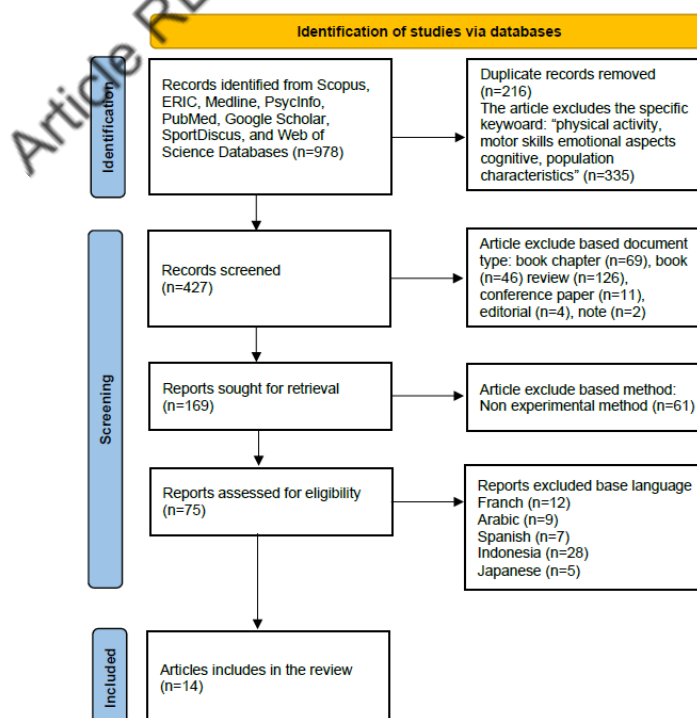
Figure 1. Word cloud



Study Organization

The study organisation in this review followed a systematic process using the PRISMA-P protocol, which comprises the stages of identification, screening, eligibility assessment, and final inclusion. The initial search yielded 978 articles from databases including Scopus, ERIC, Medline, PsycInfo, PubMed, Google Scholar, SportDiscus, and Web of Science. After removing duplicates, 427 unique articles were screened based on titles and abstracts. At this stage, 90 articles were excluded because they did not meet the initial criteria, such as not being original research or lacking a complete abstract. A total of 75 articles proceeded to full-text review, of which 61 were subsequently excluded because they provided only abstracts without complete research data. Ultimately, 14 articles that met all eligibility criteria and were retrieved using relevant keywords were included in this systematic review for analysis. The selection process under PRISMA-P ensures that only studies with high relevance and strong methodological design are considered. It also guarantees that studies with sufficient data completeness form the basis for literature synthesis.

Figure 2. PRISMA-P schematic flow



Data Extraction

The data extraction process is carried out using a standardized data extraction form, which has been prepared to collect relevant information from each included study. The data extraction process in this study was carried out by three independent reviewers, HS, FH, and MH, following systematic guidelines to ensure that the findings were objective and replicable. Each reviewer conducted an in-depth reading of the articles that had passed the complete text screening stage and recorded key information based on three main categories. First, data were collected on the year of publication and the country where the study was conducted, aiming to identify the geographical and temporal distribution of relevant research. Second, methodological information was recorded, including the study design, experimental context, participant characteristics, study duration, type of physical activity employed, and the measurement tools and outcome indicators. The third category of extracted data comprised the key findings related to the effectiveness and potential of physical activity interventions in supporting early childhood development across three main domains: motor, emotional, and cognitive.

To ensure consistency and accuracy in data extraction, each evaluator works with the established standard guidelines. In the event of differing opinions regarding data interpretation or coding, evaluators will engage in a discussion to reach a consensus. Any disagreements will be addressed and resolved in an open discussion, ensuring alignment in data assessment. If consensus cannot be reached after the discussion, a third evaluator (MH) will be asked to provide a final decision on the disputed aspect. The third evaluator will assess the issue and offer the interpretation deemed most appropriate based on the agreed-upon data extraction guidelines. This procedure also aims to ensure a high level of inter-rater reliability, ensuring that the extracted data is trustworthy and can be replicated in other studies.

