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Original Article

Unlocking abilities: enhancing executive skills through play and movement in preschool physical education

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Abstract:
Introduction: This research evaluated the effects of an intervention based on active play and movement on Executive Function (EF) development in preschoolers. It aimed to explore the improvements in cognitive domains such as inhibitory control, working memory, and cognitive flexibility, and their indirect influence on language and mathematics academic achievements. **Methodology:** The study involved 20 children from preschool, averaging 5 years in age. We applied specific pre and post-intervention assessments to measure EF. The data underwent descriptive analysis and Shapiro-Wilk tests to assess distribution normality, with Wilcoxon tests identifying significant differences in pre- and post-intervention results. **Results:** Notable gains in EF were observed following the intervention, particularly with longer intervention durations. These results align with existing literature, underscoring the importance of incorporating active and engaging learning strategies in early educational programs. **Discussion:** The intervention impacted both cognitive and socio-emotional learning, suggesting it may be beneficial for children with unique educational needs. However, the study faced limitations in the duration and methods of program evaluation, indicating a need for more extensive and targeted research.
Conclusion: This study highlights the essential role of integrating active play into early education to nurture EF development. It emphasizes the urgent need for further studies and adjustments in curricula to improve the effectiveness and inclusiveness of such programs, marking an essential step towards evolving educational centers into dynamic learning spaces.
Key Words: Executive Functions, Physical Activity, Preschool Education, Cognitive Development, Structured Intervention.

Introduction

Physical Education in the school age stands as an indispensable pillar in the comprehensive development of the student. Traditionally, its importance has been recognized in the realm of well-being and physical development; however, the spectrum of its influence goes beyond these boundaries. Clearly, its value is not limited to improving physical condition and muscle strengthening but also serves as an irreplaceable medium to foster growth in multiple dimensions of the individual. These dimensions encompass the social realm, where interaction and collaboration inherent to physical activity strengthen social and teamwork skills; the psychological sphere, where overcoming challenges and stress management promote resilience and mental well-being; and the cognitive domain, where coordination and strategy optimize mental processes such as attention, memory, and EF. This multidimensional nature of Physical Education highlights its significance as an educational tool, enabling the enrichment and strengthening of the student's formative experience. Consequently, integrating Physical Education into the school curriculum not only fulfills the purpose of promoting an active and healthy lifestyle but also fosters skills and competences crucial for evolutionary, social, and cognitive development of the student, thus consolidating as an essential component in the comprehensive educational process.

EF and self-regulation comprise a fundamental set of cognitive skills that significantly promote information retention and, correlatively, optimize concentration by obstructing potential distractions. According to the Center on the Developing Child (2012), these functions are divided into three primary modes of brain operation: working memory, mental flexibility, and self-control. As posited by Moriguchi (2014), EF act as the ability to implement relevant actions and restrict those inconvenient for achieving specific objectives. On the other hand, Diamond (2016) argues that such capabilities enable concept consolidation, prevention of impulsive unreflected responses, confronting novel and unforeseen challenges, managing temptations, and maintaining focus. Moreover, planning processes prior to decision-making fall within the scope of EFs, as pointed out by Stelzer and Cervigni (2011). Currently, the relationship and mutual dependency between EF have been corroborated, assigning them a key role in the comprehensive development of young individuals in cognitive,

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attitudinal, emotional, and social spheres. The evolution of EFs, as proposed by Cadavid (2008), is closely linked to the progressive development of the prefrontal cortex, implying that maturity in the neuroanatomical system aligns with progress in the cognitive system. In this context, Verdejo-García and Bechara (2010) differentiate EFs into skills of cognitive nature, such as following instructions and confronting challenges, and abilities of social and emotional nature, such as collaboration and prosocial behaviors. Brock et al. (2009) and Zelazo and Carlson (2012) distinguish between "hot" EFs, related to the emotional domain, and "cold" EFs, linked to the cognitive realm. Both types of EFs require the assessment of immediate consequences and the medium and long-term repercussions of specific behaviors. García-Arias (2012) contextualizes this differentiation as an executive system that regulates the interaction between cognition and motivation and manages conflict resolution. EF have been a subject of deep analysis in the academic field as a vital component of self-regulation, as presented by Diamond (2016). Reviews of studies conducted by Nguyen and Duncan (2019), Diamond and Ling (2016), and Zelazo and Carlson (2012) agree that there are three interconnected elements, being determinant in the executive processes: inhibitory control, working memory, and cognitive flexibility.

