

Ecological dynamics perspective on the role of physical activity in enhancing creative thinking and motor creativity in students

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Abstract

Recent research highlights the importance of physical activity (PA) in fostering creative thinking and motor creativity in children. The ecological dynamic approach provides a powerful framework for understanding the complex relationship between creativity, motor responses, and constraints imposed by individuals, tasks, and the environment. This study examines, from an ecological dynamics perspective, the effect of physical activity on creativity in children and elucidates the most effective methodologies and educational strategies for promoting these abilities. A comprehensive literature search was performed across Google Scholar, PubMed, Scopus, and Web of Science to identify studies published between January 2011 and June 2024. The search strategy used the following keywords: "physical activity," "children," and "motor creativity." This review encompasses both experimental studies and narrative reviews. Of the 15 articles included in this review, 7 focused on creative thinking, 4 on motor creativity, and 4 on both creative thinking and motor creativity. Most studies were performed in school settings, with participants ranging in age from 4 to 17 years. The findings of this review suggest that PA programs based on the ecological dynamic approach can considerably enhance children's originality of thought, fluidity of movement, and flexibility of motor skills. These programs leverage the interaction between individual characteristics, task requirements, and environmental factors to create rich, diverse, and adaptable learning experiences. The reviewed studies advocate for methodologies that prioritize variability, exploration, and adaptability, which are key principles of the ecological dynamic approach. In conclusion, further research is warranted, particularly in collaboration with educational institutions, to refine and expand the most effective methodological and educational strategies in the theoretical framework of the ecological dynamic approach. Such studies could substantially enhance the fostering of children's creative potential by promoting environments that facilitate ongoing interaction and adaptation between learners and their surroundings.

Keywords: physical education; children; creativity skills; nonlinear pedagogy

Introduction

Recent investigations in the field of movement sciences have underscored the body's profound role as a tool for expressing creativity (Ruiz-Ariza et al., 2019; Richard et al., 2021; Santos & Monteiro, 2021; Romance et al., 2023). As emphasized by Lucchiari et al. (2019), Ruiz-del-Pino et al. (2022), Segundo-Marcos et al. (2023), and Piya-Amornphan et al. (2020), creativity is a complex, dynamic, and multifaceted construct, entailing the generation of original, useful, and effective ideas or solutions.

Heilman (2016) outlines the creative process in three phases. The preparation phase involves acquiring the knowledge and skills required to generate a creative product. In the innovation phase, the brain unconsciously searches for a context-appropriate solution. Finally, the verification phase produces the final results of the creative process.

From an ecological perspective, all experiences children encounter from birth contribute to fostering the person-environment relationship and are considered learning experiences (Davids & Rudd, 2023). In the school context, it is especially important to provide constructive learning opportunities that enhance cognitive flexibility, equipping students to effectively address even the most complex tasks (D'Anna et al., 2022).

The educational context during childhood holds immense potential for fostering creativity, particularly in disciplines such as physical education (PE) (Neville & Makopoulou, 2021), which has been recognized for its positive impact on cognitive development (Ángel Latorre-Román et al., 2021; Coppola et al., 2024). Through the exploration of varied movement modalities and the development of strategies for overcoming motor challenges (Konstantinidou & Zisi, 2017), PE empowers students to enhance their creative thinking (Konstantinidou et al., 2011; Román et al., 2018; Tilp et al., 2020; Marinšek & Lukman, 2022).

Fostering creative thinking in children allows them to express themselves, solve problems, develop self-esteem, and adapt to diverse situations (Marcos et al., 2020; Segundo-Marcos et al., 2023). As posited by Alper and Ulutaş (2022), creative movement encompasses the simultaneous engagement of both the body and mind. It is an invaluable experience for children, enabling them to communicate, express themselves, and develop greater body awareness (Pamuk et al., 2022; Alper & Ulutaş, 2022).