Eligibility Criteria

The eligibility criteria used in the study selection process were defined rigorously to ensure the relevance and quality of the findings to be synthesised. Studies included in the review were required to meet five primary criteria: (1) they must be scholarly publications in English, published between January 2020 and June 2025, and classified as empirical research; (2) the study population must consist of children aged 3 to 7 years who are developing typically, without indications of developmental disorders; (3) participants must be in good physical health, with no medical history that could affect research outcomes; (4) the study must employ a quantitative approach with standardised measurements to assess the impact of physical activity on the developmental domains under investigation; and (5) the research design must be a Randomised Controlled Trial (RCT). Paparini et al., (2020) RCT is widely recognized as the most robust experimental method for evaluating the effectiveness of interventions. The search was restricted to studies published between 2020 and 2025 to ensure the findings reflect the most recent advancements in child development and physical activity. This time frame also helps to account for recent changes in research methodologies, public health policies, and evolving standards in the field.

Non-RCT studies, including cohort, cross-sectional, and qualitative studies, were excluded due to their higher risk of bias, such as selection bias and confounding, affecting the accuracy (Sarri et al., 2022). By limiting this review to RCT studies, we enhance the reliability of the findings. This approach provides stronger evidence on the impact of physical activity on the motor, emotional, and cognitive development of young children. To assess the methodological quality of the studies included, we applied the Cochrane Risk of Bias Tool and the JBI Critical Appraisal Checklist. These tools were used to evaluate the potential risk of bias that could influence the research outcomes and ensure a robust assessment of study quality.

Table 1. Analysis of research design quality criteria

Articles	Control	Pre-Post	Missing Data	Power Analysis	Validity	Effective
(Battaglia et al., 2020)	+	+	+	+	+	Y
(Cheraghi et al., 2022)	+	+	+	+	+	Y
(Esonova, 2025)	+	+	+	+	+	Y
(Fu et al., 2022)	+	+	+	+	+	Y
(Jaksic et al., 2020)	+	+	-	-	+	Y
(Jia et al., 2021)	+	+	-	+	+	Y/N
(Kojić et al., 2024)	+	+	+	+	+	Y
(Rajan & Aker, 2024)	+	+	-	-	+	Y
(San et al., 2021)	+	+	+	+	+	Y
(Sutapa et al., 2021)	+	+	+	+	+	Y
(C. Wang, 2022)	+	+	-	-	+	Y/N



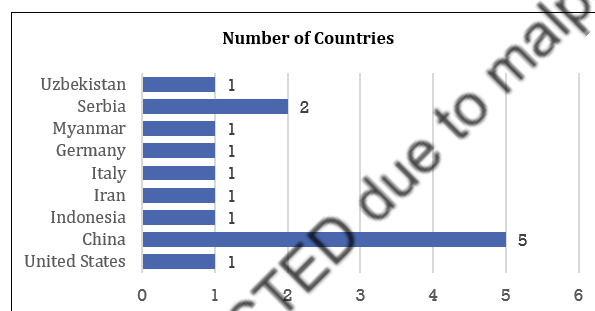
(Wick et al., 2021)	+	+	+	+	+	Y
(Wu et al., 2024)	+	+	+	+	+	Y
(Zhang et al., 2024)	+	+	-	+	+	Y

Note: The symbol "+" denotes a positive outcome (clearly stated and described in detail); "-" indicates an unfavorable outcome (poorly explained or missing); "Y" signifies a statistically significant positive effect; "N" reflects no statistically significant effect; and "+/N" indicates that meaningful improvements were observed in specific measures, while other measures showed no notable change.