Inhibitory Control is recognized as a fundamental skill within the framework of social interactions, serving as an essential component in scenarios where specific norms and regulations are prescribed. It entails the ability to manage impulses, allowing for prior reflection before any action, controlling distractions to maintain focus on a specific task, and resisting impulses that could be considered inappropriate or illicit. Diamond (2016) emphasizes the vital importance of this function for the proper management of behavior, attention, and individual emotions, to prevent engaging in behaviors that might be socially unacceptable. Concurrently, Working Memory, defined by Diamond (2016) as the ability to retain and manipulate information when it's no longer visible or present in the environment, emerges as a crucial tool for performing cognitive tasks. This specialized skill, particularly in children, allows them to keep pertinent information in mind and effectively apply it in resolving various tasks. On the other hand, Cognitive Flexibility is an ability that enables the generation and application of multiple strategies to confront and solve challenges, effectively adapting to changing situations and envisioning scenarios from different perspectives, thereby promoting the emergence of creative solutions. Diamond and Ling (2016) describe this capability as a flexible adaptation in response to varied and demanding contextual demands. The amalgamation of these conceptualizations concerning EF and self-regulation provides a comprehensive and profound view of the essential competencies for the cognitive, emotional, and social development of the individual. The interpretation of these concepts underscores the pressing need to continue research and exploration in this crucial field of neuroscience and evolutionary psychology to deepen our understanding of human cognition and its direct impact on individual and collective behavior (Figure 1).

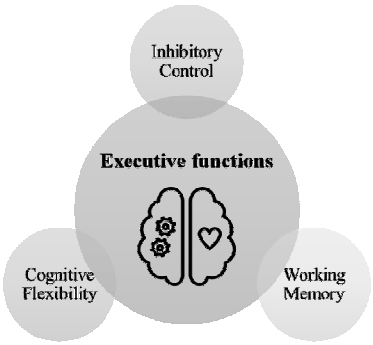

Figure 1. Integrative Diagram of Executive Functions: Inhibitory Control, Working Memory, and Cognitive Flexibility.

In the academic context of a classroom, EF encompass a range of cognitive processes that empower students to resist distractions, focus attention on the assigned task, maintain constant attention, observe turns and interventions of peers, adapt to activities proposed by the educator, and remember norms such as "raising the hand" and "waiting for one's turn". According to Howard et al. (2020), self-regulation serves as a means by which students can regulate their behavior, attention, and thought, in addition to modulating their reactions to various situations, even in the presence of distractions. Historically, there was a gap in scientific literature regarding the role of EF components in social competence and the most common behavioral changes in the relevant educational stage (Romero-López et al., 2018). However, during early childhood, an increase in individual autonomy is observed and marks the start of implementing mental strategies suitable for managing impulses, emotions, and thoughts. At this stage, adherence to social norms also begins, guiding thoughts and behaviors towards achieving goals and meeting environmental expectations (Ilgar & Karakurt, 2018). In this task, EF and self-regulation play a cardinal role, serving as foundations for subsequent learning (López, 2021). It is believed that the age period between 0 and 5 years is crucial from learning and teaching perspectives. According to studies by Diamond (2016) and Housman (2017), advancements in Neuroscience have shown that

this stage is vital for the development of competencies required in adulthood, with emotional competence and the development of self-regulation forming the basis for academic, personal, and social advancement, as well as for the promotion of mental health and well-being. Korzeniowski (2011) confirms that neuroimaging research and behavioral analysis indicate that EF undergoes rapid evolution during this phase. Additionally, Rueda et al. (2016) argue that, since the maturation of the prefrontal cortex occurs at a slower rate and certain experiences favor its development, EF are skills that can be improved through systematic interventions, primarily in childhood and school ages.