Domínguez et al. (2015) analyzed how the development of motor creativity and its components varies during childhood. Their findings indicate that motor creativity generally increases with age, albeit not uniformly across all components. Certain abilities, such as overall motor fluidity and manipulative fluidity, exhibit a more pronounced linear progression. However, other components, including symbolic flexibility and originality, display a more complex developmental pattern. Notably, between the ages of 10 and 12, the overall motor creativity score tends to be higher, while the level of originality is generally lower compared to the 8–10 age group. This suggests that although older children excel in executing fluid and flexible movements, they are less adept at generating new ideas. Consequently, the development of motor creativity is uneven across its components.

Motor creativity encompasses the ability to generate novel movement patterns and adapt strategies in response to varying situations. It plays a key role in the execution of various sports disciplines (Scibinetti et al., 2011) and influences athletes' decision-making processes during competitions (del Pino Díaz-Pereira et al., 2024). Moreover, motor creativity involves the ability to produce various motor responses that are both original and functionally applicable to a given stimulus (Richard et al., 2018; Torrents et al., 2021).

Team games, sports practices, fundamental movements, and motor improvisations provide children with opportunities to experience, observe, and develop their creativity. Motor games, in particular, offer not only a physically engaging activity but also a cognitively demanding one (Truelove et al., 2017). These games have been shown to enhance creativity (Rodríguez-Negro et al., 2024) both in the short term (Latorre-Román et al., 2018) and in the long term (Rodríguez-Negro et al., 2020). In team sports, creativity is shaped by constraints such as interindividual distance and athletes' relative speed. These factors establish a critical region where diverse action solutions arise, each influenced by a distinct combination of interacting constraints (Hristovski et al., 2012).

Children express their creativity through imagination and fantasy by changing traditional games, inventing new ones, and experimenting with novel forms of movement (Konstantinidou et al., 2011; Karaca et al., 2020). Additionally, factors such as freedom and spontaneity play a key role in fostering creativity because they enhance students' improvisation skills (Richard et al., 2021).

Designing PE lessons requires incorporating training programs that simultaneously enhance physical fitness, motor skills, and creativity (Silva et al., 2022). To promote creativity, games that engage memory and cognitive flexibility are particularly effective, using a mix of prescriptive teaching and heuristic problem-solving methods. This approach allows children to alternate between imitating the educator's demonstration, independently finding a single solution (convergent discovery), and exploring multiple ways to solve a task (divergent discovery) (Pesce et al., 2015).

The ecological approach in PE and movement science offers a robust theoretical framework for examining the connection between creativity and motor behavior. From this perspective, creativity is seen as a transformative process involving the exploration and discovery of novel behaviors to optimize motor performance. This process relies on the dynamic adaptation of synergies among various system elements during training and competition (Rudd et al., 2020). By designing constraints, adaptive exploration of new possibilities can be encouraged, fostering moments of creativity and promoting creative development (Vaughan et al., 2019). The concept of multistability and the ecological approach to movement are crucial for understanding the connection between creativity and motor behavior (Richard et al., 2021). Multistability in creative potential refers to the existence of multiple attractor states, enabling the system to quickly adapt to perturbations (Kelso, 2012). From an ecological perspective, the system's ability to transition rapidly between states in response to disruptions is key to motor creativity. For effective learning, it is essential to perturb the system, creating instability that promotes the development of creative movement.

Viewing humans as integrated, complex systems is essential, where the interaction between the individual, task, and environment during physical activity (PA) drives functional adaptations across the entire system. In this context, creativity plays a crucial role, involving the ability to develop innovative solutions and adapt flexibly to diverse situations and contexts.

Thus, the dynamic ecological approach promotes a holistic perspective on PA, with creativity serving as a key component for the well-being and health of individuals (Rudd et al., 2020). The dynamic ecological approach to movement execution emphasizes the processing of environmental cues to uncover novel motor solutions. A key concept in this approach is executive variability, which promotes a nonlinear process for solving motor tasks (Coppola et al., 2022). This variability is essential for adaptive learning because it enables individuals to explore a diverse range of movement possibilities and refine their motor skills through continuous interaction with their surroundings.