Results

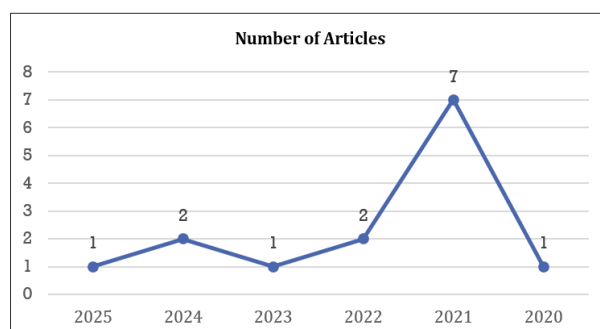
A systematic review, following the PRISMA-P approach, was conducted on articles published in Scopus, ERIC, Medline, PsycINFO, PubMed, Google Scholar, SportDiscus, and Web of Science databases. Fourteen articles were selected and deemed eligible for inclusion in this systematic review. Five studies examined the impact of physical activity on the development of motor skills. Four examined the impact on emotional development. Two studies explored the effect on cognitive development. One study investigated the impact on both motor skills and mental development, while two addressed the effect on both emotional and cognitive development. Regarding geographical distribution, the studies were conducted in the following countries: one in the United States, five in China, one in Indonesia, one in Iran, one in Italy, one in Germany, one in Myanmar, two in Serbia, and one in Uzbekistan. These findings underscore the increasing global recognition of the significance of physical activity in early childhood development.

Figure 3. Article by country or region



Among the selected research articles, twelve were conducted in school settings, one in a laboratory, and one in a childcare centre. In terms of publication year, the articles included in this review were limited to those published in 2025, comprising one article, two from 2024, one from 2023, two from 2022, seven from 2021, and two from 2020. The sample sizes across the studies varied considerably, ranging from 20 to 1,054 children aged between 3 and 7 years. The duration of the interventions spanned from 10 weeks to 12 months. This illustrates the countries that have contributed to research on physical activity, motor skills, emotional, and cognitive development.

Figure 4. Year-by-year documents



The intervention groups consisted of classes that received physical activity training programmes. The control groups included comparison classes that followed the regular curriculum without additional

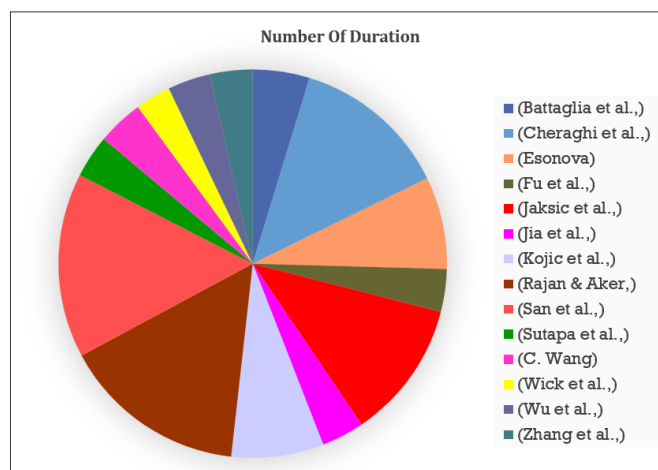
physical activity interventions. The data obtained from these studies were highly heterogeneous, requiring careful analysis throughout the systematic review process to ensure accuracy and reliability.