The first 5 years of life are essential for the development of EF. According to García-Molina et al. (2009), it is at age three when abilities intrinsic to EF emerge, and between 3 and 5 years, core cognitive skills of EF, which allow retaining and manipulating information to adjust behavior to changing contexts, develop significantly. Concurrently, with the onset of schooling, which typically begins at age three, a higher level of self-control in social, behavioral, physical, and emotional areas is demanded. Acquiring these skills is crucial to prevent behavioral maladjustments that could negatively impact development and learning. Numerous studies have investigated the impact of Physical Education and exercise on cognition and academic performance during youth and adolescence. Research like that of McPherson et al. (2018), Bailey (2006), and Bidzan-Bluma & Lipowska (2018) identify a correlation between physical-sport activity, academic performance, and cognition. Likewise, a review of studies conducted by Haapala (2012) reveals benefits of physical training in attention, concentration, and working memory capacities, as well as in language and arithmetic skills.

The findings suggest that an amplification of physical activity in educational settings can catalyze the development of EF, leading to the hypothesis that involvement in sports activities during these life stages would have a beneficial impact on cognitive and emotional faculties. As a result, the pedagogical methodology applied to physical activity stands as a crucial element for achieving goals, whether of a behavioral nature, development of fundamental physical skills, social interaction, or emotional regulation, among others (Sánchez-Alcaraz, Gómez-Mármol, Valero & Courel, 2020; Sánchez-Alcaraz, Ocaña, Gómez-Mármol & Valero, 2020). Researchers like Diamond and Ling (2016) or Singh et al. (2019) have posited that adapting the difficulty level of tasks, such that they consistently challenge the participant, is essential for the progression of EF. The goal, therefore, is to promote activities that drive active and meaningful participation from students (Arias, Egea & Gómez-Mármol, 2021). Likewise, the establishment of programs in the early childhood stage, based on computerized games, martial arts, yoga, or mindfulness (Diamond & Lee, 2011; Howard-Jones, 2014), is associated with advancements in social competence, health, quality of life, and academic success, and contributes to the mitigation of disruptive behaviors. These programs have significant implications for the comprehensive development of individuals, providing a strong foundation for strengthening cognitive and social capacities and building adaptive and resilient behavior, factors intrinsically linked to well-being and personal and academic achievement.

In this context, it is essential to emphasize the relevance of delving specifically into EF within the cognitive benefits of Physical Education. EF are high-level cognitive processes that include inhibitory control, working memory, and cognitive flexibility, which are fundamental for behavioral self-regulation, emotion management, and adaptation to new situations or demands. The optimization of these functions is crucial for the individual's comprehensive development and has significant implications for goal achievement and effective problem solving. Therefore, a detailed study of the relationship between Physical Education and EF is indispensable to better understand how intervention in the physical-educational field can be a vector for developing essential cognitive capacities. Detailed research in this area can unravel underlying mechanisms that link physical activity to strengthening EF and, therefore, provide more effective and enriching educational strategies that support students' cognitive development, thus complementing their comprehensive education. Despite the growing evidence supporting the positive impact of physical activity in various dimensions of human development, significant gaps persist in the existing literature, particularly concerning the child population aged 5-6 years, which has been insufficiently explored. Previous studies have tended to focus predominantly on older populations, leaving a knowledge gap in the early stages of educational development where the establishment of healthy habits and cognitive and socio-emotional skills can have substantial repercussions on the individual's future development. Therefore, the objectives of this study focus on examining the impact of a physical exercise program on the development of EF in preschool education students. It aims to contribute to the existing literature by providing insights and empirical evidence on the beneficial effects that physical intervention can entail on cognitive and emotional faculties at an early age, placing special emphasis on the improvement and optimization of EF. This research seeks to mitigate existing knowledge gaps and offer a more robust and detailed framework for future research and the implementation of comprehensive educational strategies that promote the holistic development of students in their early years of training.

Material & methods

Participants In this study, 20 preschool children, specifically five years old, from a single educational center located in Murcia participated. The group of participants was evenly divided between boys and girls, with 10 representatives of each gender.

Procedure

Psychomotor sessions were carried out with various activities, all aimed at improving and stimulating the children's executive functions. The activities carried out are described in detail below (table 1).