Constraints play a critical role in the dynamic ecological framework by shaping the emergence of motor behaviors. According to Seifert et al. (2018), the constraints influencing movement execution encompass the

structure of the physical environment, the biomechanics of the body, perceived sensory information, and task characteristics. Through the manipulation of these constraints, educators can create learning environments that encourage students to discard ineffective movement solutions and explore more effective ones (Romano et al., 2023). This process aligns with the principles of affordances, where the environment offers opportunities for action that can be perceived and acted upon by the individual.

PA, based on the principles of the dynamic ecological approach, stimulates problem-solving abilities, decision-making skills, and the generation of new ideas. This approach makes a substantial contribution to the holistic development of students by integrating physical and cognitive aspects into a cohesive educational experience (Coppola et al., 2024). The ecological dynamics framework views learning as an emergent process arising from the continuous interaction between the individual, the task, and the environment. This interaction fosters the development of functional synergies, allowing the learner to adapt to various constraints and achieve optimal performance (Davids & Rudd, 2021).

Considering the abovementioned information, the primary objective of this review is to perform a comprehensive analysis of scientific literature investigating the influence of PA on creative thinking and motor creativity during the developmental period. Furthermore, adopting a dynamic ecological perspective, this review aims to identify the most effective methodologies and approaches for promoting the development of these cognitive and motor abilities.

Materials and Methods

Search strategy

A literature search for this study was performed using Google Scholar, PubMed, Scopus, and Web of Science. In each selected database, a standardized search strategy was used, incorporating a combination of the following keywords: "physical activity," "children," and "motor creativity." The inclusion criterion for selecting articles was based on publication date, with studies published between 2011 and 2024 being included.

Inclusion and Exclusion Criteria

To be included in this systematic review, studies had to meet the following criteria:

- **Study Type:** Narrative reviews, systematic reviews, meta-analyses, and experimental studies.
- **Participants:** Children in the developmental age range of 4–17 years.
- **Interventions:** PA lessons.
- **Setting:** School environment.
- **Outcomes:** Creative thinking and motor creativity.

Studies that did not meet these eligibility criteria, as well as those focusing on clinical samples, were excluded from this systematic review.

Data analysis

Each selected review was carefully examined to extract pertinent information regarding the study design, objectives, participants, PA intervention, and its influence on creative thinking and motor creativity. The following data points were systematically extracted from each article: (1) authors and year of the study; (2) sample characteristics, including the number and age of participants; (3) methodology; (4) results.

Results

Selection of Studies

Several initially selected articles were removed owing to their lack of relevance, resulting in 15 articles being included in the review.

Study Characteristics

The characteristics of the studies included in this review are presented in the tables below. Table 1 outlines the experimental studies ($n = 14$), while Table 2 details the narrative review ($n = 1$).

Out of the 15 articles included in the review, 7 focused primarily on creative thinking, 4 on motor creativity, and 4 explored both creative thinking and motor creativity. Notably, the setting of the studies included in this literature review is predominantly in the context of educational institutions. Regarding the characteristics of the participants, the ages ranged from 4 to 17 years.

Results of Reported Studies

Table 1 Experimental studies

Authors and year	Sample	Age (yrs)	Methodology	Results
Piya-Amornphan et al., 2020.	1447	6–17	Creative thinking–drawing production; children survey—the student questionnaire	Exercise is essential for cognitive progress and could be an effective strategy for stimulating creativity.
Alper & Ulutaş, 2022.	40	5–6	Torrance test of creative thinking; thinking creatively in action and movement	The creative movement program is helpful in enhancing creative thinking skills and motor creativity.