Table 2. Overview of article review results

Author	Objective	Sample	Years	Results
(Battaglia et al., 2020)	Determine a physical education program on motor skill and cognitive development.	N=1054	2020	16-week physical education program enhances motor skills and cognitive learning.
(Cheraghi et al., 2022)	Determine age-appropriate play activities to promote motor development.	N=160	2022	10 months of age-appropriate play in childhood supports motor development.
(Esonova, 2025)	The profound impact of play-based learning on social-emotional development.	N=120	2025	6-month play-based learning support for social-emotional development.
(Fu et al., 2022)	Determine the efficacy of a training program on motor development in children.	N=101	2022	12-week functional training effectively enhanced gross motor skills.
(Jaksic et al., 2020)	Investigate the effects of a physical activity intervention on motor and cognitive skills.	N=132	2020	9 months of physical activity improved motor skills, but no robust evidence related to cognitive skills.
(Jia et al., 2021)	Investigated the effects of diverse exercise on cognition and mental health.	N=20	2021	12-week diverse exercise has a significantly beneficial role in promoting cognitive and mental health development.
(Kojić et al., 2024)	Investigate the impact of a specific structured movement activity on motor fitness.	N=53	2024	6-month structured movement program specifically designed to develop motor fitness.
(Rajan & Aker, 2024)	Examined the impact of an in-school dance on the social-emotional development.	N=69	2024	12 months in school was to support preschoolers' ability to integrate and build social-emotional skills.
(San et al., 2021)	Support the social and emotional development of preschool children using play.	N=90	2021	12 months of play affect preschool children's social and emotional development.
(Sutapa et al., 2021)	Determine that goal-oriented play activity in early childhood improves motor skills.	N=40	2021	Training activities conducted over 12 weeks yielded significant improvements in motor skills areas.
(C. Wang, 2022)	To determine the role of physical education in cognitive and social-emotional development.	N=366	2022	3 months of physical education significantly improves cognitive development, but not statistically significantly on social-emotional behavior.
(Wick et al., 2021)	Examined the effects of an integrative strength-dominant exercise program on cognitive performance.	N=54	2021	10-week strength-dominated exercise program increased cognitive performance.
(Wu et al., 2024)	Effects of Physical Exercise on Emotional Development	N=239	2024	12 weeks of physical exercise significantly improve emotion management skills and reduce anxiety.
(Zhang et al., 2024)	Investigate the impact of recreational gymnastics on executive function and its role in managing high cognitive conflict.	N=63	2024	Children who participated in the 12-week intervention had an enhanced ability to manage high cognitive conflict.

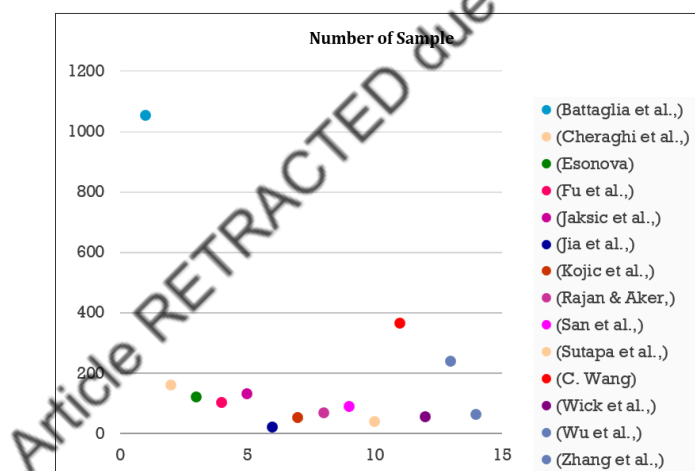
A subgroup analysis was conducted to enhance understanding of the impact of physical activity on the motor, emotional, and cognitive development of young children. This analysis considered variables such as intervention duration, sample size, type of physical activity, and measurement tools used. Regarding the duration of the intervention, most of the studies analysed had varying durations, ranging from 3 months (Wang, 2022) to 12 months (San et al., 2021), allowing for the examination of both short-term and long-term effects of physical activity programmes. Below is a diagram illustrating the duration of the intervention in the selected research articles.

Figure 5. Number of Duration Intervention



The analysis based on sample size indicates that studies with larger samples such as the one conducted by Battaglia et al., (2020) With 1,054 participants, it tends to produce more robust and generalisable findings compared to studies with smaller samples, such as the one by Jia et al., (2021) with only 20 participants. Below is a diagram illustrating the sample sizes among the selected research articles.

Figure 6. Number of Samople



The variation in types of physical activities implemented, ranging from structured physical education Battaglia et al., (2020) to play-based activities (Esonova, 2025; San et al., 2021), can impact motor and emotional development outcomes in different ways. The type of measurement tools used, such as the Test of Gross Motor Development Kojić et al., (2024) or the Social-Emotional Competence Scale Wu et al., (2024) It also plays a crucial role in the validity and reliability of the findings. This subgroup analysis suggests that these factors should be considered to assess the effectiveness of interventions more comprehensively. It also helps identify the conditions most conducive to the success of physical activity in supporting early childhood development.