N	Activity Name	Targeted Executive Functions	Activity Description
1	Sound Story: The Magic Forest	- Inhibitory Control- Working Memory	Children listen to a story related to a magic forest, promoting attention and retention of the presented information.
2	Guess, guess, which letter I start with	- Inhibitory Control - Working Memory	Use of flashcards for children to associate initials with objects and animals, promoting attention and relation between object and word.
3	Playful Balls	- Inhibitory Control - Working Memory- Cognitive Flexibility	Children move balls from one side to the other in creative and unique ways, promoting creativity and problem solving.
4	Musical Hoops	- Inhibitory Control - Working Memory- Cognitive Flexibility	Adaptation of musical chairs to promote cooperation and attention using hoops.
5	Arrange the sounds/images	- Inhibitory Control- Working Memory - Cognitive Flexibility	Children arrange sounds and images based on their order of appearance, challenging their working memory and attention.
6	Musicogram: The Forest Fairies	- Inhibitory Control - Working Memory	Musical interpretation with a musicogram, where children play instruments at specific times, promoting the following of instructions and coordination.
7	Silence, the animals are sleeping!	- Inhibitory Control - Working Memory- Cognitive Flexibility	Adventure activity where children cross a valley silently, promoting attention, creativity, and problem solving in relation to the environment.

Instruments

For the evaluation of EF, which has proven to be a valid and reliable instrument to measure these functions in the child population. Additionally, various educational materials such as flashcards, colored balls, hoops, and several musical instruments were used for the development of activities.

Statistical Analysis

A preliminary descriptive analysis will be carried out to obtain a detailed understanding of the fundamental characteristics of the data. Subsequently, to assess the normality of the data, the Kolmogorov-Smirnov or Shapiro-Wilk test will be selected depending on whether the degrees of freedom are greater or less than fifty, respectively. If the data reveal a non-normal distribution, non-parametric tests will be applied for subsequent analyses, specifically, the Wilcoxon signed-rank test to evaluate the differences in pre and post-intervention measurements. This exhaustive statistical procedure will allow a detailed and precise exploration of the impact of the intervention on the participants' EF. The Kolmogorov-Smirnov or Shapiro-Wilk normality test will be selected, depending on whether the degrees of freedom are greater or less than fifty, respectively, to assess the data distribution. If the data do not fit a normal distribution, the option will be to use non-parametric tests in subsequent analyses. In this case, the Wilcoxon signed-rank test will be applied to compare pre and post-intervention measurements, as this test is appropriate for evaluating related differences in situations where data do not follow a normal distribution. This approach will robustly infer the effects of the intervention on the participants' EF. A significance level of $p < 0.05$ was considered for all analyses. The obtained data were analyzed using SPSS 25.0 software.

Results

Descriptive Analysis

Table 1 shows an overall increase in central tendency measures from pre to post-intervention, with the mean increasing from 40.78 to 43.21 and the median from 42.00 to 44.00. The dispersion of the post-intervention data has compacted, reflected in a decrease in the standard deviation from 6.67 to 5.60 and in the variance from 44.62 to 31.39. This suggests a general improvement and greater consistency in the participants' scores after the intervention.

Table 1. Descriptive Statistics Pre and Post Intervention

		Pre	Post
Mean		40.78	43.21
Median		42.00	44.00
Mode		40.00	43.00
Deviation Deviation		6.67	5.60
Variance		44.62	31.39
Range		26.00	21.00
Minimum		23.00	29.00
Maximum		49.00	50.00
Percentile	25th	40.00	41.00
	50th	42.00	44.00
	75th	45.00	47.00

Comparative analysis

The results from the Shapiro-Wilk test for Pre and Post intervention data showed significance values of .006 and .016, respectively (table 2). Given that both p-values are below the typical significance level of .05, the null hypothesis that the samples come from a normally distributed population is rejected. This indicates that, in both cases, the data do not follow a normal distribution, and therefore non-parametric statistical tests should be employed for subsequent analyses since they do not assume data normality.

The choice of the Shapiro-Wilk test in this context is likely due to its suitability for smaller samples, being more accurate and reliable in these cases compared to other normality tests.