Pamuk et al., 2022.	158	4–6	General information form; thinking creatively in action and movement	Children who participate in sports have higher motor creativity scores compared to those who do not.
Santos & Monteiro, 2021.	198	6–10	Questionnaire for sports experiences; vertical jump test; 15-meter straight sprint; change of direction test; Torrance test of creative thinking; computerized notational analysis of creative behaviors during games	Sports creativity is linked to the fluency and originality of creative thinking, with a stronger correlation to fluency.
Romance et al., 2023.	169	10–11	Torrance test of creative thinking; ActiGraph	The results indicated a positive relationship between strenuous exercise and creativity.
Domínguez et al., 2015.	84	8–12	TCAM; tests of motor creativity by Bertsch	Motor creativity increases between the ages of 6 and 12.
Del Pino Díaz-Pereira et al., 2024.	500	6–12	GTS	Regular practice of sports activity is associated with a greater expression of motor creativity, characterized by higher fluidity and originality in movements.
Neville & Makopoulou, 2021.	40	7–8	Guilford's (1967) alternative uses task	Physical activity, particularly dance, can promote the development of creativity.
Rodríguez-Negro et al., 2024.	43	10–12	CREA; PAQ-C	Play can be an effective way to enhance creativity.
Ángel Latorre-Román et al., 2021.	114	8–10	Leger test; school aptitude test; creative imagination test for children; trail making tests	Active recreation, particularly high-intensity training, has a positive impact on creativity.
Ruiz-Ariza et al., 2019.	184	12–16	Test CREA; Trait and emotional intelligence questionnaire short form	Participating in PE sessions involving high-intensity cooperative interval training can enhance creativity.
Román et al., 2018.	96	8–12	Creative imagination test for children	Acute aerobic exercise improves students' creativity.
Tilp et al., 2020.	69	11–14	Salzburg reading screening; Ekstrom French kit; Frankfurt attention inventory; Torrance tests of creative thinking; alternative uses task	Interventions involving coordination and movement have been shown to positively influence the fluency of creative thinking.
Richard et al., 2018.	173	9	Runco creative assessment battery; test Bertsch	The creativity-focused program considerably affected the originality of thought, fluidity, and flexibility of movements.

Piya-Amornphan et al. (2020) studied students aged 6–17 years and found that to maximize the benefits of creative thinking, physical activities (particularly in the form of active play) were essential. Similarly, Alper and Ulutaş (2022) reported that a creative movement program enhanced both creative thinking and creativity in 5–6-year-old children.

Pamuk et al. (2022) found that children who engaged in sports achieved better results in motor creativity, fluency, and originality compared to their sedentary peers. Similarly, Santos and Monteiro (2021) explored the relationship between motor skills, creative thinking, and sports creativity in children aged 6–10 years. Their study revealed correlations between motor skills and creative thinking, with higher scores in fluency and originality linked to better performance in sprinting and vertical jumping.

Romance et al. (2023) explored the relationship between creative capacity and PA in 10–11-year-old children. Their findings indicated a positive correlation between vigorous PA (vigorous and moderate-to-vigorous PA) and creativity. A study by Domínguez, Díaz-Pereira, and Martínez-Vidal (2015) investigating motor creativity observed a gradual enhancement of this ability between ages 6 and 12. Notably, motor fluency increased considerably between ages 6 and 8, reaching a plateau at approximately age 10. Flexibility exhibited consistent growth during this period, while originality and imagination remained relatively stable.

Del Pino Díaz-Pereira et al. (2024) investigated the relationship between motor creativity and athletic status in students. Their findings demonstrated that motor experiences had a positive impact on creative development. Neville and Makopoulou (2021) examined the effects of a dance-based PE program on children's

creativity in a primary school setting. Their results indicated that such a program positively influenced motor creativity.