In this study, the results of the systematic review are presented in a descriptive manner. This approach was chosen due to the significant heterogeneity in methodology, research design, and physical intervention characteristics across the analysed studies. Quantitative synthesis, such as calculating mean differences or Cohen's d, could not be directly applied in this review. This is due to the marked variation in sample sizes, measurement instruments used, and the type and intensity of physical interventions applied in each study. Some studies did not provide sufficient data for advanced statistical analysis or only

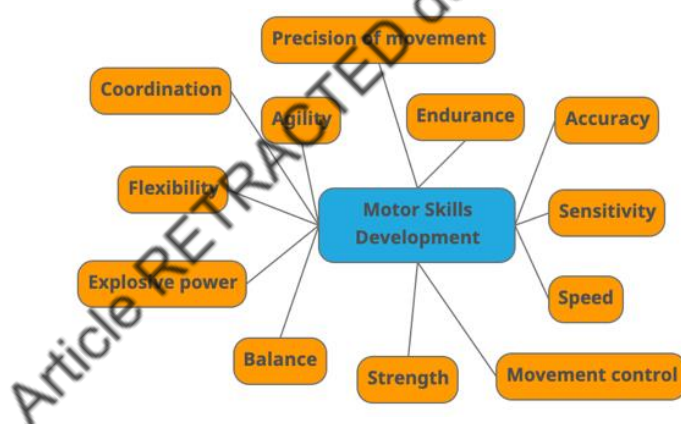
presented findings in a qualitative form, making it difficult to perform quantitative comparisons between the intervention and control groups. As a solution, this study presents the available findings in descriptive reports. The aim is to provide a more comprehensive understanding of the impact of physical activity on the motor, emotional, and cognitive development of young children. Nevertheless, quantitative synthesis may be a more suitable approach for future research. This would be particularly effective with more uniform and standardised data, allowing for measurable and comprehensive comparisons.

Effect of Physical Activity on Motor Skills Development

Kojić et al. (2024) found that all variables related to motor skills development showed significant improvement. The specific variable of strength, measured using the standing long jump, showed that the control group demonstrated greater improvement than the intervention group. Similarly, the study by Jaksic et al. (2020) the study reported that motor skills variables, such as speed, agility, coordination, and balance, all improved significantly in the intervention group compared to the control group. An improvement in strength was positive, but it was not statistically significant when compared with the control group.

In the studies by (Fu et al., 2022; Sutapa et al., 2021; Battaglia et al., 2020) All motor skills development variables, including both gross and fine motor skills, showed positive and statistically significant improvements in the intervention groups. All researchers in this study acknowledged that their respective investigations involved varying complexity and unique contextual factors. Consequently, they noted that the findings remain incomplete and that further, more rigorous research is necessary to strengthen the evidence base in the future. Here is the mind map of the dominant elements considered most important in the development of variable motor skills in kindergarten students that we identified during this study.

Figure 7. Network analysis of motor skills development in kindergarten students



The instruments employed to measure motor skills in young children included the Test of Gross Motor Development (TGMD), Ages and Stages Questionnaire – Third Edition (ASQ-3), Test of Gross Motor Development – Second Edition (TGMD-2), Flamingo Balance Test (FLA), Standing Long Jump (SLJ), Plate Tapping Test (PTT), Obstacle Course Backwards (OCB), Shuttle Run Test 4 × 5 m (SRT), and Gross Motor Skill Test (GMST). Each of these tests has distinct characteristics, yet all share the common objective of evaluating motor skills development. The components assessed include strength, speed, endurance, agility, balance, coordination, explosive power, flexibility, hand-eye coordination, movement control, fluency, precision, and movement accuracy. Since the study participants were young children, researchers conducted the assessments carefully to ensure accuracy, comfort, and safety.

Effect of Physical Activity on Emotional Development

The findings of Esonova (2025) indicate that kindergarten students' emotional development, including emotional regulation, social skills, empathy, and self-confidence, showed positive and statistically significant improvements in the intervention group. These improvements were greater than those observed in the control group. This contrasts with the results of (Rajan & Aker, 2024), who reported that empathy

and social support improved significantly in the intervention group relative to the control group. In contrast, although improved, self-expression did not differ significantly from the control group.