Table 2. Normality test

	Shapiro-Wilk		
	Statistician	gl	Sig.
Pre	,847	19	,006
Post	,873	19	,016

The Wilcoxon test revealed a value of $Z=-3.450$ $Z=-3.450$, and the bilateral asymptotic significance level was $p=.001$. This significance value was considerably below the conventional threshold of .05, leading to the rejection of the null hypothesis that there were no significant differences between the scores obtained before and after the intervention. The negative value of Z indicated that the scores after the intervention were significantly higher than the scores before the intervention. Therefore, findings from the Wilcoxon test suggested that the implemented intervention had a positive and significant effect on the participants' performance, evidencing a notable improvement in their scores of the assessed EF from Pre to Post intervention. The effect size was 0.79, which is considered high (Table 3).

Table 3. Comparison of Executive Function Scores Pre and Post Intervention Using the Wilcoxon Test

	Post - Pre	**R (magnitude of effect)**
Z	-3,450[b]	0,79
Sig. asintótica(bilateral)	,001	

Dicussion

The objective of this study was to explore the potential for enhancement in EF through interventions centered on physical activity and play. The findings of this research suggest that implementing an intervention during Physical Education sessions with young students can foster significant enhancements in their EF. This infers a correlation between the incorporation of play-based strategies and physical activities and the subsequent improvement in the EF. However, it is essential to underline that the specific nature of the chosen programs and methods play a pivotal role in determining the extent of the observed impact.

This result is consistent with existing evidence in the field. For instance, the research by Rosas, Espinoza, Porflitt, and Ceric (2019) illuminated the positive impacts of various play modalities on the development of EF in children during their early educational stages. Notably, this study emphasized the significant relationship between pre-intervention EF measures and subsequent mathematical performance post-intervention. Similarly, interventions like the one conducted by Traverso, Viterbori, and Usai (2015) accentuated the efficacy of group-based play methods, honing in on the core elements of EF, and showcasing substantial improvements in areas like working memory, cognitive flexibility, and overall intelligence quotient. These enhancements are not limited to any geographical context. In fact, programs from the United States and Canada have demonstrated noteworthy cognitive and socio-emotional advancements in the realm of EF development by seamlessly integrating physical activity (as illustrated by Bodrova and Leong, 2007). In this backdrop, there's been successful demonstration of programs like "Move," which weave together exercises of varying intensities and foster concurrent learning through the children's active engagement (as evidenced by Wright et al., 2016).

Yet, it's imperative to acknowledge the heterogeneity in the efficacy of different exercises on EF, as highlighted by scholars like Diamond (2016), Diamond & Ling (2016), Ishihara et al. (2017), and Tomporowski et al. (2015). Even though play-centric strategies can bolster EF, the degree of enhancement and meaningful improvements are inherently contingent on the nature, mode, and duration of the implemented programs and games. This underscores the necessity for educators and practitioners to tailor their approaches, keeping in mind the diverse needs of their students and the specific outcomes they aim to achieve.

Conclusions

In conclusion, the findings from this preliminary study suggest that play-based strategies and physical activity have the potential to significantly enhance EF in children in early educational stages. Notable progress was observed in areas such as language and mathematics, underscoring the importance of integrating playful and active methods into the educational process. Comparing with longer-duration interventions suggests that long-term programs could yield even more pronounced benefits, highlighting the need to incorporate these interventions consistently into the curriculum. The significance of physical activity in driving cognitive and

socio-emotional development was established, emphasizing the urgency of promoting active lifestyles from a young age and transforming educational institutions into champions of mental and physical health. Despite the progress seen, it's crucial to acknowledge the study's limitations, including the program's implementation time and the use of a holistic assessment of EF. This underscores the need for more detailed future research that addresses each child's individual needs and explores the specific influence of different interventions on children with special educational needs. The insights from this study provide valuable perspectives on executive function development and academic performance in early childhood education. They suggest that with well-structured interventions, play and physical activity can be pivotal tools for cognitive development and emotional well-being during childhood.

Conflicts of interest: If the authors have any conflicts of interest to declare.
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