Rodríguez-Negro et al. (2024) studied the relationship between PA and creativity in students aged 10–12 years. Their results demonstrated an improvement in creativity following the intervention program. Similarly, Ángel Latorre-Román et al. (2021) suggested that active recreation based on high-intensity training is an effective tool for enhancing student creativity.

Ruiz-Ariza et al. (2019) assessed the effects of high-intensity interval cooperative training on creativity in 12–16-year-old students. Their findings suggest that brief programs of collaborative high-intensity activities can enhance the creative process. Román et al. (2018) investigated the impact of a single aerobic PE class on school-age children's creativity. Their results indicate that aerobic exercise can positively influence this cognitive ability.

Tilp et al. (2020) investigated the effects of a motor exercise and coordination intervention on academic performance, attention capacity, and various aspects of creative potential. Their findings revealed that regular physical exercise during morning breaks enhanced specific aspects of creative potential, particularly fluidity.

Richard et al. (2018) examined the impact of a creative exercise program on children's cognitive and motor creativity in comparison to a conventional exercise program. Their findings showed that the creative program significantly enhanced the originality of thought, movement fluency, and flexibility.

Table 2 Narrative review

Authors and year	Number of studies	Age (yrs)	Methodology	Results
Silva et al., 2022.	97	School-age	Inclusion criteria: (1) relevant data on the application of multivariate training programs; (2) impact of multivariate training programs on motor competence and creativity.	Multivariate training programs performed during PE classes are an effective tool for simultaneously developing physical fitness, motor skills, and creativity.

The narrative review by Silva et al. (2022) examined the benefits of implementing multivariate programs in PE classes, focusing on their impact on physical fitness, motor skills, and creativity in children and adolescents.

Discussion

Recent research emphasizes the pivotal role of PA in fostering creative thinking and motor creativity during childhood. Many studies underscore the effectiveness of educational interventions in enhancing creativity, consistently indicating that PA positively impacts both creative thinking and motor creativity. However, there are considerable differences in the types of activities used during PE lessons, which can influence the outcomes.

This study analyzes research examining the impact of PA on creative thinking and motor creativity in childhood from an ecological–dynamic perspective. It aims to determine the most effective methodologies and approaches for promoting these skills in educational settings.

Current studies, including those by Piya-Amornphan et al. (2020), Rodríguez-Negro et al. (2024), Ángel Latorre-Román et al. (2021), Tilp et al. (2020), Román et al. (2018), Romance et al. (2023), and Ruiz-Ariza et al. (2019), consistently highlight a positive correlation between PA and creative abilities. Notably, the type of activity investigated varies across these studies.

Piya-Amornphan et al. (2020) and Rodríguez-Negro et al. (2024) highlight the importance of designing active play activities to maximize the benefits of creative thinking. Piya-Amornphan et al. (2020) targeted students aged 6–17, whereas Rodríguez-Negro et al. (2024) focused on those aged 10–12.

Ángel Latorre-Román et al. (2021) and Tilp et al. (2020) emphasize the importance of PA during recess. Ángel Latorre-Román et al. (2021) observed that high-intensity PA enhances creativity in students aged 8–12, likely owing to neurophysiological changes that improve cognitive performance. Tilp et al. (2020) found that motor–coordinative exercises for 11–14-year-olds had modest but positive effects on creative fluidity.

Román et al. (2018) demonstrated that aerobic PE lessons enhanced cognitive abilities compared to those in a control group. Romance et al. (2023) highlighted the effectiveness of intense PA in improving both originality and flexibility in creativity. Ruiz-Ariza et al. (2019) found that Cooperative High-Intensity Interval Training (C-HIIT) for students aged 12–16 significantly enhanced creativity, recommending 16 min of C-HIIT at the beginning of PE lessons.