In the study by San et al. (2021) Variables such as interest, joy, initiative, fear, and anger demonstrated significant positive changes in the intervention group. In contrast, dependency showed an increase that was not statistically significant when compared with the control group. Furthermore, Wu et al. (2024) found that, in the intervention group, anger, aggression, and anxious withdrawal significantly improved from pre-test to post-test, while social competence did not change significantly. A particularly unique result was observed in the study by Jia et al. (2021), which reported no measurable improvement in emotional development in either the intervention or control groups. Only cognitive development showed a positive effect in that study. Here is the mind map of the dominant elements identified as most important in the variable cognitive development in kindergarten students that we discovered during this study.

Figure 8. Network analysis of emotional development in kindergarten students'



Emotional development was assessed using a variety of instruments, including the Social-Emotional Competence Scale (SECS) and the Desired Results Developmental Profile (DRDP). Other tools used included the Preschoolers' Social and Emotional Development Scale, Ages & Stages Questionnaires: Social-Emotional (ASQ: SE), Positive and Negative Affect Schedule for Children (PANAS-C), and the Strengths and Difficulties Questionnaire (SDQ). In practice, emotional data from kindergarten children were collected through interviews, surveys, and questionnaires.

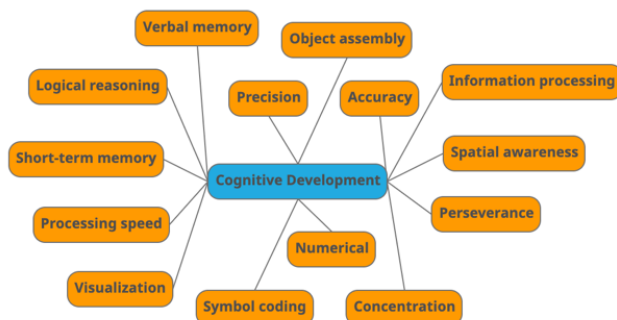
Effect of Physical Activity on Cognitive Development

Each study addressed different aspects of cognitive development, influenced by variables such as student characteristics, environmental conditions, culture, economic context, and the references used. Notably, Zhang et al. (2024) conducted their research in a school equipped with advanced facilities and digital infrastructure. This setup allowed data collection to be carried out using digital devices or tablets operated directly by the kindergarten students. The study and analysis by Haapala et al. (2025) revealed significant positive improvements in elements of cognitive development, such as matching numbers, planned codes, nonverbal, and sentence repetition. These improvements were observed in the intervention group compared to the control group. However, verbal spatial relations and expressive attention also improved, although not significantly, compared to the control group. Similar findings were reported by Jaksic et al. (2020), where visual and logical thinking, planning, and sequencing improved significantly. However, simultaneous processing showed positive development without statistical significance.

In the study by Wick et al. (2021), processing speed, concentration, perseverance, and cognitive flexibility demonstrated significant positive changes relative to the control group. However, there was no statistically significant difference in accuracy between pre-test and post-test scores. In contrast, the findings from Zhang et al. (2024) indicated that all cognitive variables assessed showed significant and positive improvements in the intervention group. These variables included snack delay, wrapped gift, stop signal time, circle drawing, letter memory, and keep track. An interesting result emerged from the study by C. Wang (2022). The study reported no statistically significant effect of physical activity on

cognitive development; however, it found a significant improvement in emotional development following the physical activity intervention. Here is the mind map of the dominant elements considered most important in the variable cognitive development in kindergarten students that we identified during this study.

Figure 9. Network analysis of cognitive development in kindergarten students'



Cognition is a remarkably complex and intricate domain, especially when examining physical activity. The instruments used include the Cambridge Neuropsychological Test Automated Battery (CANTAB), Raven's Coloured Progressive Matrices (CPM), and the Cognitive Assessment System (CAS). Other tools included are the Wechsler Preschool and Primary Scale of Intelligence (WPPSI), Intelligence and Development Scales – Preschool (IDS-P), and the Dimensional Change Card Sort (DCCS). Each instrument involves different procedures and methods, ranging from play-based activities and simple tasks to interviews, card-sorting exercises, and the use of digital devices or tablets. Hal tersebut digunakan untuk mendapatkan data tentang.