Pamuk et al. (2022), del Pino Díaz-Pereira et al. (2024), and Neville and Makopoulou (2021) explored the impact of PA on motor creativity. Pamuk et al. (2022) and del Pino Díaz-Pereira et al. (2024) found that students participating in sports showed greater improvements in motor creativity compared to their sedentary peers. According to del Pino Díaz-Pereira et al. (2024), sports activities allow children to express creativity through diverse and unique movements, fostering decision-making and adaptability. Neville and Makopoulou (2021) reported that dance-based PE programs enhanced motor creativity, improving both the fluidity of ideas and the originality of movements.

Domínguez et al. (2015) observed age-dependent increases in aspects of motor creativity, with significant improvements in motor fluidity between ages 6–8 and consistent flexibility gains up to age 12. However, originality and imagination showed no significant changes, highlighting the complexity of motor creativity development.

Alper and Ulutaş (2022), Silva et al. (2022), and Richard et al. (2018) emphasized the positive impact of PA on creative thinking and motor creativity. Alper and Ulutaş (2022) and Richard et al. (2018) underscored the importance of creative movement programs, which help children develop unique problem-solving skills and express emotions through creative movements. Silva et al. (2022) suggested that multivariate programs could enhance both creative thinking and motor creativity.

Santos and Monteiro (2021) provided insights into the interaction between motor skills, creative thinking, and sports creativity, revealing a positive association between motor skills and psychometric indicators of creative thinking. They emphasized the importance of motor fluidity in motor creativity.

Incorporating an ecological dynamic approach, these studies highlight the importance of viewing creativity as an emergent property arising from the interaction between the individual, task, and environmental constraints. By manipulating these constraints, educators can design rich, varied, and adaptive learning environments that promote both creativity and motor skill development.

In summary, while the studies consistently highlight the positive impact of PA on creativity, they differ in the types of activities and age groups examined. A common recommendation is to incorporate creative movement activities into PE programs to enhance both cognitive and motor aspects of creativity in children. The ecological dynamic approach provides a strong framework for designing these interventions, emphasizing the importance of adaptive interactions between the learner and their environment in fostering creative development.

Conclusion

This study confirms the essential role of PA in the development of creative thinking and motor creativity during childhood. The results of the analyzed studies demonstrate a clear positive correlation between PA and creative abilities, with various intervention methods proving effective.

Studies by Piya-Amornphan et al. (2020) and Rodríguez-Negro et al. (2024) emphasize that PA in the form of active play is particularly effective in enhancing creative thinking in children, targeting different age groups. High-intensity interventions, as described by Ángel Latorre-Román et al. (2021) and Ruiz-Ariza et al. (2019), show that physical training can induce neurophysiological changes that improve cognitive performance and motor creativity.

The role of motor coordination and physical exercise during recess is highlighted by studies such as Tilp et al. (2020) and Román et al. (2018), which demonstrate benefits in the fluidity and flexibility of creative movements. Additionally, PE programs based on aerobic activities and dance, as suggested by Neville and Makopoulou (2021), are effective in enhancing motor creativity.

Variations in results based on the type of activity and age groups studied underscore the need for a personalized approach to implementing PA programs. Studies such as those by Pamuk et al. (2022) and del Pino Díaz-Pereira et al. (2024) indicate that children engaged in sports show significant improvements in motor creativity compared to their sedentary peers, suggesting that incorporating sports into educational programs can foster creative development.

Finally, studies by Alper and Ulutaş (2022) and Silva et al. (2022) emphasize the importance of creative movement and multivariate programs in stimulating both creative thinking and motor creativity. Adopting methodologies based on the ecological–dynamic approach appears particularly promising for maximizing these benefits.

In conclusion, synergistic collaboration between the scientific community, educational institutions, and teacher training is essential for developing and implementing educational approaches that maximize children's creative potential. PA interventions, carefully tailored to diverse developmental needs and based on the ecological–dynamic approach, can effectively promote the overall development and well-being of young students. By incorporating principles of variability, adaptability, and affordances into PA programs, educators can create enriching environments that promote both cognitive and motor creativity.

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