Discussion

This study aims to explore in depth the impact of physical activity on the development of motor skills, emotional aspects, and cognitive capacity in kindergarten students. Through a systematic review approach, this research seeks to identify, evaluate, and synthesise the effectiveness of physical activity interventions across these three developmental domains. A systematic review is designed to generate comprehensive, evidence-based conclusions from existing studies (Kolaski et al., 2023). This study aims to address gaps in the scientific literature, which has often been fragmented and sectoral. It offers an integrated, cross-dimensional analysis of the benefits of physical activity in supporting academic readiness, emotional stability, and the maturity of motor skills in children aged 3 to 7 years. The motor, emotional, and cognitive aspects of early childhood development progress simultaneously and are interrelated (Gandotra et al., 2023; Lamirault et al., 2020). Interventions targeting all three domains in a unified manner are believed to yield more optimal developmental outcomes. This study analysed 14 peer-reviewed articles that met rigorous selection criteria. It provides a comprehensive understanding of the effectiveness of physical activity on motor skill, emotional, and cognitive development in kindergarten students.

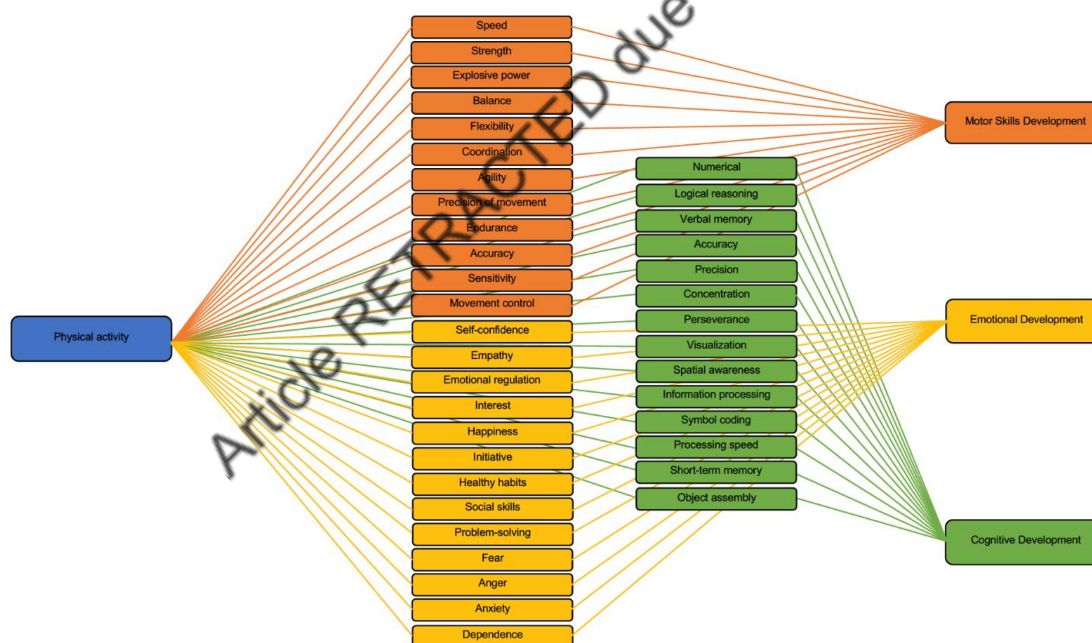
The study by Bai et al. (2021) highlighted a strong association between motor skill development, self-regulation abilities, and academic readiness. Viegas et al., (2023) and Jylänki et al., (2022) further supported these findings, stating that physical activity improves motor performance in preschool-aged children. However, several studies in this review noted that improvements in specific strength-related aspects, such as the standing long jump, were not always statistically significant. In some cases, the control groups outperformed the intervention groups. This suggests a need for more tailored and adaptive intervention designs responsive to the specific characteristics of the physical activities being implemented.

In contrast, the study by Jaksic et al., (2020) did not find a significant improvement in emotional aspects following a physical activity intervention for kindergarten students. This may reflect the influence of several factors, such as cultural context, implementation methods, measurement tools, and the quality

of children's engagement in the activities. It is widely acknowledged that a complex and multifaceted environment, encompassing family, school, and broader cultural norms, has a significant influence on child development. Therefore, responses to interventions can vary considerably across populations. Rademacher et al., (2022) find that adapting interventions to local characteristics and applying more context-sensitive approaches are essential to achieving optimal outcomes in the emotional development of young children. In conclusion, involving collaborative and emotionally engaging activities, physical activity holds substantial potential to support the holistic and sustained emotional development of young children.

Physical activity plays a crucial role in the simultaneous development of motor, emotional, and cognitive domains in early childhood, as these developmental areas are deeply interconnected. According to Gandotra et al., (2023), motor skills development, emotional regulation, and cognitive abilities progress in parallel, with each domain influencing the others. Physical activity, through structured and unstructured movement, enhances motor skills by improving coordination, balance, and strength, which are essential for both academic readiness and physical Independence (Jones et al., 2021). Engaging in physical activities has been shown to contribute to emotional well-being by fostering self-regulation, reducing stress, and enhancing social interactions (Kliziene et al., 2021). On a cognitive level, physical activity promotes brain function, supporting memory, attention, and problem-solving skills, which are critical for cognitive development in young children (Greco et al., 2023). Based on the research findings, the results of the network analysis can be depicted in the form of a mind map, illustrating the relationship between physical activity and the motor skills, emotional, and cognitive development of kindergarten students.

Figure 10. Network analysis of physical activity on kindergarten students' motor skills, emotional, and cognitive development



A novel contribution of this systematic review is its successful identification of cross-domain linkages between physical activity and the simultaneous development of motor, emotional, and cognitive skills in early childhood. This integrated approach has rarely been addressed in such an analytical framework. This study also presents a wide geographical distribution pattern, encompassing eleven countries with diverse cultural characteristics, demonstrating that the effectiveness of physical activity on child development appears to be universal. These align with Zidny et al., (2020), who say that ecological systems theory highlights that the interaction between environmental factors and daily activities can influence all aspects of development in an integrated way. A holistic approach to early stimulation can simulta-

neously promote cognitive, socio-emotional, and motor development through meaningful physical activity (Gea et al., 2025). The results of this study reinforce existing empirical evidence. They also pave the way for the development of comprehensive physical activity intervention models to support school readiness and early childhood well-being globally.

The findings of this study provide a scientific foundation for designing educational programmes that focus on cognitive development. They also emphasize the integration of physical activity as a medium to stimulate motor, emotional, and cognitive development simultaneously. This approach is in line with (Mirshekari et al., 2024) which emphasises the vital role of kinaesthetic and interpersonal intelligences in early childhood learning. These intelligences should be facilitated through activities that engage multiple dimensions of development. These findings are consistent with (Rudd et al., 2020; Van Geert, 2020) who view development as the outcome of complex interactions among biological, environmental, and experiential factors. This suggests that deliberately designed physical activities can catalyze more stable and integrated developmental coordination. The practical value of this study lies in its implementable recommendations for teachers, early childhood education providers, and educational policymakers. It advocates that physical activity should be considered a core component of a healthy, contextual, and sustainable learning strategy, rather than merely supplementary.

Conclusions

This study found that structured, enjoyable, and developmentally appropriate physical activity has a significantly positive impact on the motor, emotional, and cognitive development of kindergarten students. Physical activity interventions were shown to be more effective than conventional approaches, as they stimulate motor coordination, emotional stability, and executive brain functions in an integrated manner. The findings indicate that the benefits of physical activity are multidimensional and universal, although they remain influenced by cultural context and programme design. These results reinforce the importance of a holistic learning approach in early childhood education, positioning physical activity as a core element in developmental stimulation strategies rather than a supplementary component. The outcomes of this study may serve as a valuable reference for stakeholders in developing policies for early childhood education. These policies and practices can be more integrative and focused on promoting children's overall well-being.

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